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**INDUCED VARIABILITY FOR QUANTITATIVE AND  
SOME QUALITY TRAITS IN WHEAT IN  
M<sub>2</sub> GENERATION**

**BY  
RAVIKUMAR TAMRADHWAJ SUKHADEV**

T 1291



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**In**

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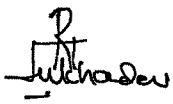
**DEPARTMENT OF BOTANY  
MARATHWADA AGRICULTURAL UNIVERSITY  
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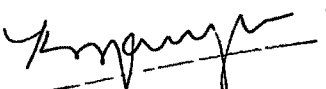
  
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**CERTIFICATE I**

Shri Ravikumar Tamradhwaj Sukhadev has satisfactorily prosecuted his course of research for a period of not less than four semesters and that the dissertation entitled "INDUCED VARIABILITY FOR QUANTITATIVE AND SOME QUALITY TRAITS IN WHEAT IN M<sub>2</sub> GENERATION", submitted by him is the results of original research work and is of sufficiently high standard to warrant its presentation to the M.Sc. (Agri) examination. I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

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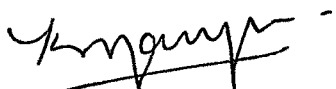
  
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**CERTIFICATE II**


This is to certify that the dissertation entitled "INDUCED VARIABILITY FOR QUANTITATIVE AND SOME QUALITY TRAITS IN WHEAT IN M<sub>2</sub> GENERATION", submitted by Ravikumar Tamradhwaj Sukhadev, to the Marathwada Agricultural University, in partial fulfilment of the requirement for the degree of Master of Science (Agriculture) in the subject of Agricultural Botany (Genetics and Plant Breeding) has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

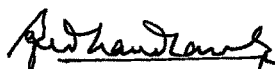
  
External Examiner


  
( K. A. NAYEEM )  
Guide

Advisors :

  
( Y. S. Nerkar )

  
( D. B. Wankhede )

  
( H. M. Syed )

  
( P. R. Waghmare )

  
Associate Dean & Principal

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CHAPTER-I INTRODUCTION

Wheat (Triticum spp.) is one of the principal food grain crops of the world. It serves as a staple food for most of the people in the world. Wheat is commercially important crop due to its 'Gluten' content. In terms of both area and production, India today ranks fourth among the wheat growing countries of the world and contributes approximately 26 per cent of the total food grain production. With the increase in world population and change in food habits growing demands for increase in wheat production become essential, thus improvement in wheat yield has been a continuous process. This was possible through high yielding wheat varieties and adoption of improved agronomic practices.

India, has the record harvest of wheat grains to the tune of 46.1 m.tonnes during Rabi 1984-85, and the average yields are 20.89 Q/ha. In Maharashtra State wheat occupied 11.28 lakh hectares with production of 9.88 lakh tonnes, the average yields are 7.92 Q/ha. These lower yields in Maharashtra are due to unfavourable climatic conditions i.e. high temperatures at grain filling, erratic nature of rains, etc.

The improvement in quality traits like gluten, protein lysine, pelshenke and sedimentation test etc. can be done by using various breeding methods. Genetic variability in plant population is pre-requisite for selection.

Artificial mutagenesis has already proved an effective and efficient tool for creating new and useful genetic variability for both practical breeding and genetic studies of crop plants. Improvements in quality traits of wheat varieties will be attempted in the present investigation.

Improvements in economic traits of field and horticultural cultivars evolved through mutation breeding have resulted largely from mutation that modify simply inherited traits (Sigurbjornsson B. and Mick A. 1969). However, Gaul (1964-65) and Gaul et al. (1969), have written extensively about the role of "Micromutations" for plant improvement. A micromutation is a mutational event which causes very small modification of the phenotype of a trait. Such mutations should be useful for improving quantitatively inherited traits (e.g. grain yield) without disturbing the major part of genotypic and phenotypic architecture of the crop plant.

Induced mutation are considered as an alternative to naturally occurring variation as a source of germplasm for improvement programmes and as an alternative to hybridization and recombination in plant breeding. The results of Gustafsson (1947, 1957), Mackey (1956), Natrajan et al (1958), Swaminathan (1963), Singh (1968) and Konzak (1972) have clearly indicated that wheat being self-fertilising polyploid, is more suitable for improvement by mutation breeding.

Sigurbjornsson and Mücke (1974) have given the achievements by mutation breeding in various crops and ornamentals by release of 145 outstanding varieties in different countries. In case of crop varieties, out of 98 released, 8 are of bread wheat and 4 of durum wheat. This indicates that mutation breeding is serving as an efficient additional tool in the hands of breeders for bringing about the crop improvement. Hence, the present investigation were undertaken to evolve high yielding good quality wheats possessing temperature tolerance.

The experimental material consists of five genotypes of wheat viz, Ajancho, HD-2189, NIML-1, C-306 and Hindi-62. These varieties were treated with gamma rays with various doses and were grown in 1984-85 as  $M_1$  generation, in 1985-86 as  $M_2$  generation; with the following objectives.

1. To evaluate the effect of irradiation on yield and other quantitative characters in  $M_1$  and  $M_2$  generations.
2. To study the quality characters viz., protein, gluten, lysine, sedimentation value, pelshenke ash etc.
3. To isolate agro-economically better types.



### 2.1 The role of mutations in crop improvement :

The concept of inducing mutations and utilizing them in plant breeding was first suggested by Hugo De-vries (1901) and the pioneer work of Muller (1927) and Stadler (1928) on artificial induction of mutation by X-ray irradiations; entered into a new era in increasing new genetic variability and subsequently its utilization in crop improvement.

Potentialities of mutation breeding are described by Jona (1969). He suggested that mutation breeding is neither a short cut nor a substitute for conventional and well established breeding methods but is very potential aid to plant breeding.

Induced mutations can generate useful variation in multigenic characters and where appropriate selection has been applied improvements in yield adoptability, maturity time and numerous other quantitative traits have been obtained. The extent to which induced mutations are a satisfactory alternative to natural variation for the improvement of such traits is largely determined by the importance of linked groups of genes and the degree to which selection has built linked gene complexes which will be of adoptive significance in plant breeding situations.

In crop plants, the direct release of induced mutations for commercial use have taken place in white mustard (Anderson and Olsson, 1954), barley (Gustafsson, 1963), Peanut (Gregory, 1960), Bread wheat (Varughese and Swaminathan, 1967) and in many other crops. An example of the induced mutant in recombination breeding for development of outstanding new varieties is the "Hellas" variety of barley developed at the Swedish seed association Svalof, by crossing Pallas (mutant) with Herlen.

The important varieties developed are like Pallas, Mari and Midas (barley), Reimei (rice), Florad and Alamo X (Dats), Raidon (Soybean), Kievsky mutant (lupine), Aruna (castor), NE 4 X peanut and wheat varieties like N.P.836 (Jagatheson et al. 1961), Shasbati sonora (Varughese and Swaminathan, 1967) in India, Lewis and Stadler (1964) in U.S.A. Sinvalocho Gama (1962) in Argentina, Zenkouzi-Komugi (1969) in Japan and Novosibirskai-67 (1969-70) in U.S.S.R of bread wheat and castelporziane (1965), castelfusano (1968), Castel del Monte (1969) and Castelnuo V. (1971) in Italy of durum type.

The Mexican wheat varieties Sonora 63, Sonora 64 and Lorma Rajo which have red grains were subjected to mutagenic (EMS and gamma ray) treatments with a view to select mutants with amber grains since Indian farmers and consumers prefer grains with colour (Varughese and Swaminathan 1966).

Swaminathan (1969) has aptly summarized the role of mutation breeding in a changing agriculture.

The role of induced mutations in quality improvement has been discussed by several workers (Swaminathan et al. 1969,1970; Johnson et al. 1969; Smutupt, 1970). Some Success has been already achieved in this direction, for grained mutants, isolated from sonora-64, were found to possess higher amount of protein and lysine (Varughose and Swaminathan,1966; Swaminathan et al., 1969).

Singurbjornsson (1970) stated high lysine genotypes are found only very rarely, and mutation breeding offers possibility of improvement. He further state that rapid and alarming erosion of our genetic resources which are of vital if sustained progress in plant breeding is to be expected. Mutagenesis can be used for artificial creation of variation to enhance genetic resources.

Brounmann and Fossati (1974) irradiated five varieties and observed increased tolerance in  $M_7$  for Leptosphaeria nodurum while selecting on basis of grain appearance and 1000 grain weight. In varieties champion and Zenith observed 12-15 percent increase in test weight than control in  $M_3$  and  $M_6$ .

Devender Kumar (1977) obtained promising mutant HUN-Sdf.1 after gamma irradiation of K 68, which was significantly shorter and had about same number of tillers per plant and grains per spike, had a significantly higher test weight and a 50 percent higher total yield.

Kulshrestha and Mathur (1978) isolated mutant resembling to Sonolika, Arjun and Kalyansona, in respect to days to heading, maturity, height and test weight in wheat variety Zaafrane after gamma irradiation. They concluded that genes responsible for evolution of Sonolika, Arjun and Kalyansona are available in Zaafrane.

## 2.2. Types of mutations and their value in plant breeding.

Swaminathan (1965) has classified mutations into 2 major groups : (1) Those which can be recognized by study of individual plants, and (2) Those which can be recognized only by a study of the characters of families. In the former group there are three sub-groups based on the magnitude and type of genetic change involved.

- A) Visible mutations.
- B) Macro-mutations.
- C) Systematic mutations, the latter group of mutations involve changes in quantitative characters controlled by polygenes.

**Visible mutations**

These mutations can be identified either by the naked eye or by the use of appropriate screening procedures, such as the creation of artificial epiphytotic diseases and the adoption of biochemical sieves. These mutations could be either (i) lethal or (ii) viable.

**Viable mutations**

These mutations provide valuable informations about the mode of action of different mutagenic agents as well as the mutation pattern of specific gene locus. They are specifically useful for linkage studies. Increase in the frequency of viable mutations induced by gamma rays was high when expressed on  $M_2$  seedling basis, but reverse situation existed when mutation frequency was expressed on the basis of segregating  $M_2$  families, suggesting that the loci responsible for their expression have mutated, simultaneously on homologous chromosomes (Goud 1967).

**Macromutations :**

These are the mutations in which the change though inherited as a single unit of recombination affect a constellation of characters. Such mutations might be due to genuine or pseudo-pleiotrophism. The macro-mutations were induced by gamma irradiation of Karcag 522 compared with 30,000 R is 20-30 cm shorter and has stronger straw a 3-5 gm higher 1000 grain weight

(42-43 gm) a significantly higher yield and equal protein content and flour quality. The broad-leaved dwarf mutant kg AM 522 from treatment with 25,000 R is 60-70 cm in height, 7-10 days later in maturity than karcag 522 and 5-6 q/kh lower in yield (1kh=1.42 acres=0.57 ha) it has a low 1000 grain, wt. (28.32 gm) and an increased protein content but reduced flour quality (Viglas, P.1971).

#### Micro-mutations :

Oka *et al.* (1968) concluded that micro-mutations could occur in positive as well as negative direction at the same frequency on the X-rays treatment in rice.

Mutations for polygenically controlled traits, can be isolated and fixed only through the adoption of biometrical procedures. Trujillo *et al.* (1971) found that for selecting the desirable micro-mutants after mutagenic treatment, it has proved useful to select first generation progenies containing individuals in which marked variation occurs in "different" characters, such as ear length. Progressive micromutations for yield are detected more frequently in the fourth generation of such progenies than in that of less variable progenies. Improvements of upto 13% over the initial variety have been achieved by this method in some lines through improved tillering, in other through increased test weight.

### 2.3 Induced Polygenic Variability :

Most of the economic traits in crop plants are quantitative in nature and are controlled by polygenic system. Usefulness of radiation for inducing mutations in polygenic characters was not realized fully until the work of Greory (1965) in peanuts.

Scissiroli (1965) reviewing the work on induced variability reported that almost all the polygenic characters showed increased variability after mutagenic treatments in various crop plant.

Muhammad and Syed (1965) studied the effect of ionizing radiation on seven wheat varieties with three doses of gamma rays resulted in reduction in germination, plant height and tiller number in the  $R_1$  generation. The test weight was increased in 3 varieties at the highest dose. In three varieties, a number of double eared and dwarf mutants were found in the  $R_2$ .

Scossirelli (1966) reported grains of the tetraploid Triticum durum 'cappelli' and the hexaploid T.aestivum 'Damiano' were exposed to doses of 10 kr and 20 kr of X-rays. The higher dose was lethal at the seedling stage. Radiation treatment were-shown to increase the amount of genetic variability for many quantitative traits.

The increase of variation was high for some traits in the tetraploid species and for other traits in the hexaploid species. It is suggested that artificial selection may use of such induced genetic variability for improvement of production characteristics.

Makarova (1966) used gamma rays for irradiation of dried grains of wheat *Agropyran* hybrids. These seeds were irradiated with doses of 10 and 15 br.gamma rays. In the  $M_1$ , there were no changes, However in  $M_2$  forms with greater ear density red instead of white grain, large grain, vitreous grain, short and tall culms and resistance to lodging appeared.

Goud (1967) reported the selection for quantitative characters such as spike number and 100 grain weight has been effective in irradiated populations. Some selection are significantly superior to other within the treatments although there were no significant difference between treatments. The direction of incidence of polygenic mutations follows a trend opposite to the previous selection history. In a bold grained variety NI 876, the seed size was reduced, in the irradiated population where selection was not exercised but in a small grained variety, NP 870 seed size was increased in irradiated populations compared with the control.

Maslavo and Stepanova (1967) isolated mutation with increased yield, earliness, standing capacity and size of ear after treatment with physical and chemical mutagens in wheat.

Bhal et al (1969) studied effects of X-irradiation on NP-823 and NP-860 and observed decreased mean height with increased X-rays in  $M_2$  and there were significant increases in variation for plant height and ear length.

Syed and Muhommad (1968) treated T.vulgare varieties viz., Dirk, C-5667, C-271, C-273, C-591 and Norin 53 and T.durum variety  $T_1$  were irradiated with 20,25 and 30 kr doses. The effect of number of spikes per plant, number of kernels per spikelet and final yield was lowered the yield. Most of the effect was restricted to the  $M_1$ .

Robbelen and Trujillo Figueroa (1969) treated the seeds of spring wheat line 3880 (48 with EMS). In  $M_2$ , 100 families having high variance (Group I) and 100 families having similar variance to control (Group II) were selected. In  $M_3$  progeny, variation and number of lines segregating for new mutation were higher in group I than in group II. In  $M_4$ , some lines (Group I) has significantly high yielded than control. In is concluded that early selection on the basis of  $M_2$  variance is a valid procedure in mutation breeding.

Khadr (1970) found significant variability in seed weight and its components in treated material of Giza-150 and Sonora-64 and their hybrids. The variation resulting from EMS treatment and hybridization were largely independent and cumulative.

Trujillo and Rios Betancourt (1970) reported an increase in variability and a reduction in mean value for culm length, number of spikelets, density of main spike and yield per plant as compared with the control in T.aestivum. The  $M_4$  generation showed greater variability than the  $M_2$  after drastic mutations segregating in the  $M_3$  had been eliminated. There was a increase in variance among the  $M_4$  for main culm length, number of spikelets, main spike length and test weight than  $M_2$ .

Kandaurov et al. (1972) observed variability in vegetative period, yield, unproductivity susceptibility to disease after treating hybrid varieties of wheat with chemical mutagens in  $M_3$ .

Mehta (1972) after treating seeds with EMS, screened 5 lakh plants of  $M_2$  and  $M_3$  generations for earlines and plant height, and 9000  $M_2$  plants for spikelet fertility, grain colour, grain filling and other characters and it resulted in isolation of several interesting mutants.

Ishkumar and Gupta (1973) studied induced polygenic variability in autotetraploid barley in  $M_2$  and  $M_3$  generations of EMS and gamma-irradiated material. They found, in general, the mean plant height and tiller number decreased at higher dose<sup>of</sup> EMS and heading date was delayed in all the treated plants.

Jana and Roy (1973) treated Dular and IH-8 rice varieties with EMS and ethyleneoxide. In the  $M_2$  generation there was considerable increase in variance for six characters. Mutagenic treatment followed by selection shifted the mean values mostly towards desired direction. The shift was not unidirectional nor equally effective for all the characters.

Sharma et al. (1974), in order to induce earliness in late maturing varieties of rice treated seeds with EMS and maximum variability as expressed by mean, variance and standard deviation was observed in 12 hours treatment.

Larik (1975) reported the increase in variance heritability and genic advance with increased dose of gamma rays for three characters viz., plant height, culm diameter and heading days in hexaploid wheat.

Sharma et al. (1982) reported variations in polygenic traits were induced by treating the  $F_1$  seeds with 0.4% EMS solution in some spring wheat crosses and ranges,

means and variances of mutagen treatment progenies were compared with their normal analogues. The effect of biparental mating and mutagen treatment on character associations was also studied, ranges and variances increased with the mutagen treatment in most of the cases, suggesting the efficiency of mutagen treatment of  $F_1$  seeds in increasing  $F_2$  variability.

Genetic variability :

The improvement of a crop is dependent on the magnitude of genetic variability and the extent of heritability of the desired characters. A critical survey of genetic variability is therefore a pre-requisite for planning and evaluating a breeding programme. The induction of mutation for factors which govern the heredity of quantitative characters is a promising tool for creating new genotypes.

Bagnara (1965) observed in all treatments increased genetic variability except EMS in case of culm length and last internode length in a variety cappoli when treated with X-rays, gamma rays, fast neutrons and EMS.

Swaminathan et al. (1965) reported the genetic variability in several varieties of barley, rice and bread wheat by X-ray, gamma ray, fast neutrons, EMS, nitrosomethylurea and N-methyl-N-nitroso-N-nitrosoguanidine (NG).

Shahani and Abidi (1965) studied effects of different five doses of gamma rays induce variation in plant height, earhead length and culm diameter in wheat variety H-68. Plant height decreased and ear length and stem thickness increased with radiation doses.

Bozzini et al. (1967) studied a marked increase in genetic variability of heading date (towards lateness), plant height (towards short straw), number of tillers/plant (towards a low number), number of fertile spikelets per ear (towards sterility) and number of spikelets per ear (towards both plus and minus variants) in plants of cappelli after the Vth recurrent mutagenic treatment. Variability in number of internodes on the main stem was not affected by X-rays. The results were not significantly different from those obtained as a result of a single mutagenic treatment.

Scossiroli (1968) treated grains of tetraploid Triticum durum 'Cappelli' and the hexaploid T.aestivum 'Damiano' were exposed to doses of 10 KR and 20 KR of X-rays. The higher dose was lethal at seedling stage. Radiation treatments were shown to increase the genetic variability for many quantitative traits.

The increase of variation was higher for some traits in the tetraploid species and for other traits in the hexaploid species.

It is suggested that artificial selection may make use of such induced genetic variability for improvement of production characteristics.

Dumonovic et al. (1969) studied the hexaploid varieties Ol3, Bankut 1203 and the hybrid 39 X Magdalena were irradiated with gamma rays. The variance for weight of kernels per plot, plant height, weight, of kernels per plant and number of plant per plot several lines selected from the  $X_5$  of Ol3 surpassed the control by 20-30%.

Orav . (1969) reported four spring wheat cultivars were treated with gamma rays. Doses of 10 and 12 KR inhibited development and lengthened the vegetative period. In the  $M_3$ , the variation increased for height. With all doses, grain weight in the  $M_2$  and  $M_3$  less than in the control.

Singh et al. (1970) studied genotypic variability in 16 varieties of T.durum under irrigated conditions and found that high genetic coefficient of variability was observed for the number of grains per ear, number of tillers per plant, 1000 grain weight and grain yield per plant.

Jain and Aulakh (1971) studied genetic variation in 80 strains of wheat (T.aestivum L.) and observed a high range of variation for characters of highest economic importance. The genotypic coefficient of variation was considerable for the yield, grains per ear and tiller number.

Khadr and Kassem (1971) studied gamma rays and EMS induced variation in wheat and reported that irradiation was more efficient than EMS for inducing genetic variability in heading date, plant height and test weight in the variety Giza-155, genetic variation was greater in the  $M_3$  than in the  $M_2$ .

Mishra (1971) studied phenotypic and genotypic variabilities in 13 dwarf wheat varieties and reported wide range of both variabilities for number of grain per spike and 1000-grain weight.

Mollado et al. (1972) studied gamma rays induced variation in wheat and reported that 10 and 15 KR doses increased mean values of the characters under study, while the higher doses tended to reduce them for plant height, the greatest intra family variation was induced by 15, 20 and 25 KR; while for tillers/plant and grain weight per plant. Five, 10 and 15 KR produced the greatest variation. In comparison with the control, plant height was more variable with all doses and tillers per plant and grain weight per plant were more variable with 5, 10 and 15 KR. No variation according to dose was found for test weight, Genetic variance between families was greatest at 5 KR for all the characters.

Oryluk (1972) observed greater genotypic variability and heritability for height in the short mutants than in the tall and increased in  $M_3$  and  $M_4$ . Short mutant did not differ from the parents in number of fertile tillers.

Gill and Brar (1973) recorded high genetic coefficient of variability for sedimentation value, grain yield, 100-grain weight and plant height in 77 varieties of wheat (T.aestivum L.).

Jana and Roy (1973) after treating dry seeds of two rice varieties, Dular and IR-8, with EMS and Ethylene oxide, observed a considerable increase in variance, for six characters. They have concluded that the nature and amount of induced genetic variability provides scope for selection of characters contributing to ards higher yield.

