Mutation and recombination are the two essential tools for creating genetic variability which can be exploited in the evolution of new types. Induction of mutations particularly for the quantitative traits is useful in the improvement of economic traits. The quantitative traits (Mather, 1949) are governed by polygenes occurring in systems, the members of which have small similar and supplementary effect. No allelomorph of one polygene has unconditional advantage over the other and great potential variability can lie hidden in the form of balanced combinations. Polygenes are the genes of smooth adaptive change and appear to be the root cause of speciation (Mather, 1945).

Identification of polygenic mutations is, therefore, not easy as the identification of major gene mutants. Hugo Devries (1901) and Johannsen (1906, 1913) observed spontaneous occurrence of mutations of both major and small effects. The importance of minor mutations in evolution was first stressed by Baur (1924). In his classical paper on the racial differences in Antirrhinum he proposed the term 'Kleimutationen' which can be paralleled to 'micro-mutations'. This was subsequently also supported by Stubbe
and Vonwettstein (1941). The spontaneous mutations occur in a very low frequency and it was only after the experiments of Muller (1927) and Stadler (1928) on Drosophila and maize, respectively it was known that through X-rays treatment the rate of mutations can be accelerated. Work on mutation breeding was taken up by Gustafsson in Sweden in 1928. Since then it has been recognized that artificially created mutations cause variability essentially similar to natural mutations. Recently the use of various physical and chemical mutagens has been made to create mutations to be used in crop improvement. The usefulness of such variation in crop improvement has been extensively dealt by Gustafsson and Gadd (1965a, b, c, d and e). The mutations can be utilized in many ways and the classification to this effect has been provided by Gaul (1965).

A number of papers have been published from time to time reviewing the work of various workers in the induction of artificial mutations. This provides an interesting reading of the lacunae and future line of work. A reference may be made to Singleton (1955), Prakken (1959), Matsuo and Yamaguchi (1962), Gaul (1963), Gaul (1964), Disler (1965), Scossiroli (1965), Swaminathan (1965), Niles (1967), Gregory (1966, 1968), Scarascia-Mugnoza (1968), Brock (1970, 1971) and Sparrow et al. (1971).

Use of Induced Mutations

The mutations induced in polygenic systems can be used in two ways (a) directly as a new variety if the selected mutant
satisfies our desirability standards and (b) in hybridization programmes when the selected mutant has only one or two advantages. The first possibility seems to be a remote one because of pleiotropy, multiple mutations of linked genes, background mutations, and probably a major loss of chromosomal material (Micke 1969a).

In Sweden, Germany, U.S.A., Canada, Italy and India, in spite of the difficulties in mutation breeding, a number of varieties of direct commercial importance have been evolved. The list has been prepared by Sigurbjornsson and Micke (1969). Out of a total of 31 varieties in cereals (4 rice, 13 barley, 4 oats), 10 belong to wheat (Sigurbjornsson, 1970). The mutation work in India is in progress since 1955 and with the establishment of gamma gardens at the Bose Research Institute, Calcutta in 1959 and at the Indian Agricultural Research Institute, New Delhi, in 1960, new vista in crop improvement was opened. Two varieties in wheat have been released so far. NP 836 has awns and better yield than its awnless parent NP 799, and the variety Sharbati Sonora has amber grain and better yield than the red grained Mexican mother line - Sonora 64.

Numerous short and stiff strawed, lodging resistant mutant lines have been recovered through treatments with physical and chemical mutagens in tetraploid and hexaploid wheats. Mackey (1954a, b, 1955, 1960) obtained several short-strawed mutants in winter wheat (T. aestivum) Skandia III. Straw shortening revealed a negative pleiotropy for yielding ability. Natrajan et al. (1958) got stiff strawed mutants in the awnless variety
NP 809 and Sen et al. (1953) recovered 15 lodging resistant and better yielding mutants than the mother variety. Similar mutants have been obtained by Oltman (1950), Whitehouse (1958), Noulard (1959), D' Amato et al. (1960), Prieucenciu et al. (1962), Tavcar (1962), and Uchikawa (1962) in hexaploid wheat. Karapetjan (1962, 1