Tikka et al. (1973) observed high phenotypic variation for most of the plant characters in wheat especially ear bearing tillers, ear length, days to flower and main shoot length. Highest genotypic coefficient of variation was obtained for yield per plant (31.63) and least for days to flower (4.46).

Tripathi et al. (1973) studied 16 varieties of durum wheat to estimate the phenotypic and genotypic variability for 9 characters. Highest value for genetic coefficient of variation were obtained for days to 75 per cent flowering and number of grain per plant.

Vishwanatha and Kohli (1973) reported, in 212 wheat varieties, highly significant differences in grain yield, number of ear bearing tillers, number of fertile spikelets per ear, test weight and plant height. The characters test weight and grain yield per plant showed high genetic coefficient of variation.

Ibrahim and Sharaan (1974) studied  $M_3$  and  $M_4$  lines selected for early heading from  $M_2$  of the barley variety Giza 117 after gamma irradiation of seeds. They found low variability for height and high variability for number of ears per plant in  $M_3$  and  $M_4$ . The genetic coefficient of variation for ear length and number of grains per ear were lower.

Singh and Kumar (1974) studied induced genetic variability by gamma irradiation in K 69 and reported that the hardness, test weight, specific gravity and yield were less than the phenotypic coefficients of variability.

Savov (1974) treated ten varieties and their intervarietal hybrids with varying doses of gamma rays, the mutations induced included forms with shorter stems (57-60 cm), a larger leaf surface area (29-39 cm), a shorter growth period (3-6 days earlier) and a more compact ear structure. Some mutants belonging to the species T. spelta were obtained.

From T.aestivum and in some cases, especially in P 570/ WL V Uskhod (Ascent) forms were induced with a type of ear in which the spikelets were clustered in a way reminiscent of the gene Elymus. These ears were more productive than the normal but less fertile.

Larik (1975) reported increased variance with increasing the dose of gamma radiation on seeds of our wheat varieties. He has observed highest genotypic coefficient of variation in the variety Wisconsin supreme.

Randhawa et al. (1975) studied genetic variation in 21 strains of wheat (T.aestivum L.) and reported high genetic coefficient of variation for test weight plant height, peduncle length and yield per plant.

Yashvir et al. (1975) observed greater genotypic variability for height in the short mutants than in the tall, erect leaves, reduced ear length variable awn length and awlessness, heading time and maturity, ranging from 95-110 days as compared to 100 days in control.

Bhatnagar et al. (1977) studied 40 huskless varieties of barley and found that varieties showed significant differences among all characters studied. The genetic coefficient of variation was high for ear per plant, fodder yield, tillers per plant, leaves per plant, grain yield.

Listikova and Shcherbakov (1977) reported increased degree of tillering with radiation dose and fell in grain set. They also reported increased variation in yield components which was usually accompanied by a reduction in the mean value.

Reddy and Reddy (1977) noticed mutants for grain shape, panicle characters, height, growth period and yield in  $M_2$ ,  $M_3$  and  $M_4$  after presoaking grain of rice varieties Tellakattera, IR 47 and IR-8 with various concentrations of EMS and DES.

#### Heritability and genetic advance

For improvement of yield in self-pollinated crops, selection of a particular component character influencing yield is of great value. Heritability and genetic advance are most important parameters for a successful breeding programme as heritability provides a quantitative estimate of the relative importance of heredity and environment in determining the expression of a trait on which genetic advance depends.

Johannsen (1909) formulated the concept that both heritable and non-heritable agencies contribute to phenotypic variation in bulk population, while variation in pure lines is solely environmental.

Lush (1940) described heritability in 'broad sense' as the proportion of genetic to total or phenotypic variation in the 'narrow sense' as the ratio of fixable genetic variability to total variation.

Frankel (1947) has emphasized the importance of the knowledge of heritability of metric characters in plant population.

Gandhi et al. (1964) reported large heritability estimate for ear numbers, test weight, ear length, plant height, spikelets per ear and flowering days, moderate for grain yield and leaf area: and low for grain per cent. Ears per plant, 100-grain weight and ear length were found to have high heritability and a high genetic gain.

Yasuda (1965) studying variability in 10 spring wheat varieties and the inter relations of earliness of 208 autumnsown wheat varieties and observed high heritability and genetic advance for characters like heading and growth of leaves in spring wheat.

Singh et al. (1970) while studying variability in 16 varieties of T.durum Desf. under irrigated condition, reported high heritability estimates alongwith high genetic gain for the number of grain per ear, test weight and yield per plant.

Trehan et al. (1970) studied heritability for 9 quantitative characters in 83 varieties of barley and observed high heritability and genetic advance for characters like tillers per plant, length of peduncle, length of ear and seeds per ear.

Jan and Aulakh (1971) studied variability in 30 strains of wheat and reported an appreciable amount of heritability for the days to maturity, days to flowering, spikelets per ear and grain weight per ear. There was a high genetic advance for the yield. The grain weight per ear was found to have high heritability and the highest genetic advance.

Mishra (1971) reported high heritability and high genetic advance for characters like 100-grain weight, number of spikelets per spike, number of grains per spike and length of spike.

Kumar et al. (1972) reported low heritability for yield, ears per plant and number of grains per ear. In general, high value of genetic advance were noticed for the test weight and the yield; and moderate values for the number of ears per plant and the number of spikelets per ear.

Mollado et al. (1972) reported heritability increased for plant height and 100 grain weight following doses of 20 and 25 K<sub>2</sub>O and there was a reduction in the heritability of the other two characters. The highest values were found for the 5 K<sub>2</sub>O dose, with the exception of grain weight per plant, variability of these characters was also compared between 2 selection group, one selected for various agronomic characters (A) and one selected completely at random (B) variance was greater for tiller per plant and grain weight per plant at 5 and 10 K<sub>2</sub>O doses in group A than in group B. Analysis of variance of both groups at 3 doses, however should the great difference to be in the characters tillers/plant and grain wt./plant.

Gill and Brar (1973) noted high estimate of heritability for protein, spike length, sedimentation value, 100-grain weight, days to earing, plant height and spikelets per spike in 77 varieties of wheat (T. aestivum L.). Heritability estimates were low for grain yield, calcium and ash content of grain and other characters.

Nanda and Roy (1973) while studying induced mutations in rice observed that heritability estimates in treated populations were less than the predicted heritability in M<sub>3</sub> generation.

Tikka et al. (1973) reported high to moderate heritability for all characters in wheat which ranged from 41.52 per cent for grains per spike to 86.24 per cent for ear bearing tillers.

Tripathi et al. (1973) studied characters of 16 varieties of durum wheat. They reported, heritability in broad sense and expected genetic gain were maximum for panicle length, number of grains per plant and number of spikelets per panicle, high heritability estimates with medium value of genetic gain were observed for plant height and 1000-grain weight.

Vishwanatha and Kohli (1973) reported large heritability estimates in respect of number of spikelets per ear and test weight, thousand grain weight and grain yield per plant, high heritability as well as high genetic advance.

Siddique and Ghafoor (1974) studied  $M_2$  generations derived by treating C-591, Nayab and Indus-66 with X-rays, EMS and combination of both mutagenic agents. They have stated that estimates of heritability and expected genetic gain indicated that selection for higher yield would be more effective among mutants of Nayab and Indus-66 than among C-591 mutants.

Singh and Kumar (1974) reported high heritability estimates for grain hardness and test weight (73.59 and 71.17 respectively), moderate for yield (43.13 percent) and low for grain specific gravity (16.67 per cent).

Estimated genetic advance at 5 per cent selection intensity ranged from 2.34 to 22.18.

Larik (1975) reported that increasing the dose of gamma radiation on seeds of four varieties resulted in increased heritability estimate and expected genetic advance for plant height, culm diameter and days to heading. A variety Wisconsin supreme had the highest estimates of heritability.

Randhawa et al. (1975) reported high heritability and genetic advance for plant height, peduncle length, 1000-grain weight and the number of grains per ear.

Ziauddin Ahmed et al. (1977) reported higher narrow sense heritability for plant height and 1000-kernel weight than other characters. The genetic advance in percentage of mean was higher for the number of productive tillers per plant in  $F_2$  and  $F_3$  generations, followed by plant height and 1000 kernel weight in  $F_2$  and grain weight and plant height in  $F_3$ .

Singh et al. (1978) reported high heritability maximum expected gain and fairly good amount of expected additive genetic variance ( $6^2g$ ) for 1000-kernel weight and lowest for the plant height.

CHAPTER-III MATERIALS AND METHODS

### 3.1 Experimental material :

The material used for the present study comprised of five genotypes of wheat viz., Ajantha, HD-2189, NIML-1, C-306 and Hindi-62. Out of which NIML-1 is a multiline derivative of NI 146 which is T.durum type. The remaining varieties are of T.aestivum group.

### 3.2 Experimental methods :

#### 3.2.1 Mutagenic treatments :

Dry and bold grains of uniform sized, were taken from the Triticum aestivum L. ( $2n=42$ ) and Triticum durum ( $2n=28$ ) species. These seeds were treated with gamma rays at the Bhabha Atomic Research Centre, Trombay, Bombay. The source of irradiation was  $^{60}\text{Co}$ , with a dose rate of 3.KR/minute. 50 grammes of each variety were treated in each treatment, the doses were 10, 20 and 30 KR. Untreated seeds were taken as control. Those doses were selected as per the inferences drawn by Foltyn (1967); he indicated 10, 20 & 30 KR as useful range for mutation breeding in wheat.

#### 3.2.2 Raising of $M_1$ generation :

The irradiated material was sown with control in the field immediately after it was received from Trombay. The sowing of this  $M_1$  generation (replicated trial) was done during rabi season on 20th November, 1984 with dibbling method, two seeds/hill was dibbled at Wheat Research fields, Marathwada Agricultural University, Parbhani.

Table-1 : Salient features of varieties used for study.

	Ajantha	HD-2189	NIML-1	C-306	Hindi-62
Species	<u>I. aestivum</u>	<u>I. aestivum</u>	<u>I. durum</u>	<u>I. aestivum</u>	<u>I. aestivum</u>
Parentage	WJ 5 X Yaqul-53	HD-1960 X HD-1931	Multiline of NI 146	(Regent-1974 X CHZ <sup>2</sup> )C 591 X (P 19 X 281)	
Origin	E.A.U. Parbhani.	L.R.I., Delhi	Delhi	HAU, Hissar	Indore
Days to flowering	42-47	58-60	60-62	65-67	68-70
Days to maturity	90	120	118	125	130
Special Characters.	Early, Specially suited for rainfed area where yield is very poor.	Tolerant to all rusts High yielding in Maharashtra	It is suitable for chapati and bread making grain is amber, lustran	Quality wheat, High yielding rainfed variety and possess tolerance to high temperature conditions in M.P.	A promising rainfed variety of M.P. and also thermo- insensitive.

Material was sown with 23 x 10cm spacing and all agronomic and plant protection measures were applied as per recommendations for wheat. The design was randomised block design with three replications. The randomly selected plants were harvested separately.

#### 3.2.4 General care of the crop :

Normal agronomic practices like use of fertilizer, inter-culturing operations, plant protection measures were adopted. Protective irrigations were given as and when required.

### 3.3 Observations recorded in $M_1$ generation :

#### 3.3.1 Germination count.

Germination count was taken on 15th day in the field sown material.

#### 3.3.2 50% flowering :

Number of days from the date of sowing till the 50 percent plants in the progeny had emerged the flowers were recorded.

#### 3.3.3 Plant height (in cm)

Recorded in centimeters, the measurement include the height above soil surface to the top of the ear minus awns. This is recorded when the plant, were approaching maturity.

#### 3.3.4 Length of earhead (Main spike) :

Length of earhead (main) spike was measured in centimeters from the base of ear to the tip of the ear. (excluding awn length).

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**3.3.5 Number of fertile spikelets per main spike :**

Number of fertile spikelets i.e. in which grains were filled on the main spike were counted.

**3.3.6 Number of effective tillers/plant :**

Number of tillers bearing ears were counted as effective tillers.

**3.3.7 Days to maturity :**

Days to physiological maturity from the date of sowing.

**3.3.8 Number of grains/earhead :**

Number of grains per earhead (main spike) were counted by harvesting the earhead separately.

**3.3.9 100 grain weight :**

100 grains were counted for three times separately from the bulk of each progeny and weighted separately in grams using electrical monopan balance and averaged out.

**3.3.10 Grain yield per plant :**

Grain yield per plant was taken from each selected five plants separately in grams by using electrical monopan balance.

**3.44. Raising of  $M_2$  generation :**

Individual  $M_2$  plant progenies were grown in three replications by sowing material on 20th November, 1985.

These progenies were evaluated in factorial randomised block design with replication. These progenies were sown in single row of 3 meter length with 23cm x 10cm spacing as with three replications.

### 3.5 Observation recorded in $M_2$ generations.

#### 3.5.1 Viable mutants :

Mutants having economic value like early maturity, dwarf types, early dwarf, tall and early, profuse tillering types, late, etc. were screened and recorded.

#### 3.5.2 Biometrical observations :

Five plants were selected randomly in each entry of replicated trial and observations of these plants were recorded, as given for  $M_1$  at 3.3. in this chapter.

### 3.6 The preparation of samples for quality analysis :

The samples were ground in hand operated stone grinder, sieved through flour sieve (728 holes/sq.in.) thereby obtaining 91-92 percent extraction of flour.

#### B. 6.1 Protein Content (M x 5.7)

It was estimated by micro-Kjeldal method. Weighed sample (1 gm) was digested in concentrated sulphuric acid (36 N) using catalyst mixture, till the content were clear and free from black particles. The contents were diluted to 250 ml, 5ml of this sample was taken for distillation was carried out to collect ammonia in 4 percent boric acid solution containing methyl red and bromocresol green indicator.

About 70 ml of distillate was collected and then taken for titration against 0.01 N HCl till greenish or pink colour was obtained.

Simultaneously a blank reading also carried out. The per cent nitrogen was calculated by the following formula.

$$\text{Percent Nitrogen} = \frac{\text{(Sample titrate - Blank titrate)}}{\text{wt. of sample in mg.}} \times \text{NHCL} \times \text{dilution factor} \times \frac{14.007 \times 100}{100}$$

### 3.6.2 Gluten content :

Weighed sample (25 g) was taken into a white enamel bowl and sufficient tap water (15ml) was added to form firm dough ball. Dough was kept in water at room temperature for one hour. After one hour the dough was washed gently in the stream of tap water over bolting cloth, until it was noted before drying at 130°C.

### 3.6.3 Ash content

Weighed sample (5 gm) placed in silica crucible was incinerated in muffle furnace maintained at 550°C for 5 hours. The weight of ash was taken and expressed as percent ash in samples.

### 3.6.4 Lysine content

Lysine was estimated by the calorimetric method

### 3.6.5 Pelshenke Value :

Carried out by the method described by Pelshenke (1930).

### 3.6.6. Sedimentation test :

Were carried out by the method described by Zeleny (1947).

### 3.7 Statistical methods :

The large amount of data can be made intelligible only with the application of statistics. Hence, analysis of variance was worked out for all the quantitative characters studied, to find out whether there are significant differences among the variants with respect to these characters.

For analysis of variance the following constants were used.

$$\text{Correction factor (C.F.)} = \frac{\text{Grand total}^2}{\text{Number of variant progenies} \times \text{Number of replications.}}$$

$$\text{Total sum of squares (T.S.S.)} = \text{Sum of squares from all individuals observations} - \text{correction factor.}$$

$$\text{Replication sum of squares (R.S.S.)} = \frac{\text{Sum of squares of replication totals} - \text{C.F.}}{\text{Number of variant progenies}}$$

Variant progenies sum of squares (V.S.S.) =  $\frac{\text{Sum of squares of variant progenies totals}}{\text{Number of replications}} = \text{C.F.}$

Error sum of squares (E.S.S.) = T.S.S. - (V.S.S. + R.S.S.)

The mean sum of squares for variant progenies was obtained by  $\frac{\text{Sum of squares for variant progenies}}{\text{C.F. for variation progenies}}$

The mean sum of squares for error was obtained by  $\frac{\text{Sum of squares for error}}{\text{D.F. for error}}$

'F' value was calculated by the formula,

$F = \text{Variance ratio} = \frac{\text{M.S.S. for variant progenies}}{\text{M.S.S. for error}}$

$\text{S.E.} = \frac{\text{M.S.S. for error}}{\text{No. of replications}}$

Critical difference (C.D.) was calculated to find out whether there are significant differences among the variant progenies with respect to the characters studied.

$\text{C.D.} = \text{Standard error} \times \sqrt{2} \times 't'$

Where 't' = Value of 't' at 5% level.

The genotypic and phenotypic variances were calculated by following the expected M.S.S as follows:

#### Analysis of variance

Source of variation	df	S.S.	M.S.S.	Expected M.S.S.
Replications	r-1	-	M <sub>1</sub>	-
Variant progenies	v-1	-	M <sub>2</sub>	$\sigma_E^2 + r\sigma_G^2$
Error	(r-1)(v-1)	-	M <sub>3</sub>	$\sigma_E^2$

$$\sigma_G^2 = \frac{M_2 - M_3}{r}$$

$$\sigma_p^2 = \sigma_G^2 + \sigma_E^2$$

Where,

$v$  is no. of variant progenies

$r$  is no. of replications

$M_1$  is replication mean sum of squares

$M_2$  is variant progenies mean sum of squares

$M_3$  is error mean sum of squares

M.S.S. is mean sum of squares

$\sigma_E^2$  is environmental variance

$r\sigma_G^2$  is  $r$  times genotypic variance

$\sigma_p^2$  is phenotypic variance.

The phenotypic and genotypic coefficients of variability (C.V.) were calculated according to Burton (1952).

$$\text{Phenotypic C.V.} = \frac{\sigma_p}{\bar{x}} \times 100$$

$$\text{Genotypic C.V.} = \frac{\sigma_g}{\bar{x}} \times 100$$

Where,  $\sigma_p$  and  $\sigma_g$  denote phenotypic and genotypic standard deviations respectively and  $\bar{x}$  is the average mean of the characters.

$$\text{Phenotypic standard deviation } (\sigma_p) = \sigma_p^2$$

$$\text{Genotypic standard deviation } (\sigma_g) = \sigma_G^2$$

The heritability estimates were calculated according to the method suggested by Lush (1940) in broad sense

$$\text{Heritability (H)} = \frac{\sigma_G^2}{\sigma_p^2} \times 100$$

Where,  $\sigma_G^2$  is genetic variance and  $\sigma_p^2$  is phenotypic variance.

The heritability estimates were classified according to Robinson (1966) as given below:

1. Low heritability : 5-10%
2. Medium heritability : 10-30%
3. High heritability : 10-60%

The expected genetic advance was calculated for each character by the formula suggested by Lush (1949).

$$\text{Genetic advance} = \frac{K \times \sigma_G^2}{\sigma_p}$$

Where K = selection differential at 5% level and  $\sigma_G^2$  is the genetic variance and  $\sigma_p$  is the phenotypic standard deviation.

Genetic advance expressed in per cent of mean as  $\frac{\text{Genetic advance}}{\text{Mean X}} = X 100$  for comparison

CHAPTER-IV EXPERIMENTAL RESULTS

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The data taken from the laboratory experiments and field experiments to study the mutagenic effects for various characters of five wheat varieties viz., Ajantha, HD-2189, NIML-1, C-306 and Hindi-62 in the two successive mutagenic generations  $M_1$  and  $M_2$ ; are presented in this chapter. The results obtained in the present investigation are furnished in the following sub-sections.

#### 4.1 Studies in $M_1$ generation :

##### 4.1.1 Germination percentage :

Analysis of variance revealed statistically significant treatment differences for germination percentage. The effect of varieties was non-significant while, the effect of doses was significant.

##### Varietal differences :

The highest germination percentage (80.22%) was recorded for the variety NIML-1. However, the germination percentage in rest of four varieties was statistically at par with NIML-1 variety. The germination percentage in C-306 variety (74.81%) was lowest.

##### Effect of doses :

The effect of gamma ray doses was significant. The germination in control was highest (82.51%) and followed by 10 KR dose and 20 KR dose. The germination of 30 KR exhibited significantly lowest percent (65.92%).

INDEX

- CONTROL
- 10 KR
- 20 KR
- 30 KR

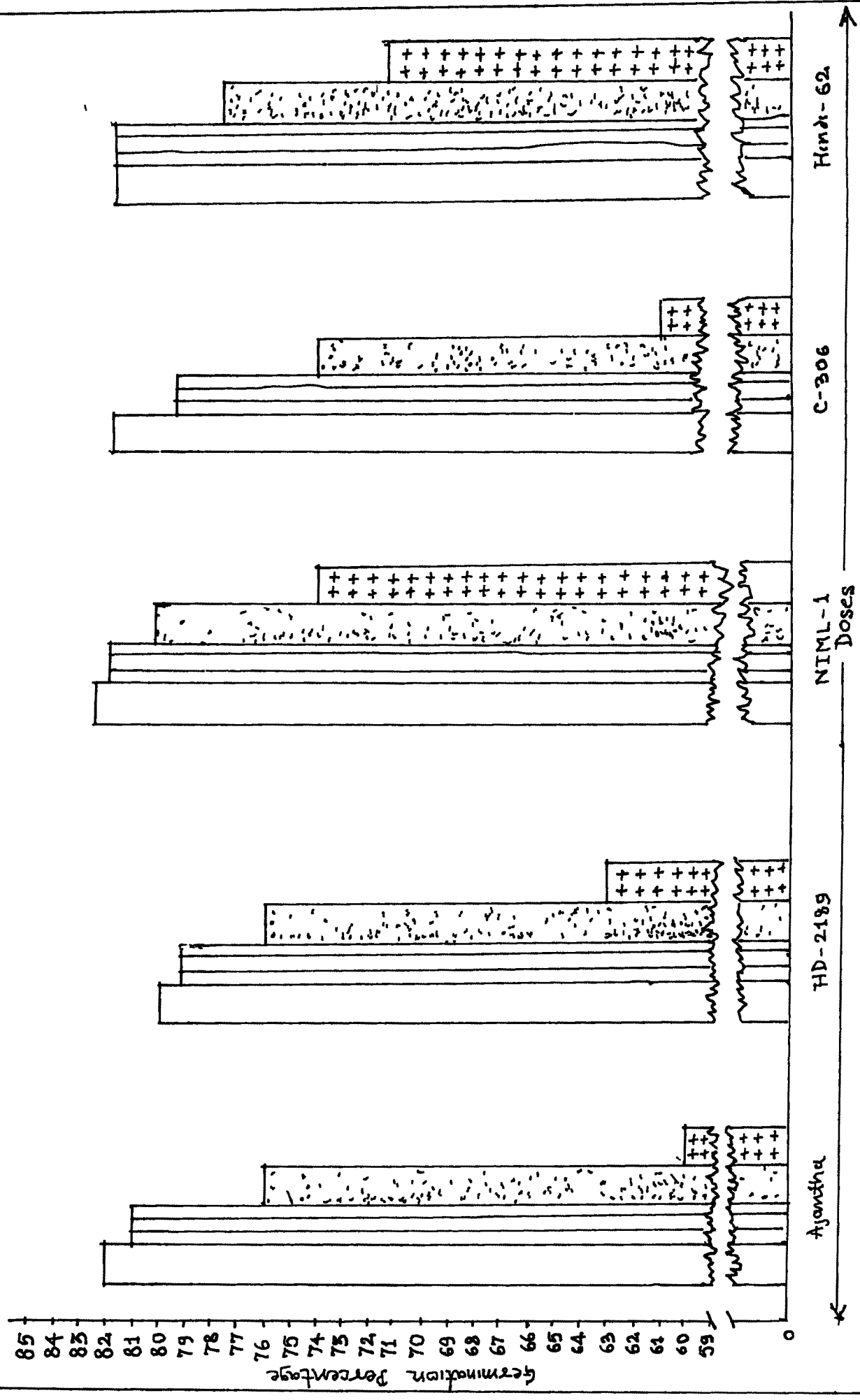


Fig 1 Effect Of Gamma Ray Doses On Germination Percentage

The results revealed reduction in the germination percentage due to increase in the dose of mutagen (Table 7).

Variety x dose interaction :

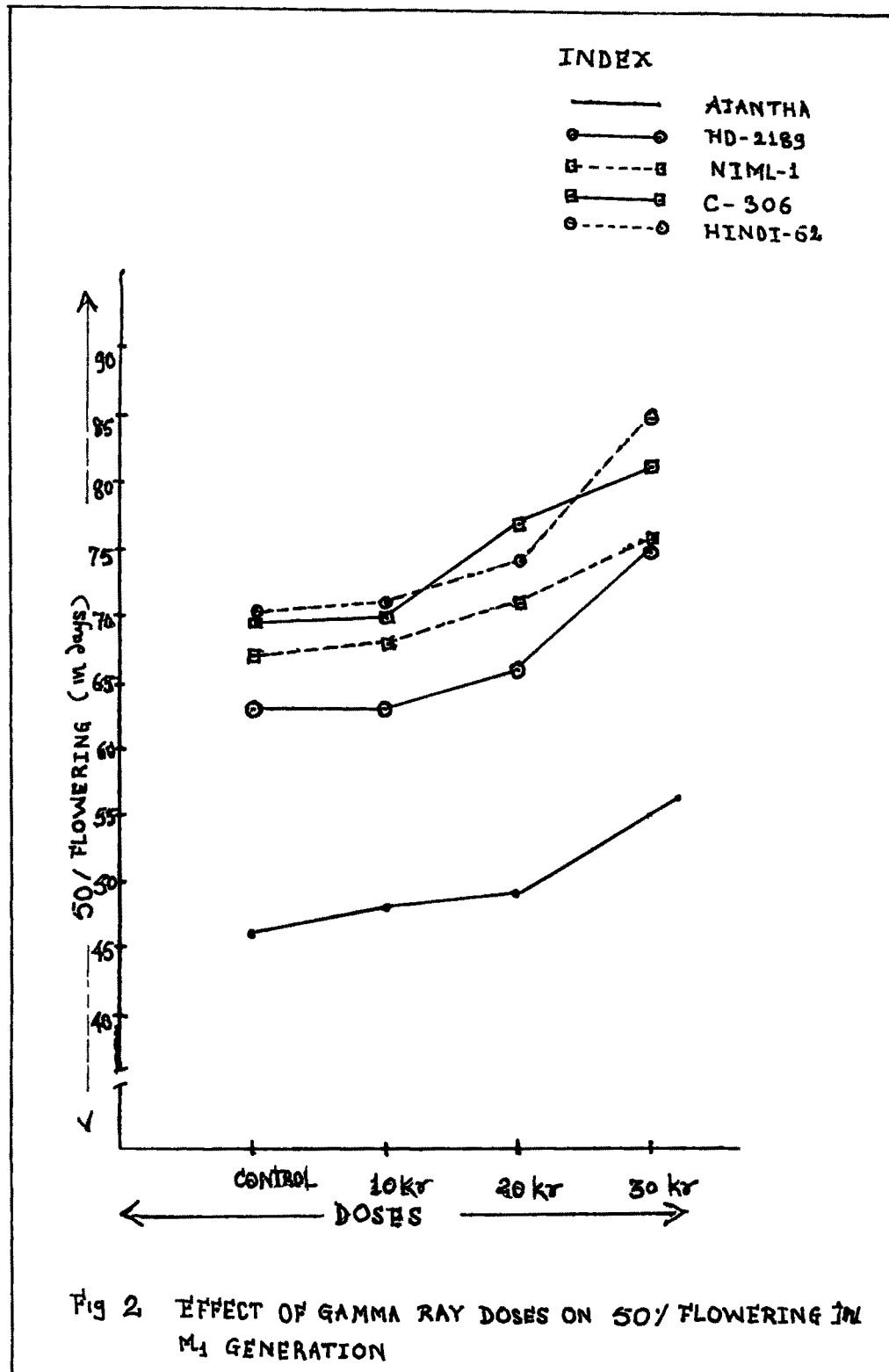
The interaction was significant. The germination percentage was highest in the control (non-treated) and lowest in 30 KR dose for all the five varieties. However, the germination percentage of 30 KR dose was statistically at par with control in the varieties NIML-1 and Hindi-62. The germination percentage in Ajantha with 30 KR dose was statistically lowest (59.07) than other treatments. The effect of 20 KR and 10 KR dose in all the varieties was at par with control. These results revealed decrease in the germination percentage, in all the five wheat varieties.

4.1.2 Days to 50% flowering (in days) :

The parameter days to 50% flowering is considered as an index of maturity. Early varieties of wheat for rainfed conditions will prove advantageous. These can escape the drought similarly early varieties under irrigated is the need to fit in the multiple cropping system.

Varietal difference :

The five wheat varieties revealed significant differences (Table 2). Hindi-62 indicated its lateness (75.75 days) for 50% flowering followed by C-306 (74.25 days) and were at par with each other. Variety Ajantha exhibited significantly lowest (49.54 days) for days to 50 percent flowering.



**Table 2 ANOVA for the effect of irradiation on five characters in  $M_1$  generation.**

Sources	df	Germination %	50% flowering	Plant height	Days to maturity	No. of tillers/plant
Replications	2	3.58	5.26	102.11	177.61	25.41
Treatments	19	168.65	415.07	374.85	864.64	17.20
Varieties	4	74.9†	1949.†*	820.26*	3551.73†	41.8†
Doses	3	860.21	19.68	1097.10	382.72	34.44
V X D	12	27.00	2.57	45.82	156.08	4.68
Error	38	69.24	3.17	20.42	155.44	10.28

\*  $p = 0.05$ , \*\*  $p = 0.01$

**Table 3 ANOVA for the effect of irradiation on yield components in  $M_1$  generation.**

Sources	df	Length of main spike (cm)	Number of spikelet	No. of grains/earhead	Grain yield per plant	100 grain weight
Replications	2	0.04	23.17	9.29	5.69	0.86
Treatments	19	3.34	4.04	17.35	0.83	0.34
Varieties	4	13.20	13.42	87.43	2.69	0.73
Doses	3	0.98	3.29	18.83	0.28	0.13
V X D	12	0.65	1.10	10.29	0.34	0.26
Error	38	0.54	1.40	6.49	0.98	0.28

\*  $p = 0.05$ , \*\*  $p = 0.01$

**Effect of doses :**

The effect of gamma rays doses were significant. The early flowering was observed in the control (65.80 days), which was significantly lowest (early) than other doses. The dose of 30 KR significantly increased the 50% flowering period (75.33 days).

**Variety x dose interaction :**

Data presented in the (Table 7) revealed that variety x dose interaction was significant. The 50% flowering period was early in control in all the five varieties and late flowering period was recorded in the 30 KR doses. The effect of 10 KR doses was at par with control in all the varieties except Ajantha, which showed significant difference (47.66 days). Twenty KR dose was also significant for the effect of mutagenic dose for flowering period towards lateness.

**4.1.3 Plant height (in cm) :**

Plant height is an index of plant growth. In wheat, plant height has greater importance as it is related to harvest index, lodging resistance etc. Due consideration is given to height while breeding for rainfed conditions. Analysis of variance revealed significant treatment differences.

**Varietal differences :**

The highest plant height (95.40 cm) was recorded in NIML-1 which was significantly superior over rest of all varieties. Least plant height (75.50 cm) was recorded in

the variety C-306 which was significantly inferior amongst all the varieties.

Effect of doses :

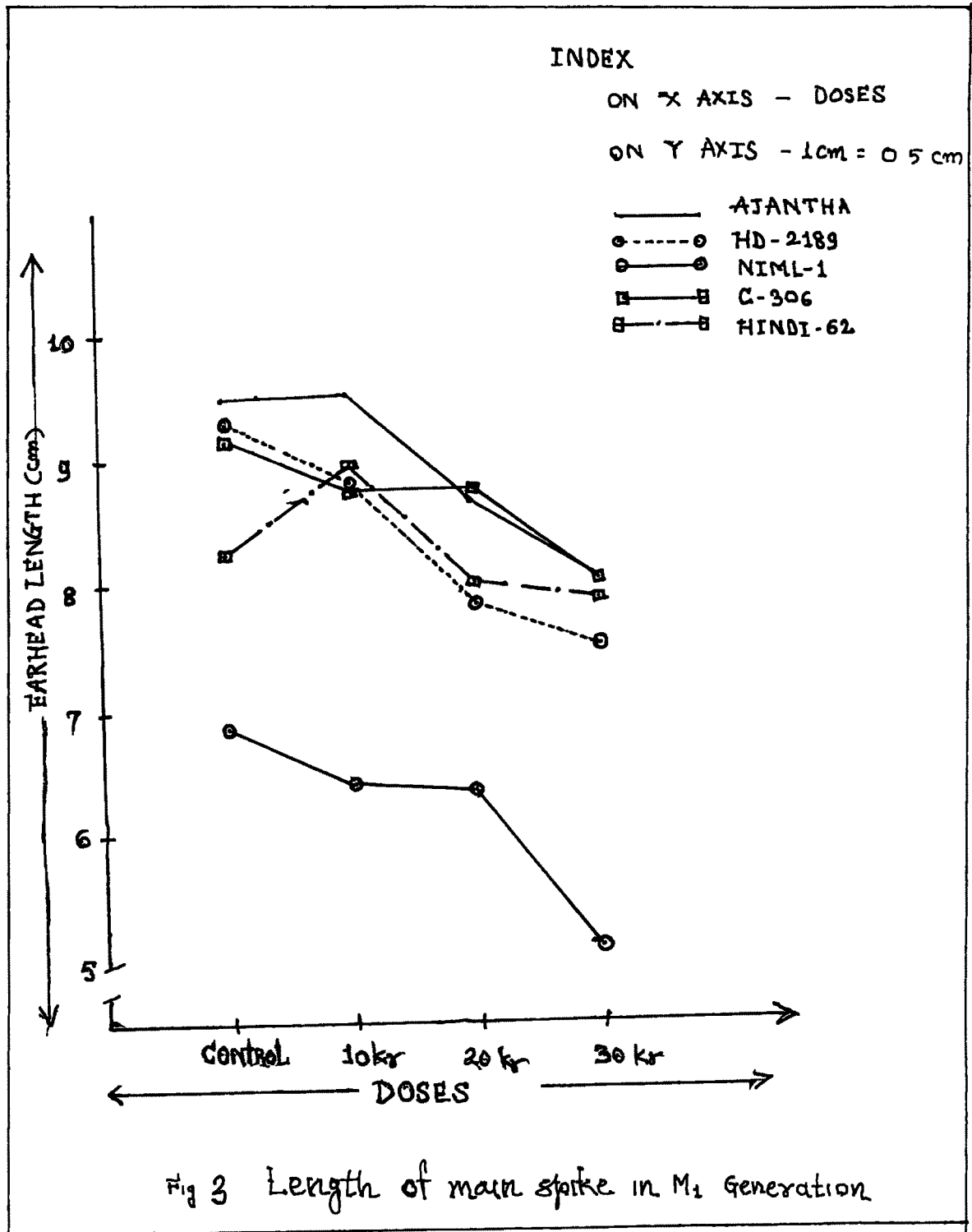
The effect of gamma ray doses was significant on plant height. The plant height in the control was highest (93.60 cm), which was significantly superior over rest of doses. The plant height was increased in 30 KR doses (74.44 cm). These results exhibited effect of doses on plant height.

Interaction effects :

Data presented in (table 7) revealed that variety x dose interaction was significant. The highest plant height was recorded in control NIML-1 i.e. 103.46 cm which was statistically significant, over other treatments. The plant height was highest in control and lowest in 30 KR doses in all the five varieties. However, the plant height in 10 KR dose was statistically at par with control in all the varieties except C-306. The plant height in 10 KR for C-306 was statistically lowest (74.80 cm) than other treatments. In general, the mutagen dose exhibited decrease in plant height in all five wheat varieties.

4.1.4 Length of mainspike (earhead in cm):

The spike length is the most important as it bears comparatively more number of spikelets and ultimately increased the number of grain resulting in increased grain yield.



**Table 7** Effect of irradiation on five varieties of wheat in  $M_1$  generation.

Treatment	Germination percentage.	50% flowering	Plant height	Days to physiological maturity	Number of tillers/plant
<b>Varieties :</b>					
Ajantha	75.09	49.54	90.20	96.50	14.51
ID-2189	75.13	67.08	78.18	125.58	12.30
NIML-1	80.22	70.67	95.40	128.50	10.80
C-306	74.81	74.25	75.50	134.16	13.80
HINDI-62	78.69	75.75	83.43	139.66	18.55
SE $\pm$	2.40	0.514	1.30	3.59	0.92
CD	NS	1.42	3.61	9.97	2.56
<b>Doses :</b>					
Control	82.51	65.80	93.60	122.60	11.28
10 KR	81.37	67.93	88.02	123.93	13.82
20 KR	77.36	69.00	83.12	125.86	13.60
30 KR	65.92	75.33	75.44	127.96	14.87
SE $\pm$	2.14	0.460	1.16	3.21	0.82
CD	5.95	1.27	3.23	NS	2.29
<b>Variety x dose :</b>					
Ajantha control	82.95	46.33	98.00	93.33	12.86
10 KR	81.66	47.66	94.80	96.33	14.40
20 KR	76.68	49.00	88.26	97.33	13.73
30 KR	59.07	55.33	79.76	99.00	17.06
ID-2189 control	80.92	63.66	86.00	120.33	11.76
10 KR	79.81	63.00	80.13	123.66	12.00
20 KR	76.44	66.66	75.06	127.00	12.60
30 KR	63.36	75.00	71.53	129.33	12.53
NIML-1 control	83.51	67.33	103.46	122.00	8.40
10 KR	82.03	68.00	101.23	128.00	9.20
20 KR	80.73	71.66	99.66	129.33	10.96
30 KR	74.62	75.66	77.23	130.60	11.66
C-306 control	82.40	69.66	90.00	130.33	12.40
10 KR	80.75	70.00	74.80	132.66	12.98
20 KR	74.81	77.00	71.80	134.66	14.20
30 KR	61.29	81.00	65.40	137.00	14.46
Hindi-62 control	82.77	70.00	90.53	123.00	10.96
10 KR	82.59	71.00	89.13	139.00	11.06
20 KR	78.14	74.00	80.80	141.00	16.53
30 KR	71.29	85.00	73.26	143.66	18.63
SE $\pm$	4.80	1.02	2.60	7.19	1.85
CD	13.31	2.85	7.23	19.95	5.13

**Varietal difference :**

There were statistically significant differences among the varieties for spike length, Significantly highest length of main spike was noticed in Ajantha (9.33 cm). The earhead length of HD-2189 and Hindi-62 was at par with Ajantha. Short earhead length was observed in NIML-1 which was significantly inferior.

**Effect of doses :**

The effect of gamma ray doses were statistically significant for spike length. The highest length of main spike (i.e. 8.59 cm) exhibited in control. The dose of 10 KR was at par with control the length of main spike was significantly lowest (7.45 cm) in 30 KR. The results showed reduction in the earhead length due to increase in the dose of mutagen.

**Interaction effects :**

The variety x dose interaction was significant. The main spike length was highest in the control and lowest in the 30 KR dose in all varieties. However, the main spike length in 20 KR and 10 KR doses was statistically at par with control, in all the wheat varieties. The length of main spike was statistically lowest (5.10 cm) in NIML-1 of 30 KR dose than other treatments. In general, the irradiation dose reduces the length of main spike in all wheat varieties.

#### 4.1.5 Number of spikelets per main spike :

Number of spikelets per main spike is an important character because greater number of fertile spikelets will produce more number of grains per main spike which is important for rainfed wheats.

#### Varietal differences :

More spikelet number per main spike was recorded in Hindi-62 (17.76). The Ajantha and ID-2189 varieties were at par with Hindi-62. Lowest spikelet number per earhead was found in NIML-1 (15.23). The varietal differences were significant.

#### Effect of doses :

The different doses of gamma ray showed significant differences. The highest number of spikelets were in control (17.11) and was at par with 10 KR dose. The number of spikelets was significantly decreased in 20 KR treatment. The dose of 30 KR exhibited significantly lowest (15.69) number of spikelets. The results revealed reduction in number of spikelets due to increase in the doses of gamma rays.

#### Interaction effects :

The variety x dose interaction was significant. The spikelet number was highest in the control and lowest for 30 KR dose in all the five varieties. However, the spikelet number in 30 KR dose was statistically at par with control in all the varieties except ID-2189.

The spikelet number in NIML-1 with 30 KR dose was statistically lowest (14.00) than other treatments. These results revealed differential response of wheat genotypes to irradiation doses. Generally, the irradiation dose revealed decrease in the spikelet number in all the five wheat varieties.

#### 4.1.6 Number of effective tillers per plant :

Number of effective tillers is also an important character influencing yield in wheat. In general profuse tillering is desirable for irrigated wheat, while less number of tillers is desirable for rainfed wheat, as there will be more requirement of water for profused tillering.

#### Varietal differences :

The five varieties revealed significant number of tillers per plant. Hindi-62 indicated significantly highest number of tillers/plant (15.55). The varieties Ajantha and C-306 were at par with Hindi-62, NIML-1 exhibited significantly lowest number of tillers (190.80) which was statistically inferior.

#### Effect of doses :

Irradiation with different doses was significant. The number of tillers were lowest in control and highest in the 30 KR doses in all the five varieties. The number of tillers for 10 KR and 20 KR treatment were at par with 30 KR dose. The lowest number of tillers exhibited in control which was statistically inferior.

Table 8 Effect of irradiation on five varieties of wheat on yield components, in M<sub>1</sub> generation.

Treatment	Length of main spike (cm)	Number of spikelets	Number of grains/earhead	Grain yield/plant	100 grain weight
<b>Varieties :</b>					
Ajantha	9.33	17.50	38.76	6.19	3.73
HD-2189	8.79	17.06	41.03	7.071	4.21
NIML-1	6.64	15.23	36.68	6.15	3.87
C-306	8.68	16.06	40.80	6.35	3.67
Hindi-62	8.87	17.76	39.66	6.66	3.55
SE ±	0.212	0.34	0.73	0.28	0.15
CD	0.58	0.94	2.03	0.79	0.42
<b>Doses :</b>					
Control	8.59	17.11	39.61	6.65	3.85
10 KR	8.48	16.38	38.41	6.57	3.55
20 KR	7.89	16.20	37.65	6.40	3.60
30 KR	7.45	15.69	37.30	6.22	3.93
SE ±	0.19	0.30	0.65	0.25	0.13
CD	0.52	0.84	1.82	NS	0.37
<b>Variety x dose :</b>					
Ajantha control	9.46	17.43	38.13	6.25	3.80
10 KR	9.50	16.46	39.20	6.47	3.63
20 KR	8.63	16.20	37.13	5.92	3.56
30 KR	8.03	16.93	33.60	6.12	3.92
HD-2189 control	9.30	17.53	39.73	7.26	4.20
10 KR	8.80	17.00	41.26	6.77	4.14
20 KR	7.86	16.80	41.73	6.90	4.04
30 KR	7.50	15.86	38.40	6.85	4.38
NIML-1 control	6.83	15.66	35.66	6.21	3.86
10 KR	6.40	15.53	33.33	6.12	3.13
20 KR	6.33	14.66	36.93	6.25	3.50
30 KR	5.10	14.00	30.80	6.27	3.89
C-306 control	9.13	17.13	42.13	6.62	3.75
10 KR	8.76	16.93	41.06	6.59	3.56
20 KR	8.76	16.20	39.04	5.70	3.59
30 KR	8.06	15.00	40.60	6.70	3.79
Hindi-62 control	8.23	17.80	42.40	7.14	3.55
10 KR	8.96	17.73	37.20	6.89	3.39
20 KR	7.90	16.86	38.06	5.90	3.39
30 KR	8.00	16.66	40.00	6.71	3.68
SE ±	0.42	0.68	1.47	0.57	0.30
CD	1.17	1.89	4.07	1.58	NS

**Interaction effect :**

The interaction effect was significant. The tillers were highest in the 30 KR dose and lowest in control in all the five varieties. However, the tillers number per plant in 30 KR dose was statistically at par with control in all the varieties except Hindi-62. The highest number of tillers were recorded in 30 KR dose of Hindi-62 (18.83) which was statistically superior over other varieties. The lowest tiller number (8.40) was exhibited in NIML-1 of control. In general, the mutagen dose revealed increase in the tiller number per plant in all five varieties.

**4.1.7 Days to physiological maturity :**

The parameter days to physiological maturity from the date of sowing is considered. Early varieties of wheat for rainfed conditions will prove advantageous as these can escape the drought, generally occurring in later part of rabi season, as it escape from the insect pest and diseases, etc.

**Varietal differences :**

The effect of gamma ray doses was non-significant. The late maturity was noticed in 30 KR dose (127.93 days) and earliness in maturity was found in control. In general, lateness in maturity in all varieties increased with increasing dose of mutagen.

**Interaction effect :**

The variety x dose interaction was non-significant. The early maturity was recorded in the control and late (highest) days to maturity was in 30 KR dose in all varieties. However, the days to maturity in 30 KR dose was statistically at par with control in all varieties except Hindi-62. The days to maturity in Hindi-62. The days to maturity in Hindi-62 with 30 KR dose was highest (143.66) than other treatments. These results revealed increase in the days to physiological maturity towards lateness with increasing mutagen doses.

**4.1.8 Number of grains per main spike :**

The number of grains per main spike is an important character influencing the grain yield. To get greater number of grains per spike without losing the average grain weight, will add towards higher yields.

**Varietal difference :**

The five varieties revealed significant differences for number of grains per spike. The data revealed that (Table 8) variety HD-2189 (41.03) had highest grain numbers. The variety C-306 and Hindi-62 were at par with HD-2189 which had grain numbers 40.80 and 39.66 respectively. The lowest grain number was exhibited by NIML-1 (36.68) variety.

**Effect of doses :**

The effect of gamma ray doses was also significant. The grain numbers per main spike were highest for control and was at par with 10 KR dose. The number of grains per main spike were significantly reduced in 20 KR treatment than control. The dose of 30 KR exhibited significantly lowest (37.30) number of grains per main spike. The results revealed reduction in number of grains due to increase in the dose of mutagen.

**Interaction effects :**

The variety x dose interaction was also significant. The number of grains was highest in the control and lowest in 30 KR dose. However, number of grains per main spike in 30 KR dose was statistically at par with control in four varieties, NIML-1 with 30 KR dose was statistically lowest (30.80) than other treatments. Higher doses of gamma rays reduced the number of grains per plant in all the varieties.

**4.1.9 100 grain weight (gms) :**

100 grain weight is an important character which influences the yielding ability. The results revealed significant varietal differences.

**Varietal differences :**

100 grain weight was recorded highest in HD-2189 (4.21 gm) which was significantly superior over other treatments, while NIML-1 variety was statistically at par

with ID-2189. Least 100 grain weight was found in Hindi-62 (3.55 gm) which was statistically inferior.

Effect of doses :

The effect of different doses of gamma rays was also significant. The highest grain weight was observed in 30 KR dose (3.93 gm) and was at par with control and 20 KR treatment. The dose of 10 KR exhibited significantly lowest (3.55 gm) 100 grain weight. The results revealed reduction in 100 grain weight at lower doses while increased at higher doses (like 30 KR).

Interaction effects :

The dose x variety interaction was non-significant. The dose 10 KR and 20 KR exhibited lowest 100 grain weight in all the varieties. The weight of 100 grains were slightly increased in 30 KR dose. The doses of 10 KR and 20 KR reduced the weight of 100 grains while the higher dose like 30 KR increased the 100 grain weight in all five varieties.

4.1.10 Grain yield per plant (in gms) :

Grain yield is the most important character and ultimate aim of the breeder is to improve this by knowing various statistical parameters, as it is complex characters and influenced by number of other characters.

**Table 4 ANOVA for the effect of irradiation on four quantitative characters in  $M_2$  generation.**

Sources	df	Plant height %	50% flowering	Days to maturity	No. of tillers/plant
Replications	2	373.44	4.65	130.2	2.25
Treatments	19	289.73	429.85	977.63	3.15
Varieties	4	112.52*	2009.45*	3857.18**	2.43*
Doses	3	942.18	33.30	368.93	4.55
V X D	12	185.69	2.45	169.96	3.05
Error	38	161.33	2.54	170.18	1.40

\*  $p = 0.05$ , \*\*  $p = 0.01$

**Table 5 ANOVA for effect of irradiation on yield components.**

Sources	df	Length of main spike	Number of spikelets	Number of grains/earhead	Grain yield/plant	100 grain weight
Replications	2	8.88	20.80	21.18	0.87	0.18
Treatments	19	4.75	6.21	51.55	1.76	0.40
Varieties	4	16.28*	11.61*	95.09	3.09	0.72*
Doses	3	2.81	4.51	34.18	3.67	0.33
V X D	12	1.40	4.85	41.38	0.84	0.31
Error	38	1.21	8.25	41.88	1.38	0.35

\*  $p = 0.05$ , \*\*  $p = 0.01$

**Varietal difference :**

The significant differences were found for grain yield. HD-2189 variety (7.07) significantly superior over Ajantha (6.15) and NIML-1 (6.15) while grain yield of C-306 and Hindi-62 were at par with HD-2189.

**Effect of doses :**

Non-significant differences exhibited within different doses of irradiation. The grain yield in control was highest (6.65 gm), while lowest grain yield was exhibited in 30 KR dose (6.22 gm). These results revealed reduction in grain yield due to increase in the dose of mutagen.

**Interaction effects :**

Data presented in the (Table 8) revealed that variety x dose interaction was non-significant. The grain yield per plant was highest in control (except Ajantha). Among the doses of irradiation 10 KR exhibited highest grain yield per plant for the variety Ajantha. The lowest grain yield per plant was observed for 20 KR dose. The 30 KR dose displayed at par grain yield as compared to the control. These results revealed differential response of wheat genotypes to irradiation doses. In general, the 20 KR dose of gamma rays exhibited reduction in the grain yield than 30 KR doses in all the varieties.

#### 4.1.1.1 Chimeras for double spike character :

Chimeras for double spike character were screened and isolated in  $M_1$  generation, which was induced due to gamma rays. Three chimeras for double spike character were found in different varieties as under. (i) HD-2189 with 30 KR dose which had branched spikelets. (ii) Second was observed in NIML-1 variety for 30 KR dose, in this peculiar chimera, there were two spikes due to bifurcation of peduncle. This bifurcation was from the base of spike. (iii) Third double spike was observed in C-306 in 30 KR dose which had long branched peduncle and possessed spikelets. All these three plants were dwarf.

The inheritance study suggested that the character was not heritable and may have arisen as a radiomorph in these three varieties.

#### 4.2 Studies in $M_2$ generation :

##### 4.2.1 Mutations for plant height :

##### 4.2.1.1 Dwarf mutants :

Mutants having varying degree for dwarfness were observed. Dwarfs statured plants possessing less height of 8 to 16 cm or 20 to 30% reduction in height were isolated. Such mutants were found in HD-2189 30 KR which had 40 cm plant height, Ajantha 30 KR exhibited 45 cm plant height. Ajantha being tall and subjected to lodging, it is desirable to isolate dwarf statured plants from this variety.

#### 4.2.1.2 Tall mutants :

Mutants having more height by 8 to 16 cm or more than respective control were observed. Most of the mutants were isolated from 20 KR and 30 KR doses for Ajantha possessing plant height of 95 cm and 98 cm respectively. Similarly in variety NIML-1 for 30 KR doses plants upto 97 cm and in C-306 upto 94 cm and in Hindi-62 upto 99cm plant height were isolated and harvested separately.

#### 4.222 Mutations affecting maturity :

##### 4.2.2.1 Early mutants :

In recent years for achieving 100% cropping intensity it is essential to fit wheat in sequence cropping for Rabi season. Hence it is necessary to head early maturing and adjusting to short winter season. These mutants were matured earlier by 4-10 days than their respective control. In Ajantha by 4 days and NIML-1 20 KR by 6 days and in HD-2189 by 8 days.

##### 4.2.2.2 Late mutants :

Late mutants are those mutants which matured later by 4-10 days than their respective controls. Late mutants occurs specially in Hindi-62 20 KR by 5 days, Hindi-62 30 KR by 10 days and C-306 30 KR by 10 days.

##### 4.2.2.3 Early and dwarf mutants :

These mutants were less in height and matured earlier than their respective controls. Such type of mutants were noticed in varieties viz., and NIML-1, for 30 KR doses.

#### 4.2.2.4 Early and tall mutants :

These were earlier in maturity and were taller than their respective controls. Such type of mutants were observed in Ajantha 20 KR, C-306 30 KR, wheat varieties.

#### 4.2.3 Mutations affecting ear characters :

##### 4.2.3.1 Tip sterility mutants :

Mutants having sterile spikelets at the tip of the ear are termed as tip sterility mutants. Such type of mutants were isolated from HD-2189 30 KR.

##### 4.2.3.2 Elongated ear :

These are interesting mutants and also economical. In these mutants length of spike has been increased, these were found in NIIM-1 30 KR and C-306 30 KR.

##### 4.2.3.3 Bold and elongated ear :

In this mutants length of main spike was increased than their controls, the size of spikelets was also increased and having bold grains. Such peculiar mutants were found in Ajantha 30 KR. These are also desirable and economical mutants.

##### 4.2.3.4 Double spikelet mutants :

Such chimera was found in  $M_2$  generation also. In these mutants two spikelets was observed in 30 KR of C-306 variety.

#### 4.2.4 Biometrical observations :

The observations were recorded like  $M_1$  generation.

**Table 9 Effect of irradiation on five varieties of wheat in M<sub>2</sub> generation.**

Treatment	50% flowering	Plant height	Length of earhead	Number of spikelets
<b><u>Varieties :</u></b>				
Ajantha	49.00	75.50	7.58	13.71
HD-2189	62.58	72.95	7.64	13.63
NIML-1	67.33	71.73	4.88	12.63
C-306	69.41	78.41	7.21	15.29
Hindi-62	83.91	78.26	7.33	14.78
SE ±	0.46	3.88	0.31	0.82
CD	1.27	NS	0.88	2.29
<b><u>Doses :</u></b>				
Control	64.46	63.57	6.34	12.57
10 KR	65.93	78.05	6.97	13.84
20 KR	66.53	79.13	7.34	14.43
30 KR	68.06	80.65	7.13	15.19
SE ±	0.41	3.45	0.28	0.74
CD	1.14	9.63	0.78	2.05
<b><u>Variety x dose :</u></b>				
Ajantha control	46.66	65.73	6.46	11.33
10 KR	48.00	78.13	7.80	12.33
20 KR	48.33	80.46	8.16	15.26
30 KR	49.00	77.66	8.13	15.93
HD-2189 control	61.66	58.73	7.56	12.40
10 KR	62.33	77.53	7.46	13.80
20 KR	63.00	82.06	8.10	13.60
30 KR	63.33	83.46	7.46	14.73
NIML-1 control	64.00	60.93	4.88	10.33
10 KR	67.00	78.26	4.53	13.33
20 KR	67.33	78.80	4.80	13.40
30 KR	71.00	83.53	5.36	13.46
C-306 control	68.00	70.40	5.20	14.86
10 KR	69.00	81.20	8.03	15.16
20 KR	70.00	79.00	8.10	15.26
30 KR	77.66	83.00	7.53	15.90
Hindi-62 control	82.00	82.06	7.60	13.93
10 KR	83.33	80.13	7.03	14.60
20 KR	84.00	75.33	7.56	14.66
30 KR	86.00	80.53	7.16	15.93
SE ±	0.92	7.77	0.63	1.65
CD	2.55	21.55	1.76	4.59

#### 4.2.4.1 Plant height (in cm) :

##### Varietal difference :

The varieties revealed non-significant differences. for plant height. C-306 indicated highest plant height (78.26 cm) followed by Hindi-62. The shortest plant height was observed in NIML-1 (71.63 cm).

##### Effect of doses :

The doses of gamma rays exhibited significant difference. The plant height in control was lowest (63.57 cm). The plant height in 30 KR dose exhibited highest (80.65 cm) which was significantly superior over control and were at par with 10 KR and 20 KR doses. The control revealed significantly lowest plant height. The results revealed increased in the plant height due to increased in the doses of mutagen.

##### Interaction effects :

There was significant results between the variety x dose interaction. The highest plant height was found in 20 KR dose. However, the plant height in control dose was statistically at par with 30 KR, in all the varieties except HD-2189 and NIML-1. The plant height in HD-2189 with control was statistically lowest (58.73) than other treatments. The 10 KR, 20 KR doses was at par with 30 KR dose. In general, the mutagen dose revealed increase in the plant height in all the five varieties.

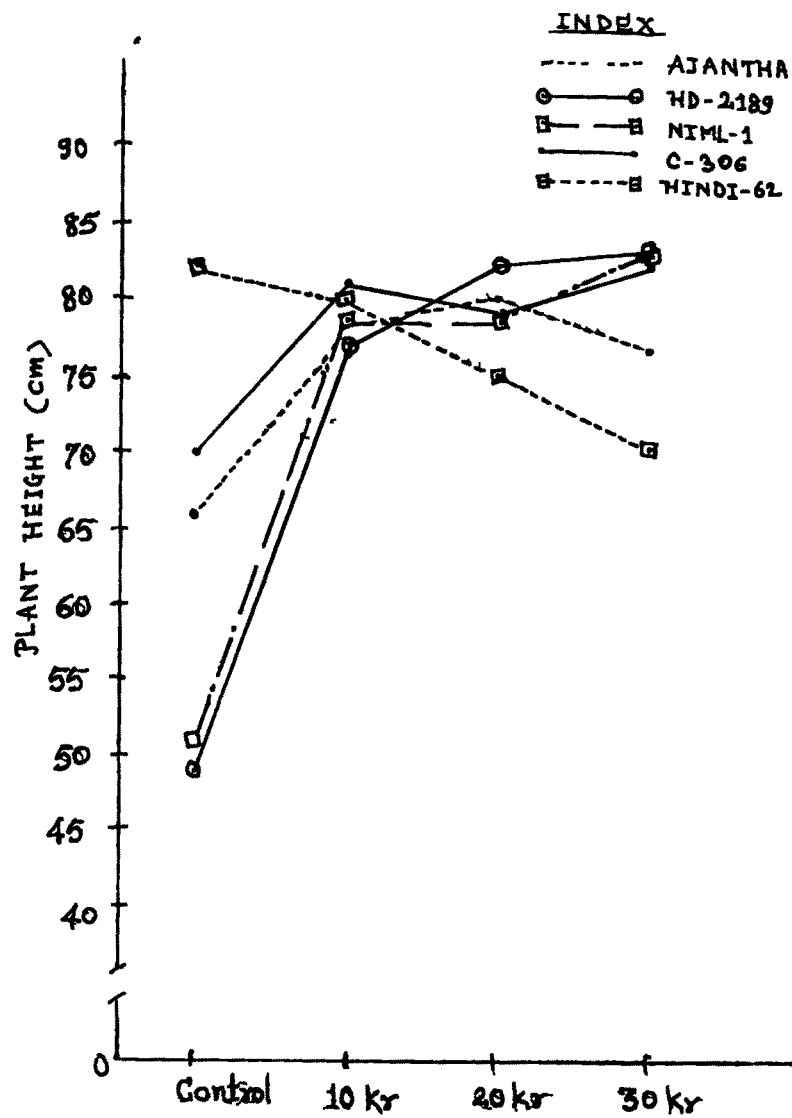


Fig 4 EFFECT OF GAMMA RAY DOSES ON PLANT HEIGHT (cm)  
IN M<sub>2</sub> GENERATION

#### 4.2.4.2 50 percent flowering (in days) :

##### Varietal differences :

The five varieties revealed significant differences for 50 percent flowering. Early flowering was noticed in Ajantha (48 days) which was significantly inferior over other varieties. Highest days to flowering indicated by Hindi-62 (83.91 days) which was significantly superior over other varieties.

##### Effect of doses :

The effect of gamma ray doses was significant. The highest days to flowering (lateness) was exhibited in 30 KR dose (68.06 days) which was significantly superior over other doses. The control revealed significantly lowest (64.46 days) days to flower or earliness. The results revealed reduction in the lateness of flowering days due to increase in the dose.

##### Interaction effect :

Data presented in the (Table 9) revealed that variety x dose interaction was significant. The highest flowering period was at 30 KR doses, and was at par with 20 KR doses in Ajantha, HD-2189 variety. Rest of all varieties are significant. The flowering period was short in control of all the varieties. In general, the mutagen dose revealed increase the lateness of flowering period as dose increased.

#### 4.2.4.3 Length of main spike (in cm) :

##### Varietal difference :

The varieties revealed significant differences for length of main spike. The variety ID-2189 indicated significantly highest length of ear (7.64 cm), while the varieties Ajantha, Hindi-62, C-306 were at par with ID-2189. The variety NIML-1 showed significantly short length of main spike (4.88 cm) which was statistically inferior.

##### Effect of doses :

There was significant differences between different doses of mutagen. The length was (7.34 cm) highest in 20 KR dose and was at par with 30 KR and 10 KR. The length was significantly reduced in control (6.34 cm). The results exhibited increase in the length of main spike with increased dose of mutagen.

##### Interaction effects :

The results clearly indicated that the variety x dose interaction was significant. The length of main spike was highest in 30 KR, 20 KR dose and lowest in control in all varieties. However, the length of main spike in 30 KR in Ajantha and NIML-1 were at par with control, while length was highest in 20 KR of ID-2189. Hindi-62 were at par with control except C-306.

Table 10 Effect of irradiation on five varieties of wheat in M<sub>2</sub> generation.

Treatment	Number of tillers/ plant	Days to physiological maturity	Number of grains/ ear	Grain yield/ plant	100 grain weight
<b>Varieties :</b>					
Ajantha	9.66	93.25	36.33	6.81	3.65
ID-2189	9.93	121.33	39.49	7.02	3.10
NIML-1	10.21	119.91	32.92	5.93	3.63
C-306	10.12	133.58	39.95	7.27	3.60
Hindi-62	10.08	139.91	37.78	6.94	3.23
SE ±	0.34	3.76	1.86	0.33	0.17
CD	0.94	10.43	5.17	0.94	0.47
<b>Doses :</b>					
Control	10.10	114.4	35.97	6.28	3.23
10 KR	10.26	122.33	37.54	7.11	3.32
20 KR	10.47	124.33	39.34	6.50	3.56
30 KR	10.81	125.33	36.37	7.20	3.67
SE ±	0.30	3.36	1.67	0.30	0.15
CD	0.84	9.33	NS	0.84	0.42
<b>Variety x Dose :</b>					
Ajantha control	9.43	91.00	34.3	5.99	3.70
10 KR	9.26	91.66	36.3	7.61	3.84
20 KR	9.03	94.00	38.53	6.72	3.54
30 KR	10.93	96.33	38.7	7.92	3.84
ID-2189 control	8.76	118.33	38.63	6.73	2.54
10 KR	9.13	121.00	35.33	6.77	2.96
20 KR	9.20	132.00	42.93	6.84	3.49
30 KR	11.93	123.00	40.06	7.74	3.49
NIML-1 control	9.8	92.66	27.06	5.93	3.17
10 KR	9.9	127.00	31.4	5.86	3.54
20 KR	9.8	129.66	35.3	5.61	3.56
30 KR	9.36	130.33	32.13	6.34	3.64
C-306 control	10.2	131.00	39.53	7.22	2.66
10 KR	10.3	132.00	42.73	8.27	3.66
20 KR	9.46	135.00	45.00	6.63	3.42
30 KR	10.53	136.33	42.53	6.95	3.49
Hindi-62 control	10.33	139.00	36.33	7.06	3.59
10 KR	10.00	140.00	36.93	7.07	3.53
20 KR	10.86	140.00	38.93	6.2	3.53
30 KR	10.39	140.66	37.93	7.42	3.57
SE ±	0.68	7.53	3.73	0.67	0.34
CD	1.89	20.87	NS	1.88	0.95

The length of main spike in C-306 with 20 KR dose was statistically superior (8.1 cm) over other treatments. C-306 with control was statistically lowest (5.2 cm) than other varieties. Generally, the mutagen dose revealed increase in the length of earhead in all varieties (see table 9).

#### 4.2.4.4 Number of spikelets per main spike :

##### Varietal difference :

The varietal differences showed significant results. C-306 indicated significantly highest spikelet number and varieties Ajantha, ID-2189, Hindi-62 were at par with C-306. The spikelet number of NIML-1 was lowest (12.63).

##### Effect of dose :

The effect of gamma ray doses was also significant. The number of spikelets in 30 KR was highest (15.19) and was at par with 20 KR and 10 KR doses. The spikelet number was significantly lowest in control (12.57). The results revealed addition in number of spikelets due to increase in the dose of irradiation.

##### Interaction effects :

The variety x dose interaction was significant. The number of spikelets was highest in 30 KR and lowest in control in all the varieties. However, the spikelet number in control was statistically at par with 30 KR in

all varieties except Ajantha. The spikelet number in Ajantha with control was statistically lowest (11.33) than other treatments. These results exhibited mutagen dose had increased spikelet number with increasing doses in all the five varieties.

#### 4.2.4.5 Number of effective tillers per plant:

##### Varietal differences :

There were statistically significant differences among all the wheat varieties. Highest number of tillers were showed by Hindi-62 (10.88) which was significantly highest. The number of tillers of NIML-1 and C-306 were at par with Hindi-62. The Ajantha variety has significantly lowest (9.66) tiller number per plant.

##### Effect of doses :

The effect of different doses of gamma rays on number of tillers per plant was non significant. The highest number of tillers was recorded in 30 Kr doses in all five varieties except NIML-1. In NIML-1 with 10 Kr dose highest tiller number was recorded. The lowest tiller number were exhibited in control.

##### Interaction effects :

According to data presented in (Table 9) revealed that interaction variety x dose was significant. The tiller number was highest in the 30 Kr and lowest in control dose in all five varieties. However, the tiller number in control

was statistically at par with 30 KR dose in NIML-1 and C-306 variety. The highest tiller number was recorded in the 30 KR of Hindi-62 (13.39) which was significantly superior over other treatments, and lowest in HD-2189 control (8.76). In general, the mutagen dose revealed increase in the tiller number in all varieties.

#### 2.4.5 Days to physiological maturity :

##### Varietal differences :

The varietal difference was significant. Hindi-62 indicated significantly highest (139.91) days to maturity followed by C-306 variety. The lowest days for maturity was found in Ajantha variety (93.25) which was significantly lowest than other varieties.

##### Effect of dose :

The effect of gamma ray doses was also significant. The highest days to maturity was in 30 KR dose (125.33 days) and was at par with 20 KR and 10 KR dose. The control exhibited significantly lowest (144.40 days) days to maturity. The results revealed that increased no. of days for physiological maturity was due to increasing the doses of mutagen.

##### Interaction effects :

The interaction was also significant. The maturity period was highest in the 30 KR and lowest in the control in all the varieties. However, days to physiological

maturity in control was statistically at par with 30 KR dose in all the varieties except NIML-1. The maturity period in NIML-1 with control was statistically lowest (92.66) than other treatments. These results revealed increase in the lateness in all five varieties due to increased mutagenic doses.

#### 4.2.4.6 Number of grains per ear:

##### Varietal difference :

The varieties revealed significant differences. Hindi-62 revealed significantly highest (93.95) number of grains per ear followed by HD-2189. The varieties C-306 and Ajantha were at par with Hindi-62. The variety NIML-1 showed significantly lowest number of grains per ear.

##### Effect of dose :

The effect of gamma ray doses was non-significant. The highest number of grains were recorded in 20 KR doses while lowest in control. The dose 10 KR (lower dose) resulted more number of grains per ear than control and 30 KR dose also. These results revealed that the number of grains per ear can be increased with medium dose (i.e. 20 KR) and lower dose (i.e. 10 KR).

##### Interaction effects :

The variety x dose interaction was also non-significant. The number of grains per ear was highest in the 20 KR dose, in all the five varieties.

#### 4.2.4.7 Grain yield per plant (in gms) :

##### Varietal difference :

The five varieties revealed significant yield differences among the varieties. The variety C-306 indicated significantly highest grain yield (7.27 gm) and was at par with HD-2189, Ajantha, Hindi-62. The lowest grain yield (5.93) was noticed in NIML-1, which was significantly inferior with rest of all varieties.

##### Effect of doses :

The effect of different doses of gamma rays was significant. The grain yield in 30 KR was highest (7.28 gm) and was at par with 10 KR and 20 KR doses. The grain yield was significantly lowest (6.28 gm) in control. These results revealed that increase in the dose mutagen resulted addition in the grain yield production.

##### Interaction effects :

The variety x dose interaction was significant. The grain yield was highest in 30 KR dose and lowest in control in all the varieties. However, the grain yield in control was statistically at par with 30 KR in all the varieties except Ajantha. The grain yield in Ajantha with control was statistically lowest (5.99 gm) than other treatments of Ajantha. The effect of 20 KR was at par with 30 KR dose. These results revealed addition in grain yield with increase in the doses of mutagen.

Table 6 ANOVA for the effect of irradiation on quality characters.

Sources	df	Protein %	Gluten content (gm)	Sedimentation value (ml.)	Pelshenke value (min.)	Lysine (gm/250gm)	Ash %
Replications	2	0.16	0.25	0.63	40.55	0.0048	0.006
Treatments	19	3.84	1.98	2.22	282.61	0.013	0.0050
Varieties	4	17.76	5.81	7.51	1287.85	0.059	0.224
Doses	3	0.28	0.21	0.96	27.24	0.005	0.0006
V X D	12	0.10	1.14	0.77	11.36	0.001	0.005
Error	39	0.17	0.24	1.01	7.65	0.002	0.003

\* P = 0.05, \*\* P = 0.01

#### 4.2.4.8 100 grain weight (in gm) :

##### Varietal difference :

The varietal difference found significant. The variety Ajantha indicated highest grain yield (3.65 gm) and over at par with NIML-1, C-306 and Hindi-62. The lowest 100 grain weight was recorded by HD-2189 variety which was statistically inferior.

##### The effect of dose :

The effect of irradiation was also significant. The germination in 30 KR was highest (3.67) and was at par with 20 KR and 10 KR doses. The control exhibited significantly lowest (3.23) 100 grain weight. The results revealed increase in the 100 grain weight due to increase in the dose of mutagen.

##### Interaction effects :

The variety x dose interaction displayed significant differences. The test weight was highest in the 30 KR dose and lowest in control in all the five varieties. From (Table 10) it is clearly evident that the test weight in control was statistically at par with 30 KR dose except HD-2189 variety. The test weight in HD-2189 with control was statistically lowest (2.54) than other treatments. The effect of 20 KR was statistically similar as 30 KR. In general, the irradiation dose effect was beneficial in increasing the 100 grain weight in all the five varieties.

#### 4.2.5 Qualitative analysis :

##### 4.2.5.1 Protein :

##### Varietal differences :

Varietal difference revealed significant differences among varieties. C-306 indicated significantly highest protein content (14.73%) followed by Hindi-62. The protein content in the HD-2189 was lowest (11.50%) among the other varieties which were statistically inferior.

##### The effect of doses :

The effect of gamma rays was significant. The protein content in 30 KR was highest (14.70). The protein content in the 20 KR dose was significantly reduced. The dose of 10 KR also significantly reduced the protein content, than 30 KR dose. The control exhibited significantly lowest (13.70%) protein content. These results revealed that protein content may increase due to increase in the dose of mutagen.

##### Interaction effects :

The variety x dose interaction was also significant. The protein percentage was highest in the 30 KR dose and lowest in 10 KR dose in all five wheat varieties. However, the protein content in 10 KR dose was statistically at par with 30 KR dose in all the varieties except Hindi-62. However, Hindi-62 with 10 KR exhibited statistically lowest protein content (13.85%) than other doses. The effect of

20 KR dose in Hindi-62 doses of mutagen (like 10 K1) decreased the protein percentage. These results clearly indicated that in very few cases due to increase in dose of mutagen, protein content may be increased.

#### 4.2.5.2 Gluten :

##### Varietal difference :

There were statistically significant differences among varieties. The highest gluten content was observed in the variety Hindi-62 (13.45%) followed by C-306. Significantly lowest gluten content (11.69%) was in D-2189, which was statistically inferior than other varieties.

##### The effect of doses :

The effect of gamma ray was non-significant. The gluten content was highest in the 30 KR and lowest in control in all varieties. The dose of 10 K. revealed increase in the gluten content than control in all varieties. The 20 KR dose was like 10 K1 only 30 KR dose was found highest gluten content in all varieties.

##### Interaction effects :

Variety x dose interaction was significant. The gluten content was highest in the 30 KR doses and lowest in control in all five varieties. However, gluten content in control was statistically at par with control in all the varieties except NIML-1. The gluten content in NIML-1 control was statistically lowest (11.99) than other doses.

Table 11 Effect of irradiation on five varieties of wheat on quality characters in M<sub>2</sub> generation.

Treatment	Protein %	Gluten (gm)	Sedimentation value (ml)	Pelshanke value (min.)	Lysine (gm)	Ash %
<b>Varieties :</b>						
Ajantha	13.94	12.46	24.45	107.83	2.59	1.62
HD-2189	11.50	11.69	23.25	102.41	2.43	1.51
NIML-1	13.85	12.79	24.85	107.66	2.41	1.64
C-306	14.73	13.25	25.14	127.08	2.48	1.82
Hindi-62	13.89	13.45	25.15	121.00	2.45	1.82
SE ±	0.12	0.14	0.29	0.79	0.015	0.017
CD	0.33	0.39	0.80	2.21	0.042	0.049
<b>Doses :</b>						
Control	13.70	12.70	24.67	114.28	2.41	1.69
10 KR	13.51	12.52	24.46	111.40	2.46	1.68
20 KR	13.42	12.79	24.28	112.93	2.47	1.67
30 KR	14.70	12.85	24.86	114.48	2.49	1.67
SE ±	0.10	0.12	0.26	0.71	0.013	
CD	0.30	NS	NS	1.98	NS	NS
<b>Variety x Dose :</b>						
Ajantha control	13.81	12.38	24.40	109.66	2.56	1.65
10 KR	13.97	12.52	24.16	108.76	2.61	1.65
20 KR	13.89	13.00	24.33	106.66	2.60	1.58
30 KR	14.07	12.96	24.93	109.00	2.60	1.60
HD-2189 control	11.57	11.55	22.73	104.66	2.43	1.56
10 KR	11.44	11.49	23.50	103.00	2.44	1.47
20 KR	11.43	11.79	23.40	101.33	2.44	1.50
30 KR	11.58	11.95	23.36	103.76	2.48	1.52
NIML-1 control	13.82	11.99	25.36	110.66	2.40	1.66
10 KR	13.78	12.05	25.13	104.00	2.42	1.59
20 KR	13.85	12.92	24.16	110.00	2.41	1.69
30 KR	14.20	13.61	24.73	110.00	2.44	1.63
C-306 control	15.10	13.20	25.70	128.33	2.42	1.76
10 KR	14.54	13.48	24.73	125.33	2.52	1.88
20 KR	14.27	12.93	24.06	127.33	2.47	1.81
30 KR	15.00	13.40	25.96	127.38	2.53	1.84
Hindi-62 control	14.19	13.40	25.16	125.66	2.45	1.85
10 KR	13.85	13.74	24.70	118.00	2.44	1.83
20 KR	13.65	13.30	25.43	119.33	2.45	1.79
30 KR	14.89	13.95	25.33	121.00	2.48	1.87
SE ±	0.24	0.28	0.58	1.59	0.030	0.016
CD	0.67	0.78	1.61	4.42	0.084	0.044

The effect of the 20 K<sub>A</sub> dose was significantly increased the gluten content. The dose of 30 K<sub>A</sub> was found highest.

#### 4.2.5.3 Sedimentation value :

##### Varietal difference :

The varietal difference was significant. The highest sedimentation value was observed for Hindi-62 (25.15) and was at par with C-306, NIML-1, Ajantha varieties. The variety HD-2189 has recorded lowest (23.25) sedimentation value.

##### Effect of doses :

The mutagen doses revealed non-significant differences. The highest sedimentation value was found (24.36) for 30 K<sub>A</sub> dose. The sedimentation value was reduced in 10 K<sub>A</sub> dose.

##### Interaction effects :

According to the data presented in (Table 11) revealed that variety x dose was not significant. The sedimentation value was highest in the 30 K<sub>A</sub> dose than control in all varieties except NIML-1. NIML-1 exhibited the sedimentation value lower than the control. The dose recored the lowest sedimentation value.

#### 4.2.5.4 Pelshenke value :

##### Varietal difference :

Pelshenke value shows significant varietal differences within all varieties. Highest pelshenko value

displayed by the variety C-306 (127.08) followed by Hindi-62, Ajantha and NIML-1. The variety HD-2189 has significantly lowest (102.41) pelshenke time or value.

Effect of doses :

The mutagen dose revealed significant results between pelshenke value. The pelshenke value was highest in the 30 KR dose than 10 KR dose, however it was at par with 20 KR and control.

Interaction effects :

The variety x dose interaction was significant. The pelshenke value was highest in the control and lowest in 10 KR doses in all varieties. However, the pelshenke value of 30 KR dose was statistically at par with control in all varieties except NIML-1 and Hindi-62. The pelshenke value in HD-2189 with 20 KR dose was statistically lowest (101.33 min) than other treatments. These results revealed differential response of wheat genotypes to irradiation doses. In general, the mutagen dose revealed decrease in pelshenke value at lower doses (10 KR and 20 KR doses).

4.2.5.5 Lysine :

Varietal difference :

The varietal difference was significant. The variety Ajantha indicated significantly highest lysine content (2.59 gm) which was statistically superior over other varieties. The lowest lysine content was noticed in NIML-1 which was statistically inferior.

**Effect of doses :**

The effect of different doses of gamma was also significant. The lysine was highest in 30 KR (2.49 gm) and at par with 10 KR and 20 KR doses. The lysine content was statistically lowest (2.41 gm) in control. These results revealed the lysine content may be increased due to mutagen effects. These studies need further vigorous testing.

**Interaction effects :**

Variety x dose interaction was significant. The lysine content in the 30 KR dose was highest. However, the lysine content in all the varieties except C-306 was similar to that of control. In the variety, C-306 the 30 KR dose the lysine percentage was 2.53 .

**4.2.5.6 Ash content :****Varietal difference :**

The highest ash content was recorded in Hindi-62 (1.82%) which was significantly superior over rest of all varieties except C-306. The least ash percentage was recorded in HD-2189 which was significantly inferior amongst rest of varieties.

**Effect of doses :**

The effect of gamma ray doses was non-significant. The ash per cent was highest in the control and lowest in 20 KR and 30 KR doses. The 10 KR and control was statistically at par with 30 KR dose level.

Table 12 Effect of Irradiation on five characters of Ajantha variety in M<sub>1</sub> generation.

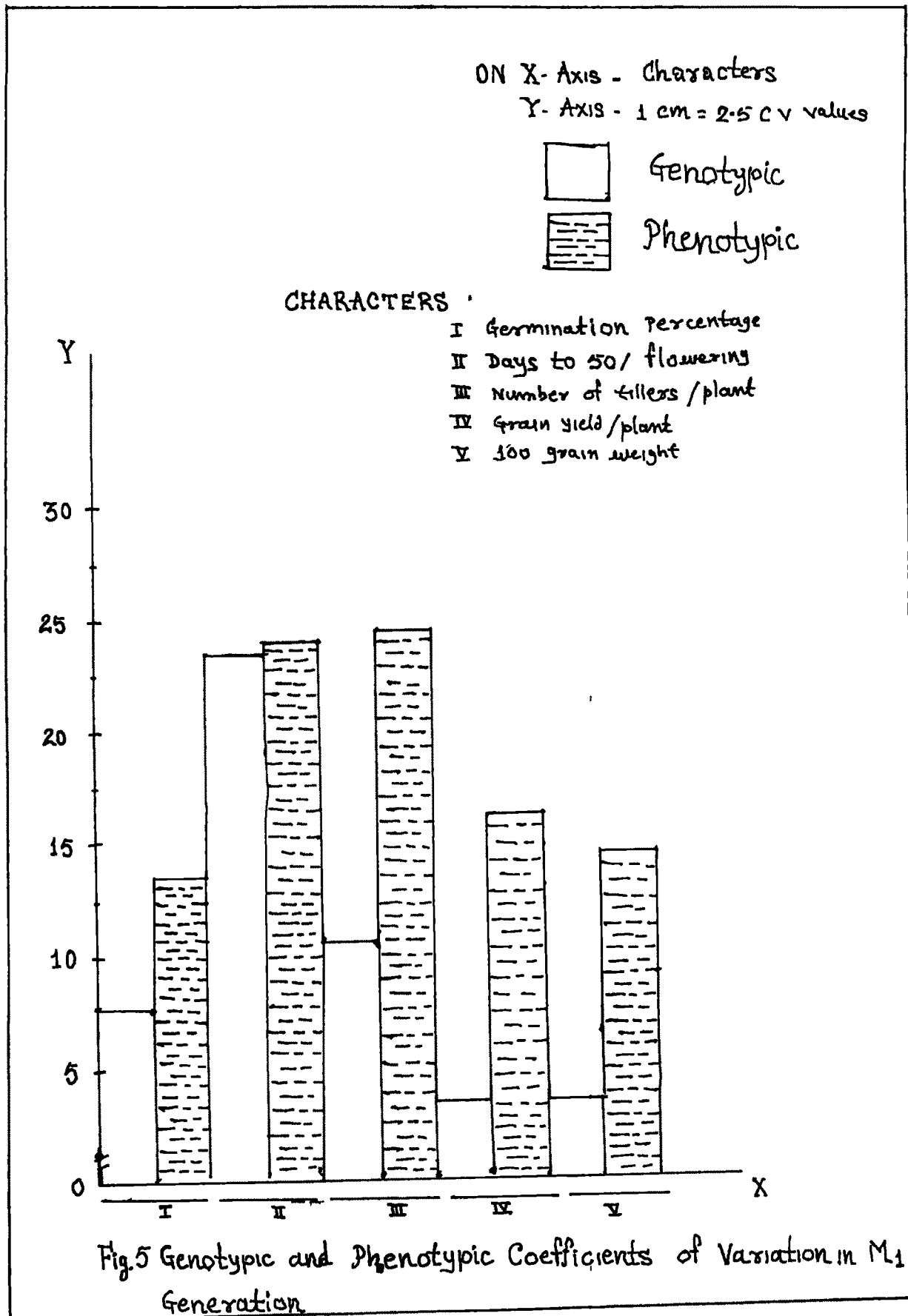
Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %
Germination %	59.07-82.95	75.09	4.80	33.13	7.66	13.46	32.40	6.66	8.87
Days to 50% flowering	46.33-55.33	49.54	2.85	137.30	23.65	23.92	97.74	23.68	47.80
Number of tillers/plant	12.85-17.06	14.51	5.13	2.30	10.45	24.44	19.28	1.31	9.06
Grain yield/plant	5.92- 6.47	6.19	0.57	0.05	3.61	16.39	22.02	0.45	7.47
100 grain weight	3.55- 4.21	3.78	0.15	0.02	3.74	14.49	6.66	0.06	1.79

**Interaction effects :**

According to the data presented in (Table 11) revealed variety x dose interaction was also significant. The ash was highest in th 30 KR doses and lowest in the control for all the varieties. Highest ash percentage was recorded for 30 KR dose of Hindi-62 (1.87%) and lowest ash % was recorded in HD-2189 0 KR (1.46%).

**4.3 Genotypic and Phenotypic variations :****4.3.1 M<sub>1</sub> generation :**

In the quantitative characters, amount of variation is measured and expressed as the variances. Genotypic variation is the amount of fixable index from one generation to the next generation, whereas phenotypic variation does give a true account of the variation, which is fixable in succeeding years of generation. The environmental variation varies from one place to other and as such cannot be fixed up. The genetic co-efficient of variation has been useful in measuring the range of genetic variability simultaneously provides a basis to compare the genetic variability in the quantitative characters. In order to find out an index of total and fixable variation present in different quantitative characters, phenotypic and genotypic co-efficients of variation are estimated by using the formula given by Burton (1952). The results with various estimates like Range, Mean SE  $\pm$ , GCV, PCV, Heritability (Broad sense),



genetic advance, expected genetic advance are presented in tables for Ajantha, HD-2189, NIML-1, C-306 and Hindi-62 in two successive generations  $M_1$  and  $M_2$  generations for different characters. The genotypic and phenotypic coefficients of variations of different characters are graphically represented in (Figures 5 ).

#### 4.3.1.1 Ajantha variety :

In general, values for phenotypic variations were higher than the genotypic values in all the characters studied.

The character, germination percentage was from 59.07 to 82.95 percent with average of  $75.09\% \pm 4.80$  percent. The values of phenotypic variance for this character was greater than the genotypic variance. The phenotypic co-efficient of variability was 13.46 and genotypic was 7.66. The larger variation strongly suggests that the selection for this character on the basis of phenotypic value will not prove better in successive generation. Range of variation for days to 50 percent flowering was from 46.33 to 55.33 and mean  $49.54 \pm 2.85$  days. In this character, also phenotypic variance was greater than genotypic variance. The values for phenotypic and genotypic co-efficient of variability were 23.92 and 23.65 respectively. This indicated that whatever variability was observed for this character was much due to merits of genotypes.

Range of variation for the number of effective tillers per plant was 12.86 to 17.06 and mean  $14.51 \pm 5.13$ . In this character also phenotypic variance was greater than genotypic variance. The values for phenotypic and genotypic co-efficient of variability were 14.44 and 10.45 respectively. Further selection for this character will not prove advantageous.

Grain yield per plant is of great importance ranged from 5.92 gm to 6.47 gm. with mean value of  $6.43 \pm 0.57$  gm. The environmental variance was greater than the genotypic component of variance. This indicates that yield was much influenced by environmental factors. The phenotypic and genotypic coefficients of variation were 1.03 and 0.05 respectively.

Range of variation for 100 grain weight was from 3.66 to 4.21 gm with average mean of  $3.76 \pm 0.15$ . This character showed greater phenotypic variance than genotypic variance. The genetic coefficient of variability was 0.02 while phenotypic coefficient of variability was 0.030. Further selection for this character will not prove advantageous.

#### 4.3.1.2 HD-2189 variety :

In general, there were more phenotypic variances than genotypic variances for the characters studied.

**Table 13 Effect of irradiation on five characters of HD-2189 variety in M<sub>1</sub> generation.**

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %
Germination %	63.36-80.92	75.19	4.80	33.13	102.23	7.66	13.45	32.40	6.75 0.98
Days to 50% flowering	63.00-75.00	67.08	2.85	137.30	140.47	17.46	17.66	97.74	23.68 35.30
Number of tillers/plant	11.76-12.60	12.30	1.85	2.30	12.58	12.32	28.83	18.28	1.31 10.69
Grain yield/plant	6.77- 7.42	7.07	1.58	0.05	1.03	3.16	14.35	4.85	0.10 1.41
100 grain weight	4.04- 4.38	4.21	0.85	0.02	0.30	3.35	13.01	6.66	0.06 1.60

The character germination percentage has shown variation range from 63.36 to 80.92 percentage with average mean of 75.13 percentage  $\pm$  4.80. The values of phenotypic variance was greater than genotypic variance. The phenotypic coefficient of variability was 13.46 and genotypic 7.66.

Range of variation for days to 50 percent flowering was from 63 to 75 days and mean 67.08  $\pm$  2.85 days. This character also showed greater phenotypic variance. The phenotypic coefficient of variability was 140.47 and genotypic 137.30.

Range of variation for the character number of effective tillers per plant was 11.76 to 12.60 and mean 12.30  $\pm$  1.85. The phenotypic variance was greater than genotypic variance. The values of phenotypic and genotypic coefficient of variability were 28.83 and 12.32 respectively. Further selection will not prove advantageous.

Grain yield ranged from 6.77 to 7.42 gm with average mean value of 7.07  $\pm$  1.58 gm. The phenotypic variance was greatest than genotypic variance, much influenced by environmental factors. The phenotypic and genotypic coefficient of variability were 0.05 and 1.03 respectively.

The character 100 grain weight ranged from 4.04 to 4.38 gms with average mean 4.21  $\pm$  0.85 gms. The phenotypic variance was greater than genotypic variance. This particular character was also much influenced by environmental factors. The phenotypic coefficient of variability was 13.01 while genotypic coefficient of variability was 3.35.

#### 4.3.1.3 NIML-1 variety :

In general, there were more phenotypic variances than genotypic variances for the characters studied.

Range of variation for germination percentage has shown variation ranges from 74.62 to 83.51 percent with average mean of  $80.22 \pm 4.80$  percent. The values of phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficient of variabilities were 12.60 and 7.17 respectively.

The character, days to 50 percent flowering was from 67.33 to 75.66 days, with an average mean of  $70.67 \pm 1.02$  days. The values of phenotypic and genotypic coefficients of variation were 16.77 and 16.58 respectively.

The character, number of effective tillers per plant has shown range from 8.40 to 11.68 with average mean of  $12.55 \pm 1.85$ . The environmental variance was much larger than genotypic variance. The values for phenotypic and genotypic coefficient of variability were 12.58 and 2.30 respectively.

Range of variation for 100 grain weight was from 3.13 to 3.89 gms with the mean value of  $3.59 \pm 0.30$ . The environmental component of variance was much greater than the genotypic variance and the values for genotypic and phenotypic coefficient of variabilities were 3.93 and 15.25 respectively. This indicated that the variation present was greatly because of environmental influence, and not due to genotypes.

Table 14 Effect of irradiation on five characters of NIML-1 variety in M<sub>1</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %	
Germination %	74.62-83.51	80.22	4.80	33.13	102.23	7.17	12.60	32.40	6.66	8.30
Days to 50% flowering	67.33-75.66	70.67	1.02	137.30	140.47	16.58	16.77	97.74	23.68	33.13
Number of tillers/plant	8.40-11.66	12.55	1.85	2.30	12.58	12.08	28.26	18.28	1.31	10.47
Grain yield/plant	6.01- 6.25	6.15	0.57	0.05	1.03	3.63	16.50	6.66	0.06	0.97
100 grain weight	3.13- 3.89	3.59	0.30	0.02	0.30	3.93	15.25	22.02	0.45	12.53

The character, grain yield per plant showed the range of variation from 6.01 to 6.25 gms with the mean value of  $6.15 \pm 0.57$ . The environmental components of variance was larger than the genotypic variance, while values for genotypic and phenotypic coefficient of variabilities were 3.63 and 16.50 respectively. This revealed that further selection for this character is of no use as the variability present was mostly because of environmental influence.

#### 4.3.1.4 C-306 variety :

In general, values for phenotypic coefficient of variability were greater for all the character studied than genotypic coefficient of variability.

Range of variation for germination percentage has shown variation range from 61.29 to 82.40 percent with average mean of  $74.81 \pm 4.80$  percent. The phenotypic variance was greater than genotypic components of variance. The genotypic and phenotypic coefficient of variabilities were 7.69 and 13.51 respectively.

The character days to 50 percent flowering varied from 69.66 to 81.00 days with the mean value of  $74.25 \pm 1.02$  days. The phenotypic variance was greater than genotypic components of variance. The genotypic and phenotypic coefficient of variabilities were nearly equal i.e. 15.78 and 15.96 respectively. This indicated that whatever variability was observed for this character was much due to merits of genotypes.

Table 15 Effect of Irradiation on five characters of C-306 variety in M<sub>1</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %	
Germination %	61.29-82.40	74.81	4.80	33.13	102.23	7.69	13.51	32.40	6.66	8.90
Days to 50% flowering	69.66-81.00	74.25	1.02	137.30	140.47	15.78	15.96	97.74	23.68	31.89
Number of tillers/plant	12.40-14.40	13.49	1.85	2.30	12.58	11.24	26.29	18.28	1.31	9.74
Grain yield/plant	5.70- 6.62	6.35	0.57	0.05	0.30	2.22	8.62	6.66	0.06	0.94
100 grain weight	3.56- 3.79	3.67	0.30	0.02	1.03	6.09	27.65	22.02	0.45	12.53

Number of effective tillers per plant showed mean value of  $19.49 \pm 1.85$  and range of variation from 12.40 to 14.46. In this character also phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficients of variabilities were 11.24 and 26.29 respectively.

Range of variation for 100 grain weight varied from 5.70 to 6.62 gms with average mean of  $6.35 \pm 0.05$ gms. The phenotypic variance was much greater than the genotypic variance, while values for genotypic and phenotypic coefficients of variabilities were 6.09 and 27.65 respectively, which indicated that selection for this character is not possible as it was largely influenced by environment.

#### 4.3.1.5 Variety Hindi-62 :

In general, there were greater values of phenotypic coefficient of variability than genotypic coefficient of variability for the characters studied.

Germination percentage, showed mean value  $78.69 \pm 4.80$  percent and range of variation from 71.29 to 82.77. The value of phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficient of variabilities were 7.31 and 12.84 respectively.

Range of variation for days to 50 percent flowering varied from 70.00 days to 85.00 days with the mean value of  $75.75 \pm 1.02$  days. The phenotypic variance was greater than genotypic components of variance. The genotypic and

Table 16 Effect of irradiation on five characters of Hindi-62 variety in  $M_1$  generation.

Characters	Range	Mean	SE $\pm$	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %	
Germination %	71.29-82.77	78.69	4.80	33.13	102.23	7.31	12.84	32.40	6.66	8.47
Days to 50% flowering	70.00-85.00	75.75	1.02	137.30	140.47	15.46	15.64	97.74	23.68	31.26
Number of tillers/plant	10.96-18.83	14.29	1.85	2.30	12.58	10.61	14.82	18.28	1.31	9.20
Grain yield/plant	5.90- 7.14	6.86	0.57	0.05	1.03	3.35	15.23	22.02	0.12	1.88
100 grain weight	3.39- 3.68	3.50	0.30	0.02	0.30	4.04	15.64	6.66	0.24	7.09

phenotypic coefficient of variabilities were nearly equal i.e. 15.46 and 15.64 respectively. This indicated that whatever variability was observed for this character, was much due to merits of genotypes. Hence, selections for this character on the basis of phenotypic value will hold better in achieving genetic improvement.

Range of variation for 50 percent flowering was from 10.86 to 18.83 with average mean  $14.29 \pm 1.85$ . Environmental component of variance was more than genotypic variance with the genotypic and phenotypic coefficient of variabilities values were 10.61 and 24.82 respectively. This character will not respond to selection due to large environmental influence.

Range of variation for 100 grain weight varied from 3.39 to 3.68 gms with the mean value of  $3.50 \pm 0.30$  gms. The phenotypic component of variance was greater than genotypic variance. The value for genotypic and phenotypic coefficient of variability were 4.04 and 15.64 respectively, which indicated no scope for further selection as it was more influenced by environment.

The character, grain yield per plant varied from 5.90 to 7.14 gms with the mean value of  $6.66 \pm 0.57$  gms. The environmental component of variation was found to be more than genotypic components. The values for genotypic and phenotypic coefficients of variabilities were 3.35 and 15.33 respectively. The improvement for the character by selection is not possible.

#### 4.3.2 M<sub>2</sub> generation :

##### 4.3.2.1 Ajantha variety :

Generally, there were more phenotypic variations than genotypic for the characters studied.

The character, days to 50 percent flowering ranged from 46.86 to 49.0 days with average mean of  $48 \pm 0.92$  days. The character 50 percent days to showed greater phenotypic variance than genotypic variance, which indicated that this character was mostly influenced by environment and selection will be of no use.

Plant height exhibited variability from 65.73 to 80.46 with mean value of  $75.5 \pm 7.77$  cm. The value of phenotypic variance was more than genotypic variance. The values of genotypic and phenotypic coefficient of variabilities were 12.98 and 13.08 respectively.

Range of variability for the number of effective tillers per plant was from 9.03 to 10.93 with mean  $9.66 \pm 0.68$ . In this character also phenotypic variance was greater than genotypic variances. The values for phenotypic and genotypic coefficient of variability were 14.56 and 7.88 respectively.

100 grain weight showed variation 3.51 to 3.84 gm with average mean  $3.65 \pm 0.34$  gm. In this character also phenotypic variance was greater than other variances.

The values of genotypic and phenotypic coefficients were 3.46 and 16.71 respectively.

Table 17 Effect of Irradiation on Mantha variety in M<sub>2</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA	
Days to 50% flowering	46.86-49.00	48.00	0.92	142.43	144.97	24.86	25.08	98.24	24.09	50.11
Plant height	65.73-80.46	75.50	7.77	96.04	97.63	12.98	13.08	98.37	19.94	26.41
Number of tillers/plant	9.03-10.93	9.66	0.68	0.58	1.98	7.88	14.56	29.29	0.84	8.61
100 grain weight	3.51- 3.84	3.65	0.34	0.016	0.372	3.46	16.71	4.30	0.05	1.31
Grain yield/plant	5.72- 7.92	6.81	0.67	0.12	1.50	5.08	17.98	8.00	0.20	2.91
Protein content	13.81-14.07	13.96	0.24	1.22	1.39	7.92	8.45	87.76	2.11	15.11
Lysine content	2.56- 2.60	2.59	0.030	0.0037	0.0064	2.34	3.08	57.81	0.09	3.61
Gluten content	11.52-13.00	12.46	0.28	0.57	0.81	6.05	7.22	70.37	1.29	10.31
Pelshenke value	106-109	107.83	1.59	91.65	99.30	8.87	9.24	92.29	18.88	17.51
Sedimentation value	24.16-24.92	24.45	0.58	0.40	1.41	2.56	4.85	28.36	0.68	2.81
Ash content	1.58- 1.65	1.62	0.016	0.015	0.019	7.56	8.50	78.94	0.22	13.61

The larger variation suggests that the selection on the basis of phenotypic value will not be advantageous.

Grain yield ranged from 5.72 to 7.92 gm with mean  $6.81 \pm 0.67$  gm. In this character also, phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficient of variability were 5.08 and 17.98 respectively.

The quality characters like protein, lysine, gluten, pelshenke value, sedimentation value etc. amount of variation was measured and expressed as the variances.

Protein content showed range of variability from 13.81 to 14.07 with mean  $13.94 \pm 0.24$ . The values of phenotypic and genotypic coefficient of variabilities were 8.48 and 7.92 respectively.

Lysine content in this particular wheat variety Ajantha also ranged from 2.56 to 2.60 with mean  $2.59 \pm 0.030$ . The phenotypic variance was more than genotypic variance. The values of genotypic and phenotypic coefficient of variability were 2.34 and 3.08 respectively.

Gluten content has shown variation range from 11.52 to 13.00 gms. with mean  $12.46 \pm 0.28$  gm. The value of phenotypic variance was more than genotypic variance. The values of genotypic and phenotypic coefficient of variabilities were 6.05 and 7.22 respectively.

Pelshenke value exhibited variability from 106 to 109 min. with average  $107.83 \pm 1.59$  min. The value of phenotypic variance was more than genotypic variance.

The genotypic and phenotypic coefficients of variabilities were 8.87 and 9.24 respectively.

Range of variation for sedimentation value from 24.16 to 24.93 ml with mean  $24.45 \pm 0.58$  ml. The genotypic and phenotypic coefficients of variabilities were 2.58 and 4.85 respectively.

#### 4.3.2.2 HD-2189 variety :

In general, there were more phenotypic variations than genotypic variance for the characters studied.

The character, days to 50 percent flowering has shown variation range from 61.66 to 63.33 days with mean  $62.58 \pm 0.92$  days. Genotypic and phenotypic coefficient of variability were 19.07 and 19.23 respectively.

Plant height exhibited average mean  $72.95 \pm 7.77$  gm with variation range of 48.73 to 23.46 gm. The environmental variance was less than phenotypic variance. The phenotypic and genotypic coefficients of variability were nearly equal i.e. 13.54 and 13.43 respectively. Hence, selection on the basis of phenotypic values would definitely lead towards effectiveness of selection.

Range of variation for number of effective tillers per plant were from 8.76 to 11.93 with average mean  $9.93 \pm 0.68$ . The phenotypic variance was greater than genetic variance. The phenotypic and genotypic coefficients of variability were 14.17 and 7.60 respectively.

Table 18 Effect of irradiation on HD-2189 variety in M<sub>2</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	p	GCV	FCV	Heritability	GA	EGA %
Days to 50% flowering	61.66-63.33	62.58	0.92	142.42	144.97	19.07	19.23	98.24	24.30	37.06
Plant height	48.73-83.46	72.95	7.77	96.04	97.63	13.43	13.54	98.37	19.94	27.34
Number of tillers/plant	8.76-11.93	9.93	0.68	0.58	1.89	7.66	14.17	29.29	0.84	8.46
100 grain weight	2.54- 3.49	3.10	0.34	0.016	0.372	4.08	19.67	4.30	0.050	1.62
Grain yield/plant	6.73- 7.74	7.02	0.67	0.12	1.50	4.93	17.44	8.00	0.20	2.87
Protein content	11.44-11.58	11.50	0.24	1.22	1.39	9.60	10.25	87.76	2.11	18.37
Lysine content	2.41- 2.43	2.43	0.030	0.0037	0.0062	2.50	3.29	57.81	0.09	3.86
Gluten content	11.49-11.95	11.69	0.28	0.57	0.81	6.45	7.69	70.37	1.29	11.10
Pelshenke value	101.33-103.66	102.41	1.59	91.65	99.30	9.34	9.73	92.29	18.88	18.44
Sedimentation value	22.73-23.50	23.25	0.58	0.40	1.41	2.72	5.10	28.36	0.68	2.94
Ash	1.47- 1.54	1.51	0.016	0.015	0.019	8.11	9.12	78.94	0.22	14.56

The character 100 grain weight was from 2.54 to 3.49 gms with  $3.10 \pm 0.34$  gm. The environmental component of variance was much greater than genotypic variance and the values for genotypic and phenotypic coefficient of variabilities were 4.08 and 19.67 respectively.

Grain yield exhibited the range of variation from 6.73 to 7.74 gms with  $7.02 \pm 0.67$  gm. The environmental components of variance was larger than the genotypic variance while values for genotypic and phenotypic coefficient of variabilities were 4.93 and 17.44 respectively.

Protein content showed average mean  $11.50 \pm 0.24$  gm with variation from 11.44 to 11.58 gm. The phenotypic variance was larger than the genotypic variance. The genotypic coefficient of variability was 9.60 while phenotypic coefficient of variability was 10.25.

The character lysine content had displayed variation range from 2.41 to 2.43 gm with mean  $2.43 \pm 0.030$  gm. The values of genotypic and phenotypic coefficient variabilities were 2.50 and 3.29 respectively.

Gluten content exhibited variation range from 1.49 to 11.25 gm with mean  $11.69 \pm 0.28$  gm. The value of phenotypic variance was more than genotypic variance. The values of genotypic and phenotypic coefficient of variabilities were 6.45 and 7.69 respectively.

Pelshenke value showed average mean  $102.41 \pm 1.59$  min with 101.33 to 103.66 min. The genotypic variance was less than phenotypic variance.

The value of phenotypic and genotypic coefficient of variability were nearly equal i.e. 9.73 and 9.32 respectively. This indicated that variation for this character was less influenced by environment, as such selection on the basis of phenotypic value would definitely lead towards effectiveness of selection.

Sedimentation value has exhibited variation range from 22.73 to 23.50 ml with mean  $23.25 \pm 0.58$  ml. The environmental variance was much greater than genotypic variance. The phenotypic and genotypic coefficients of variabilities were 5.10 and 2.72 respectively.

#### 4.3.2.3 NIML-1 variety :

In general, there were more phenotypic variation than genotypic variance for the characters studied, for NIML variety.

Range of variation for days to 50 percent flowering was from 64.00 to 71.00 days with mean  $67.33 \pm 0.92$  days. This character showed slight difference between phenotypic variance and genotypic variance. Similarly the genotypic and phenotypic coefficients of variabilities were nearly equal i.e. 17.71 and 17.86 respectively. This indicated that variation for this character was less, and whatever variation present was less influenced by environmental, as such selection on the basis of phenotypic values would definitely lead towards effectiveness of selection.

Table 19 Effect of irradiation on NIML-1 variety in M<sub>2</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %	
Days to 50% flowering	64.00-71.00	67.33	0.92	142.24	144.97	17.71	17.89	98.24	24.30	36.10
Plant height	50.93-83.53	71.63	7.77	96.04	97.63	13.68	13.79	98.37	19.94	27.84
Number of tillers/plant	9.36-11.90	10.21	0.68	0.58	1.98	7.45	13.78	29.29	0.84	8.23
100 grain weight	3.54- 3.77	3.63	0.34	0.016	0.372	3.48	16.80	4.30	0.050	1.38
Grain yield/plant	5.61- 6.34	5.93	0.67	0.12	1.50	5.84	20.65	8.00	0.20	3.40
Protein content	13.78-14.20	13.85	0.24	1.22	1.39	7.97	8.51	87.76	2.11	15.25
Lysine content	2.40- 2.42	2.41	0.030	0.0037	0.0064	2.52	3.31	57.81	0.094	3.89
Gluten content	11.89-13.61	12.79	0.28	0.57	0.81	5.90	7.03	70.37	1.29	10.14
Pelshenke value	106.66-110.00	107.66	1.59	91.65	99.30	8.89	9.25	92.29	18.14	16.85
Sedimentation value	24.16-25.36	24.85	0.58	0.40	1.41	2.54	4.77	28.36	0.68	2.73
Ash content	1.59- 1.67	1.64	0.016	0.015	0.019	7.46	8.40	78.94	0.22	13.50

The character, plant height exhibited  $71.63 \pm 7.77$  cm. and mean with variation range of 50.93 to 83.53 cms. In this character, the phenotypic variance was greater than genotypic variance. The values for phenotypic and genotypic coefficient of variabilities were 13.79 and 13.68 respectively.

The number of effective tillers per plant ranged from 9.36 to 11.90 with an average mean of  $10.2 \pm 0.68$ . The values for genotypic and phenotypic coefficient of variabilities were 7.45 and 13.78 respectively.

100 grain weight ranged from 3.54 to 3.77 gms with mean of  $3.63 \pm 0.34$  gm. This character showed greater phenotypic variance than genotypic variance. The genetic coefficient of variability was 3.48, while phenotypic coefficient of variability was 16.80. Further selection for this character will not prove advantageous.

Range of variation for grain yield per plant was from 5.61 to 6.34 with mean  $5.93 \pm 0.67$  gm. The environmental variance was greater than the genotypic component of variance. This indicates that yield was much influenced by environmental factors. The phenotypic and genotypic coefficients of variation were 20.65 and 5.84 respectively.

Protein content exhibited variation range from 13.78 to 14.20 gm with mean  $13.85 \pm 0.24$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic coefficient of variation 8.51 and genotypic coefficients of variation 7.97.

The trait, lysine content showed variation range from 2.40 to 2.42 gm with mean  $2.41 \pm 0.030$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficients of variations were 3.31 and 2.52 respectively.

Gluten content varied from 11.80 to 13.61 gm with mean  $12.79 \pm 0.28$  gm. The phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficients of variations were 5.90 and 7.03 respectively.

Pelshenke value varied from 106.66 to 110 minutes with mean  $107.66 \pm 1.59$  min. The phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficients of variations were 8.89 and 9.25 respectively.

Range of variation for sedimentation value was from 24.86 to 25.36 ml with mean  $24.85 \pm 0.53$  ml. The phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficients of variation were 2.54 and 4.77 respectively.

#### 4.3.2.4 C-306 variety :

In general there were more phenotypic variations than genotypic variance for the characters studied for C-306 variety.

Days to 50 percent flowering ranged from 68.0 to 77.60 days with mean  $69.41 \pm 0.92$  days. This character

Table 20 Effect of Irradiation on C-306 variety in M<sub>2</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{C}$	p	GCV	PCV	Heritability	GA	EGA %
Days to 50% flowering	68.00-77.66	69.41	0.92	142.24	144.97	17.18	17.34	98.24	24.30	35.01
Plant height	70.40-83.00	78.41	7.77	96.04	97.63	12.49	12.60	98.37	19.94	25.43
Number of tillers/plant	9.46-10.53	10.12	0.68	0.58	1.98	7.52	13.90	29.29	0.84	8.30
100 grain weight	2.49- 3.66	3.60	0.34	0.016	0.372	3.51	16.96	4.30	0.03	0.85
Grain yield/plant	3.63- 8.27	7.27	0.17	0.12	1.50	4.76	16.84	8.00	0.20	2.77
Protein content	14.27-15.10	14.73	0.24	1.22	1.39	7.49	8.00	87.76	2.11	14.31
Lysine content	2.42- 2.52	2.48	0.030	0.0037	0.0064	2.45	3.22	57.81	0.09	3.78
Gluten content	12.40-14.20	13.25	0.28	0.57	0.81	5.69	6.79	70.37	1.29	9.79
Pelshenke value	125.33-128.33	127.08	1.59	91.65	99.30	7.53	7.84	92.29	18.88	14.86
Sedimentation value	24.06-25.96	25.14	0.58	0.40	1.41	2.51	4.72	28.36	0.68	2.72
Ash content	1.76-1.88	1.82	0.016	0.015	0.019	6.72	7.57	78.94	0.22	12.16

showed greater phenotypic variance than genotypic variance. The genotypic and phenotypic coefficient of variabilities were 17.18 and 17.34 respectively.

Plant height showed average mean  $78.41 \pm 7.77$  cm with variation range of 70.40 to 83.06 cm. The phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficients of variabilities were 8.05 and 4.74 respectively.

The character number of effective tillers per plant exhibited 9.46 to 10.53 with average mean  $10.12 \pm 0.68$ . The environmental component of variance was much greater than genotypic variance. The genotypic and phenotypic coefficients of variabilities were 7.52 and 13.90 respectively, which indicated no scope for further selection.

Range of variation for 100 grain weight was from 2.49 to 3.66 gms with the mean value of  $3.60 \pm 0.34$  gm. The environmental component of variance was much greater than the genotypic variance and the values for genotypic and phenotypic coefficient of variabilities were 3.81 and 15.94 respectively.

Grain yield per plant exhibited the range of variation from 6.63 to 8.27 gm with  $3.60 \pm 0.24$  gm. The environmental components of variance was larger than the genotypic variance, while the values for phenotypic and genotypic coefficient of variabilities were 1.50 and 0.12 respectively.

Protein content varied from 14.27 to 15.10 gm, with average mean  $14.74 \pm 0.24$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic coefficient of variation was 8.00 while genotypic coefficients of variation was 7.49.

Lysine content ranged from 2.42 to 2.52 gm with mean  $2.48 \pm 0.030$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficients of variations were 3.22 and 2.45 respectively.

The trait, gluten exhibited variation range from 12.40 to 14.20 gm with average  $13.25 \pm 0.28$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficients of variation were 6.79 and 5.69 respectively.

Peishenke value showed mean of  $127.08 \pm 1.59$  min. with variation range of 125.33 to 129.33 min. The genotypic variance was less than phenotypic variance. The genotypic coefficient of variation was 2.51 and phenotypic coefficient of variation was 4.72.

Sedimentation value ranged from 24.06 to 25.96 ml with mean  $25.14 \pm 0.58$  ml. The environmental components of variance was greater than genotypic coefficient while genotypic and phenotypic coefficient of variabilities were 2.51 and 4.72 respectively.

#### 4.3.2.5 Hindi-62 variety :

In general, values for phenotypic variations were higher than the genotypic values in all the character studied.

The character, days to 50 percent flowering, has shown variation range from 82.00 to 86.33 days, with average mean of  $83.91 \pm 0.92$  days. The values of phenotypic variance for this character was greater than the genotypic and environmental variance. The phenotypic coefficient of variability was 14.34 and genotypic was 14.21.

The plant height ranged from 70.53 to 82.06 cms with mean value of  $78.26 \pm 7.77$  cm. The value of phenotypic variance was more than genotypic variance. The values of phenotypic and genotypic coefficient variabilities were nearly equal i.e. 12.62 and 12.52 respectively. This indicated that variation for this character was less and whatever variation present was less influenced by environment, as such selection on the basis of phenotypic value would definitely lead towards effectiveness of selection.

Range of variation for the number of tillers per plant was from 10.00 to 12.33 and mean  $10.87 \pm 0.68$ . In this character the environmental variance was more than genotypic variance. This indicated that, this character was much influenced by environmental factors. The genotypic and phenotypic coefficients of variations were 7.00 and 12.94 respectively.

Table 21 Effect of irradiation on Hindi-62 variety in M<sub>2</sub> generation.

Characters	Range	Mean	SE ±	$\frac{\text{Variance}}{G}$	GCV	PCV	Heritability	GA	EGA %
Days to 50% flowering	82.00-86.33	83.91	0.92	142.24	14.21	14.34	98.24	24.30	28.96
Plant height	70.53-82.06	78.26	7.77	96.04	12.52	12.62	98.37	19.94	25.48
Number of tillers/plant	10.00-12.33	10.87	0.68	0.58	7.00	12.94	29.29	0.84	7.73
100 grain weight	3.00- 3.59	3.29	0.34	0.016	9.84	18.53	4.30	0.05	1.52
Grain yield/plant	6.20- 7.42	6.94	0.67	0.12	4.99	17.64	8.00	0.20	2.90
Protein content	13.85-14.89	13.89	0.40	1.22	7.95	8.48	87.76	2.11	15.21
Lysine content	2.44- 2.48	2.45	0.030	0.0037	2.48	3.26	57.81	0.09	3.63
Gluten content	13.05-13.80	13.45	0.28	0.57	5.61	6.69	70.37	1.29	9.64
Pelshenke value	118.00-125.66	121.00	1.59	91.65	7.91	8.23	92.29	18.88	15.60
Sedimentation value	24.70- 25.43	25.15	0.58	0.40	2.51	4.72	28.36	0.68	2.72
Ash content	1.79- 1.85	1.82	0.016	0.015	6.72	7.57	78.90	0.22	12.16

The character, grain yield per plant showed the range of variation from 6.26 to 7.42 gm with an average mean  $9.94 \pm 0.67$  gm. The environmental components of variance was larger than the genotypic variance, while values for phenotypic coefficient of variability 17.64, and genotypic coefficient of variability 4.99, this revealed further selection is of no use.

The protein content exhibited range of variation from 13.85 to 14.89 gm with mean of  $13.89 \pm 0.24$  gm. The phenotypic variance was greater than environmental and genotypic variance. The genotypic and phenotypic coefficient of variability were 7.95 and 8.48 respectively.

Lysine ranged from 2.44 to 2.48 gm 100 grain of protein with mean  $2.45 \pm 0.030$  gm. The phenotypic variance was greater than genotypic variance. The phenotypic and genotypic coefficient of variabilities were 3.26 and 2.48 respectively.

The range of variation for gluten was 11.23 to 14.28 gm with mean  $13.45 \pm 0.28$  gm. The phenotypic variance was greater than genotypic variance, while the genotypic and phenotypic coefficient of variabilities were 5.61 and 6.69 respectively.

The trait polshenke value showed the range from 118.00 to 125.66 min. with mean  $121 \pm 1.59$  min. The phenotypic variance was greater than genotypic variance. The genotypic and phenotypic coefficient of variabilities were 7.91 and 8.23 respectively.

Sedimentation value exhibited mean  $25.15 \pm 0.18$  ml with variation range of 24.70 to 25.43 ml. The environmental component of variation was more than genotypic variance, while genotypic and phenotypic coefficient of variabilities, were 2.51 and 4.72 respectively.

#### 4.4 Heritability and genetic advance :

The concept of heritability is useful, as it provides a quantitative estimate of the relative importance of heredity and environment in determining the expression of a trait, which helps in planning an efficient breeding programme. Heritability is the measurement of transmission of an attribute from generation to generation. It can be in broad sense or narrow sense. Heritability in broad sense referred to the ratio of total genetic variance which is made of additive and non-additive or epistatic effects in genetic systems, controlling the character, with the total observed variance. While in narrow sense it referred only to the ratio of additive or fixable genetic variance to total phenotypic variance. From breeders point of view, characters with high heritability are of great importance than those which are influenced readily by environmental factors, as it enables to formulate the selection programme on the phenotypic performance.

Heritability in broad sense and genetic advance alongwith other estimates like Range, Mean,  $SE \pm$ , GCV, PCV, for each important character of Ajantha, D-2189,

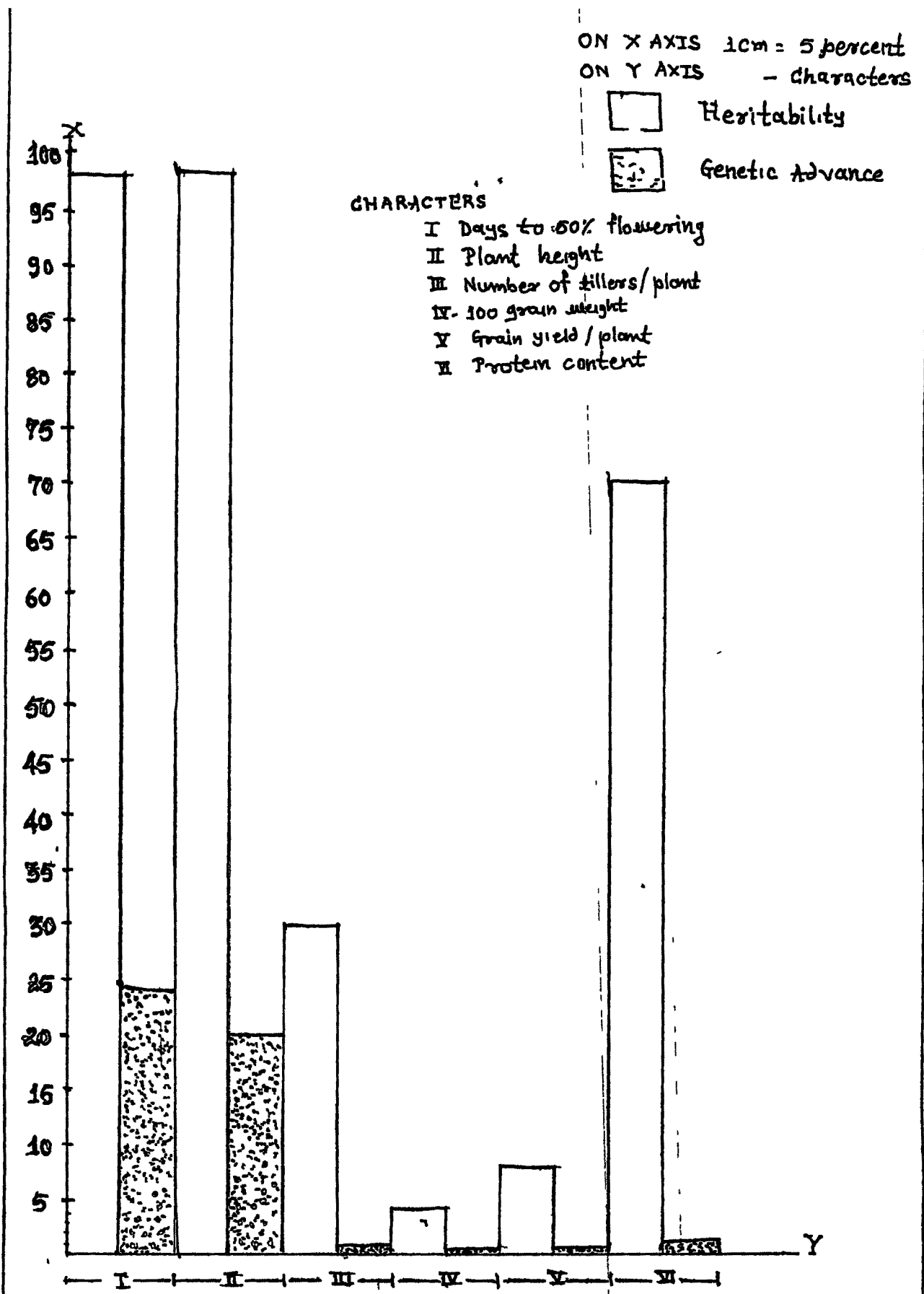


Fig. 6 HERITABILITY (broad sense) AND GENETIC ADVANCE in M<sub>2</sub>

NIML-1, C-306 and Hindi-62 are presented in Tables. Heritability and genetic advance in percent of mean of different characters for Ajantha, HD-2189, NIML-1, C-306 and Hindi-62 are graphically shown in Fig. 6.

#### 4.4.1 M<sub>1</sub> generation :

It is revealed from (Table 12) that germination percentage and days to 50 percent flowering exhibited high heritability i.e. 32.40 and 97.74 respectively. Moderate or medium heritability values for number of tillers per plant and grain yield per plant were 18.28 and 22.01 respectively. While low heritability estimates for 100 grain weight i.e. 6.66.

Expected genetic advance was high for days to 50 percent flowering (47.80 percent), while low genetic advance recorded for 100 grain weight (1.79) percent variance, while genotypic coefficient of variability was 2.51 and phenotypic coefficient of variability was 4.72, which indicated that variation present was greatly because of environmental influence.

Moderate genetic advance showed by the characters namely grain yield per plant (7.43) percent, germination percentage (8.87) percent, number of tillers per plant (9.06) percent.

#### 4.4.2 M<sub>2</sub> generation :

The quality character viz., Pelshenke value, protein content, Ash, Gluten content and lysine content were recorded in M<sub>2</sub> generation only.

From (Table 17), it is evident that the characters plant height (98.37 percent) days to 50 percent flowering (98.24 percent), Pelshenke value (92.29 percent), protein content (87.76 percent), Ash (78.94 percent), Gluten content (70.37 percent), Lysine content (57.81 percent) exhibited high heritability estimates Moderate or medium heritability estimates were recorded in Number of tillers per plant (29.29 percent), Sedimentation value (28.36 percent). The low heritability exhibited in grain yield per plant (8.00 percent) and 100 grain weight (4.30 percent).

The character days to 50 percent flowering (50.18 percent), plant height (26.42 percent) and pelshenke value (17.51 percent) showed high genetic advance, while moderate genetic advance exhibited in protein content (15.15 percent), Ash (13.67 percent), Gluten (10.35 percent), number of tillers per plant (8.69 percent).

Expected genetic advance was low lysine content (3.62 percent), grain yield per plant (2.93 percent), Sedimentation value (2.80 percent), and 100 grain weight (1.36).

CHAPTER-V DISCUSSION

The wheat provides an important source of food to world and specially to India. Among cereals wheat is having special rank for enrich protein and its use in bakery products. The concept of inducing mutations and utilising them in plant breeding was first suggested by Hugo De Vries, to command the origin of mutations, and thereby generate the allelic variability upon which recombination and selection could operate, to achieve more speedily the goal of creating superior strains. Muller (1927) also expressed the hope that practical breeders need no longer be entirely at the mercy of existing variability. The research on plant breeding has now entered in various new goals. Such new needs together with the increased knowledge of manipulating the mutation process have led in recent years to much greater success in getting induced mutations of applied value in several crops.

The work on mutation breeding in wheat reviewed by Swaminathan (1969). Unlike the other methods of plant breeding, such as exploitation of heterosis, where the practical exploitation of the phenomenon has not been handicapped by a lack of the theoretical understanding of the process itself, practical results in the field of mutation breeding will be proportional to the growth in our insight into the process of induction and recovery of mutations.

Mutation breeding can reasonably be expected to play a pivotal role in evolution of new types of plant architecture combined with quality and quantitative characters. The sources for quality traits are apparently limited. The effect of irradiation on grain yield differed among the varieties. A large increase in yield was obtained. A large increase in yield was obtained after irradiation of two varieties Saratov 29 and Narodnaya with low doses. Large increase in the protein content in the grain (2.37 percent), was observed after irradiation with a dose of 4500 R and sowing in well manured soil. The greatest increase in protein content under these conditions was observed in Narodnaya reported Chistova, (1971).

Experiments dealing with induced mutations for improving quality characters such as Gluten, Protein, Lysine, Sedimentation value, etc. have been comparatively few in crop plants. Mutants from irradiation of dry seeds of Bezostaya-1 (awn less), Rannyaya 12 (Early 12) Mironovka 808 with 10 K<sub>r</sub> gamma and X-rays were selected by appearance in the M<sub>2</sub> and their stabilized upto M<sub>6</sub> generations were studied. The mutants of Bezostaya-1 had a protein content ranging from 12.0 to 18.6% where the range in the initial variety was 12.9 - 13.9. Similar improvements in gluten content and particularly great improvement in gluten quality of all three varieties were recorded. Among the mutants B-1, 44.8% of M<sub>4</sub>s and 33.7% of M<sub>5</sub>s had a sedimentation value above 65 ml. (Gotsova et al. 1971).

The variety developed by mutation breeding sharbati sonora has more lysine per 100 grain of protein than the present Sonora-64. (Swaminathan et al. 1965).

#### 5.1 Effect of irradiation on M<sub>1</sub> generation :

The study of germination in irradiated seed gives preliminary idea about of doses. Inhibition of germination is taken as an indication of degree of radiosensitivity and damage caused mutagen (Gaul, 1958). In the present study, gamma ray doses, significantly affected the germination percentage. The germination in control was highest and it was at par with 10 KR dose.

The germination was significantly reduced in 20 KR dose than control. The dose of 30 KR exhibited significantly lowest (65.92%) germination percentage. The results revealed linear reduction in the germination with increase the dose of gamma rays. Muhammad (1965) and Goud (1967) also reported decrease in germination with increased doses of gamma rays.

The variety x dose interaction was significant. The results revealed differential response of wheat genotypes to doses of mutagen. C-306 was more susceptible to higher doses than other four varieties. Kumar Singh (1974) reported the maximum radiosensitivity occurs at 20-30 KR gamma A-ray treatment.

Increasing doses of mutagen revealed decrease in plant height (cm) in all the varieties i.e. Ajantha, ID-2189, NIML-1, C-306, Hindi-62. The reduction in plant height

ranged from 15 cm in HD-2189 to 26 cm in NIML-1 at 30 KR dose of gamma rays. Bozini et al. (1967) reported reduction in plant height due to treatments with X and gamma rays.

Days to 50 percent flowering ranged 46.33 to 85.00 days among varieties. Significant differences were noticed between varieties, doses and dose X interaction. Generally increasing doses of gamma of rays delayed 50 percent flowering. Variation for this character was greater in the Hindi-62 followed by HD-2189, C-306, Ajantha and very low variation found in NIML-1 variety.

Yashivir et al. (1975) reported that heading time and flowering period increases towards lateness in  $M_1$  and  $M_2$  generation of wheat (Triticum spp.) after treating treatment of 10-40 KR of gamma rays.

Variation for number of effective tillers per plant has shown significant differences in all varieties with all doses studied. Variation for this character was highest in the Hindi-62 followed by Ajantha, NIML-1, HD-2189. The lowest tillers per plant was observed in C-306. The dose effect was also significant indicating higher the doses of gamma rays, increased profuse tillering.

Denisov and Matgushenko (1970) observed increased variation for number of grains, length of the ear and effective tillering in the varieties viz., Mironovka 808, Mironovk 264 and Balaya Tserkov 198 after irradiation with gamma ray doses of 5, 15, and 30 KR.

They further concluded that the number of grains per ear increased by 30 percent, the length decreased by 25 percent, effective tillering increased and grain content of the ear also increased in  $M_1$  generation.

The character length of main spike has shown significant results, which indicated that selection for this character is of non-additive. Among varieties the Ajantha was superior over other while, NIML-1 was found statistically inferior. There was also significant differences for effect of doses. Highest length of ear was observed in control and at par with 10 KR dose but significantly reduced in 20 KR and significantly lowest length of ear was recorded in 30 KR. These results revealed linear reduction in the length of ear with increased variety was more susceptible to higher doses than other four varieties and maximum radiosensitivity occurs at 20-30 KR of gamma ray treatment.

Yashvir et al. (1975) also reported that in the Triticum aestivum the seeds were treated with 10-40 KR gamma rays showed reduced ear length. Variable was length and awnlessness segregation.

Variation for number of spikelets per spike has exhibited significant differences in all the varieties studied. The variety Hindi-62 possessed highest spikelet number within the ear followed by Ajantha, NIML-1. These two varieties beared short ear length and low spikelet number per spike, and were also statistically inferior with others.

The effect of doses was also significant in control with highest spikelet number and at par with 10 KR. The interaction between doses X varieties revealed different response of treatments to various doses of gamma rays. The variety C-306 was found more susceptible to gamma ray dose for number of spikelets per spike.

Domini (1968) observed spikelet fertility and grain germination decreased with increasing dose rate in  $M_1$  generation after 60 cobalt source treatment.

In the present studies, the character number of grains per main spike has shown significant difference for different varieties. HD-2189 variety has given highest number of grains per earhead followed by C-306 variety while significantly lowest grain number was recorded in NIML-1. The number of grains in control was highest and at par with 10 KR dose. The grain number was significantly reduced in 20 KR. The dose of 30 KR exhibited significantly lowest grain number per ear. The variety X dose interaction was also significant. The results exhibited NIML-1 was more susceptible to higher doses than other varieties for this trait.

Ibrahim and Sharaan (1974) observed less ear length and low number of grain per ear in  $M_1$  after gamma irradiation of seeds of barley.

The character days to physiological maturity showed significant difference in varieties of Hindi-62, NIML-1, Ajantha while C-306 was at par with Hindi-62 and HD-2189 with NIML-1, thus it can be calculated that there is further scope for selection in HD-2189, Hindi-62 and Ajantha as there was sufficient variation. The effect of doses of gamma rays was found non-significant. The late maturity (statistically highest) was observed in 30 KR and was reduced in 20 KR and 10 KR respectively. The lowest maturity (earliness) was in control in all varieties. This it is obvious that lateness is due to the increasing doses of gamma rays. The interaction effects was significant and Hindi-62 variety was more susceptible to higher doses than other varieties, because it prolongs the maturity time by more than 20 days.

Viglasi (1968) observed increase in the maturity time in wheat variety Karcay 522 when a radiation dose of 20 KR to 30 KR was given.

The character 100 grain weight showed significant varietal differences. In the present studies gamma rays doses of significantly affected the 100 grain weight. The 100 grain weight was highest in 30 KR and lowest in 10 KR.

These results revealed reduction in the 100 grain weight with lower doses of 10 and 20 KR and increased with higher dose of 30 KR treatment in all the varieties.

It indicated that 10 and 20 KR doses have shown deviation in negative directions while 30 KR dose showed positive direction. Thus, this dose provided scope for further improvement in this character.

The variety x dose interaction was also non-significant. The variety NIML-1 in durum wheat was more susceptible to different doses than other four varieties. Syed et al. (1968) reported that most of the effect of gamma irradiation was reduced the grain yield and 100 grain weight in the varieties of C-5667, C-271, C-73 Norin-53. (Triticum vulgare).

Grain yield per plant showed non-significant variation in the five wheat varieties with different doses. This suggests that there was no scope for selectiones as variability was exhausted. The grain yield was highest in control and was lowest in the 30 KR. The results revealed reduction in the grain yield with increase the dose of gamma rays.

Orav (1969) studied 3 generation in spring wheat, and showed that with all doses grain yield in  $M_1$  was less than the control. On the contrary, Trujillo Figueroa and Rios (1970) observed increase in variability and reduction in mean values for yield per plant compared with the control in  $M_1$ .

Chimeras for double spike were found in this particular generation. The chimeras for double spike character was obtained in HD-2189 variety with 30 KR dose

while 30 KR dose of NIML-1 also gives C-306 also gives dwarf mutant which having double ear.

Gill and Sethi (1969) also observed one chimera for double<sup>ear</sup> in wheat induced by gamma rays, in M<sub>1</sub> generation.

## 5.2 Economic mutations in M<sub>2</sub> generation :

### 5.2.1 Dwarf mutants :

Many mutants having varying degree of dwarfness were observed in progenies of all the varieties. Three dwarf mutant plants in different variant progenies of Ajantha, of 30 KR plants in HD-2189 with 30 KR were observed.

Wankhede and Chopde (1979) reported mutants of economic value i.e. dwarf and early maturing mutants in M<sub>2</sub> generation in T.aestivum varieties.

### 5.2.2 Early mutants :

Early maturity is very essential character both irrigated as well as rainfed wheats. In irrigated conditions it is useful to suit in multiple cropping system, while it is advantageous, to escape drought generally occurring in later part of rabi season in rainfed conditions. Mutants plants with earliness were observed in variant progenies of all varieties compared with their respective control specially in Ajantha (20 KR) by 8 days. In NIML-1 with 30 KR by 7 days and in HD-2189 with 30 KR by 8 days.

Jadhav (1978), and Wankhede and Chopde (1979) also noticed early mutants in this crop in M<sub>3</sub> generation respectively by chemical mutagens.

### 5.2.3 Early and dwarf type mutants :

Earliness with dwarf stature is most important combination of characters in wheat to fulfill the desired objectives, such types were obtained in all varieties except Hindi-62. There were two plants from Ajantha, four plants from NIML-1, two plants from C-306 and ten plants from HD-2189.

Rautet et al. (1975) also reported a mutant in Kalyansona, which after further selection bears good characters like increased resistance to rust, reduced height early maturity and good yield.

Jadhav (1978) in  $M_3$  generation and Wankhede (1977) in  $M_2$  generation observed early and dwarf type mutants by using chemical mutagens.

Early and tall type mutants were also observed in  $M_2$  generation. These type of mutants will prove usefulness in variety HD-2189 which is recommended for irrigated condition. The mutants of HD-2189 early and dwarf stature more useful irrigated conditions. Such type of mutants were recorded in Ajantha (2 plants) one plant in HD-2189 and four in variety C-306. The dwarf are mutants of Ajantha may be useful for 3-4 irrigations, and would be resistant to lodging. The normal Ajantha wheat variety, if irrigated (3-4) it succumbed to lodging. Similarly, C-306 dwarf, early with resistant to rusts would be useful under normal irrigated condition.

The variety HD-2189 is a shy tillering and hence requires 25 kgs per hectare seed more at the time of sowing. The mutants of HD-2189 with profuse tillering will reduce the extra cost on seed rate, and simultaneously it will increase the grain yield per hectare.

Increasing doses of mutagen revealed increase in the plant height (in cm). The difference in the plant height ranged from 5 cm in Hindi-62 and 25 cm in HD-2189.

According to <sup>Orav</sup> (1969) also increased the plant height in the M<sub>2</sub> generation when the seeds were exposed to gamma rays with 10-12 KR treatment.

Days to 50 percent flowering ranged from 46.86 to 86.33 days for different varieties. Significant differences were noticed among the varieties, doses and dose x variety interaction. Increasing doses of gamma rays increases the 50 percent flowering period and resulted <sup>in</sup> lateness. A variation for this character was greater in the variety C-306 followed by NIML-1 variety. Yashvir et al. (1975) also reported that heading time and flowering period increases towards lateness in M<sub>2</sub> generation of wheat after treating with various treatments of gamma rays.

The character length of main spike revealed significant results. Variety Hindi-62 was superior over others. This was noticed in 20 KR dose. These results exhibited that increase in the length of main spike was due to medium doses and it was decreased at higher doses. However, Minenkov (1975) reported increased variation in ear length

by physical mutagens in wheat. Mutants with increased size of ear after treatment with physical mutagens were isolated by Maslevo and Stepanova (1967).

Variation for number of spikelets per main spike has shown significant differences. Among the varieties, studied C-306 proved highest spikelet numbers within the ear followed by Ajantha and lowest number of spikelets were recorded in NIML-1. The statistically highest spikelet numbers were recorded in the 30 KR dose and lowest in control. There was increase in the spikelet numbers with increase in the dose of gamma rays. The variety Ajantha was found to be more susceptible to gamma ray doses.

Gill et al. (1974) also reported increased mean number of spikelets in  $M_2$  with reduced variation in next generations.

Number of effective tillers per plant has showed significant results in all variants of five varieties except NIML-1 and C-306 varieties, which indicated selection for this character will not prove advantageous. As for as rainfed condition is concerned profused tillering is not recommended (Hurd, 1968). The number of tillers per plant was increased with increasing doses. Similar results were obtained by Bozzini et al. (1967).

viz.

The character  $\Delta$ days to physiological maturity showed significant difference in variants of these varieties.

Ajantha variety was earliest, while Hindi-62 was late in physiological maturity. The effect of doses of gamma rays was found significant. The late maturity was observed in 30 KR and earliest maturity was noticed in 0 KR doses in all the varieties. The interaction effects were also significant, and the variety NIML-1 was more susceptible to higher doses than others because it has prolonged physiological maturity time by 23 days. Yashvir et al. (1975) observed increased the maturity time in bread wheat (Triticum aestivum) when these seeds treated with 10 to 40 KR gamma rays.

Number of grains per ear has been found to be significantly different. The variety C-306 has given highest number of grains per earhead followed by ID-2189 and significantly lowest grain number was recorded in NIML-1. The highest grain number was noticed in 20 KR doses and lowest in the control. The effect of dose was found non-significant. The variety x dose interaction studies were non-significant. The results thus exhibited that NIML-1 was more susceptible to higher doses than other varieties. Hence, some of variants provided scope for further improvement in this character. Borojevic (1968) reported the number of grains per ear was increased in early generations and later approached the control mean.

Grain yield per plant showed variation in the variants of five wheat varieties studied. Maximum grain yield was recorded in C-306 variety and lowest grain yield was recorded in NIML-1. The doses increased the grain yield.

100 grain weight in  $M_2$  generation gives significant results the Ajantha variety indicated highest 100 grain weight while lowest observed in HD-2189. The results showed that 400 grain weight was increases with increase in the dose which influences the yielding ability.

Muhammad and Syed (1965) also observed increase in the 100 grain weight with high doses of gamma rays.

### 5.3.2 Quality traits :

The quality traits were studied in the  $M_2$  generation only. The effect of gamma rays doses on different quality traits were studied. Protein content in the wheat samples showed significant results. Variation for this character was highest in C-306 variety, while it was lowest in HD-2189. The dose effect was also significant. Dumanovic et al. (1970) also observed an increased variation in protein content in the  $M_2$  and  $M_3$  generation.

Gluten content has shown significant results. Among varieties, Hindi-62 contained highest gluten percentage, while lowest gluten percent was observed in the HD-2189 variety. Gotsova et al. (1971) also reported improvements in gluten content and particularly gluten quality by means of X-rays and gamma rays. There was non-significant difference among the doses for gluten content. In the sedimentation value the varietal differences showed non-significant results. The highest sedimentation value

observed in Hindi-62. The dose effect was also non-significant. However, Gotsova et al. (1971) also observed increase in the variation of sedimentation value in Rannyaya-12 Mironovka-808 when treated with gamma rays and X-rays in  $M_2$  generation.

Pelshenke value displayed significant differences amongst varieties. This was highest in C-306 and lowest in the HD-2189. Generally the mutagen dose revealed decrease in Pelshenke value at lower doses.

Lysine content and ash content showed the significant differences among the varieties. The highest lysine and ash content noticed in Ajantha and Hindi-62 respectively, while lowest in NIML-1 and HD-2189. The dose effect was non-significant. Swaminathan (1965) reported the variety viz., Sharbati Sonora developed by mutation breeding has more lysine per 100 gm of protein than its parent Sonora-63.

Other mutants like lateness, double spike and tip sterility were also recorded. Similar type of mutants also reported by Mehta (1972), Wankhede (1977) and Jadhav (1978) in this crop.

### 5.3 Genotypic and Phenotypic variation :

#### 5.3.1. $M_1$ generation :

Only genetic component of total variation is important from breeders point of view. In case of Ajantha variety, phenotypic coefficients of variability was calculated which revealed that maximum variability was observed for number of

effective tillers per plant, followed by days to 50 percent flowering, grain yield per plant, 100 grain weight and germination percentage. Genotypic variability observed was lower for all the characters studied, which indicates that there was no much variation.

In HD-2189 the characters, number of effective tillers per plant and days to 50 percent flowering exhibited high phenotypic coefficients of variability followed by grain yield, germination percentage and lowest in 100 grain weight. Genotypic coefficients of variability for all the characters were lower.

Data from (Table 14) revealed that NIML-1 showed moderate genotypic coefficient of variability for days to 50 percent flowering and number of tillers per plant while other characters exhibited lower values. High phenotypic coefficient of variability was observed for number of tillers per plant followed by days to 50 percent flowering, grain yield. 100 grain weight and lowest in germination percentage.

C-306 variety showed high phenotypic coefficient of variability for 100 grain weight, number of tillers per plant, while moderate values for days to 50 percent flowering and germination percentage. The low phenotypic coefficient of variability was recorded in grain yield.

In case of Hindi-62 variety, phenotypic coefficients of variability revealed that maximum variability was observed

for number of tillers per plant and moderate for days to 50 percent flowering, 100 grain weight followed by grain yield, germination percentage.

### 5.3.2 M<sub>2</sub> generation :

The genotypic and phenotypic coefficients of variation was recorded in next successive generation. In Ajantha variety, the characters, days to 50 percent flowering and grain yield per plant exhibited high phenotypic coefficient of variability followed by 100 grain weight, number of effective tiller per plant, length of earhead, pelshenke value, ash, protein content gluten content. The lower phenotypic coefficient of variation was found for sedimentation value and lysine content. Genotypic coefficients of variability for all the characters studied were low.

HD-2189 variety showed high phenotypic coefficients of variation in characters <sup>viz.</sup> 100 grain weight and days to 50 percent flowering. Moderate phenotypic coefficients of variation was in grain yield per plant, number of tillers per plant and plant height, protein content. Pelshenke value and ash, while other characters showed less phenotypic coefficient of variability. Genotypic variability observed was lower for all the characters studied, which indicates that there was no much variation.

In NIML-1 the characters grain yield, days to 50 percent flowering and 100 grain weight exhibited high

phenotypic coefficients of variability followed by plant height, number of effective tillers per plant, pelshenke value, protein content, ash, gluten content, sedimentation value, and lysine. Genotypic coefficient of variability for all the characters were lower.

Data from Table 15, revealed that the variety C-306 showed moderate genotypic coefficient of variability for days to 50 percent flowering and plant height while other characters exhibited lower values. High phenotypic coefficient of variability was observed for days to 50 percent flowering, 100 grain weight and grain yield per plant, while moderate values for number of tillers per plant, plant height, protein content, pelshenke value, ash, while rest of all showed less phenotypic coefficient of variability.

Hindi-62 variety showed high phenotypic coefficient of variability for 100 grain weight, grain yield per plant, days to 50 percent flowering, while moderate values for number of effective tillers per plant, plant height. The lowest phenotypic coefficient of variability <sup>was observed</sup> for protein content, pelshenke values, ash, gluten, sedimentation value and gluten, have been observed.

Goul and Asstveit (1966) reported that reduction in mean culm length while increase in the genetic variance in wheat by X-rays and EMS treatments, while Singh et al. (1970) reported high genetic coefficient of variability for number of grains per main spike, 100 grain weight and grain yield

per plant. Tikka et al. (1973) observed high phenotypic variation for most of the plant characters in wheat. This confirmed the results obtained in the present findings. On the other hand Ibrahim and Sharaan (1974) reported lower genotypic coefficient of variability for earhead length and number of grain per ear.

Chavan (1980) observed maximum genetic variability for grain yield and number of effective tillers, per plant number of grains per main spike, 100 grain weight and plant height.

The phenotypic and genotypic coefficients of variability in all five varieties in  $M_1$  generation the characters, days to 50 percent flowering were nearly equal. And in  $M_2$  generation for the characters days to 50 percent flowering, plant height, protein content, lysine content, pelshenke value in all five varieties and gluten in Ajantha, were nearly equal. Thus those characters having comparatively less difference between phenotypic and genotypic coefficient of variability will lead to genetic improvement of because these were less influenced by environment. Greater differences between phenotypic and genotypic coefficients of variability revealed that the characters were much influenced by environment and thus selection will not be useful but possess more scope to increase variability in such characters. Singh and Kumar (1974) reported less genotypic coefficients of variability for 1000 grain weight and yield than the phenotypic coefficients of variability. On the

contrary Randhawa et al. (1975) reported high genetic coefficients of variability for 1000 grain weight, plant height, peduncle length and yield per plant. However, Bhathagar et al. (1977) reported high genotypic coefficient of variation for ears per plant, tillers per plant, leaves per plant and grain yield in barley.

#### 5.4 Heritability and genetic advance :

##### 5.4.1 M<sub>1</sub> generation :

High estimates of heritability for days to 50 percent flowering and germination percentage but medium heritability was exhibited by number of tillers per plant and grain per plant. The character, days to 50 percent flowering showed high heritability with moderate genetic advance, while number of tillers per plant exhibited medium heritability and moderate genetic advance. This clearly indicated that these two characters would be given more emphasis while applying selection pressure for breeding high yielding and early varieties.

##### 5.4.2 M<sub>2</sub> generation :

In case of M<sub>2</sub> generation high estimates of heritability for plant height, days to 50 percent flowering, pelshenke values, protein content, ash, gluten content, lysine content, however medium heritability was exhibited by number of tillers per plant. Sedimentation value, grain yield and 100 grain weight of these only days to 50 percent flowering, recorded with high heritability and genetic

advance while. Plant height, pelshenke value, protein content, ash, gluten content, showed high heritability with moderate genetic advance. Lysine content, sedimentation value exhibited high heritability with low genetic advance. Thus these all above characters will be given more importance during selection programme because they will express truly in succeeding generations leading to effectiveness of programme.

In general, only days to 50 percent flowering and number of tillers per plant showed high heritability with moderate genetic advance which clearly indicated that this would be increased greatly by selection. Sing et al. (1970) reported high variability estimates alongwith genetic advance again for the number of grains per ear and 100 grain weight in T. durum Desf.

Jain and Aulakh (1971) observed an appreciable amount of heritability for days to maturity, days to flowering, spikelets per ear and grain weight per ear.

Khan et al. (1972) also observed larger heritability estimates for plant height, length of spike and moderate heritability with high genetic advance for number of grains per spike.

Galal et al. (1974) reported high values of heritability estimates for stem height, spike length, grain number per spike and 100 grain weight in  $M_1$  and  $M_2$  generations.

Singh et al. (1978) reported high heritability and maximum expected gain for 1000 grain weight and lowest for plant height.



Seeds of five wheat varieties viz., Ajantha, HD-2189 NIML-1, C-306 and Hindi-62 were treated with 10, 20 and 30 KR doses of gamma rays. The treated seed of these five varieties was studied for different quantitative characters.  $M_1$  generation was raised from all varieties in field condition during rabi season.  $M_2$  generation was also raised in rabi season of successive years. The qualitative traits like protein content, gluten content, pelshenke value, sedimentation test, lysine content and ash were tested in laboratory of  $M_2$  generation. The results of present study are summarised below.

- (1) The results revealed linear reduction in seed germination with increase in the dose of gamma rays. The dose of 30 KR exhibited lowest germination, C-306 variety was more susceptible to higher doses than other varieties.
- (2) The days to 50 percent flowering prolongs the days towards lateness with increase in the dose of gamma rays. The lateness was observed with 30 KR and followed by 20 KR, 10 KR. Hindi-62 revealed higher sensitivity to mutagen in  $M_1$  for 50% flowering.
- (3) The dose of 30 KR significantly reduced the plant height. The dose of 20 KR, 10 KR were also significantly reduced the plant height. C-306 variety was more sensitive to mutagen in  $M_1$  for plant height.
- (4) The dose of 30 KR increases the period of physiological maturity (towards lateness) in all varieties. The highest lateness was observed in 30 KR dose only. However the effect of this dose was non-significant in  $M_1$ .

- (5) The results revealed that number of effective tillers per plant increased with increase in the dose of mutagen in all the varieties of  $M_1$ .
- (6) The length of main spike (cm) decreased with increasing doses of mutagen in the  $M_1$  generation.
- (7) The dose of 30 KR significantly reduced the spikelet numbers per ear in all varieties. The dose of 10 KR was at par with control and dose of 20 KR was at par with 30 KR in  $M_1$  generation.
- (8) Number of grains per earhead decreased with increasing the dose of mutagen in  $M_1$  generation.
- (9) The dose of 30 KR decreases the grain yield per plant in all varieties. The highest grain yield was observed in control and reduced dose wise. The effect of dose was non-significant in  $M_1$  generation.
- (10) The 100 grain weight was found highest in 30 KR than control. This test weight reduced in 10 KR and 20 KR doses than control and increased in 30 KR. The lowest 100 grain weight was found in 10 KR dose in all varieties of  $M_1$  generation.
- (11) Chimera's for double spike character was found in the  $M_1$  generation in three different varieties of wheat.
- (12) Dwarf mutants was found in HD-2189 (30 KR) and Ajantha (30 KR) and tall mutants were found in Ajantha 30 KR, 20 KR, NIML-1 30 KR, C-306 30 KR and Hindi-62 with 30 KR.
- (13) Some early mutants also reported in Ajantha 20 KR, NIML-1 20 KR and HD-2189 30 KR and late mutants occurred in Hindi-62 20 KR, Hindi-62 30 KR and C-306 30 KR.
- (14) Double earhead or double spikes were noticed in the  $M_2$  generation as well as in C-306 for 30 KR.

- (15) The dose of 30 KR significantly enhanced the plant height. The 20 KR and 10 KR doses also resulted in more height than control. Variety HD-2189 gives more sensitivity to gamma rays in this particular character in  $M_2$  generation.
- (16) Increasing doses of gamma rays increases the 50 percent flowering period in  $M_2$  generation.
- (17) The dose of 20 KR increased the length of main spike and 30 KR dose level was at par.
- (18) The doses of mutagens increases the number of spikelets per main spike in all varieties with increasing doses in  $M_2$  generation.
- (19) The number of tillers also increases with increasing doses of mutagens in  $M_2$  generation.
- (20) The increasing doses of mutagens increased the period of physiological maturity (towards lateness) in all varieties. The highest physiological maturity period was observed in 30 KR doses.
- (21) The dose of 30 KR significantly increased the number of grains per ear in all the varieties of  $M_2$  generation.
- (22) 30 KR dose showed highest 100 grain weight followed by 20 KR and 10 KR. The lowest 100 grain weight was found in control.
- (23) Grain yield per plant was increased with increasing in doses.
- (24) The protein content was highest in C-306 variety while lowest in HD-2189 variety of wheat. The highest gluten content was found in the variety Hindi-62 with lowest gluten content in HD-2189.

- (25) Among the five varieties of wheat sedimentation and Pelshenke values were found lowest in HD-2189 while recorded highest values of sedimentation and pelshenke in Hindi-62 and C-306 variety of wheat. The highest lysine content was estimated in Ajantha while it was lowest in NIML-1 variety of I.durum.
- (26) There was increase in the quality characters like gluten, sedimentation value, pelshenke value and lysine content with increasing doses of gamma rays, while reduction in ash percentage with increasing doses in  $M_2$  generation.

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\*Original not seen.

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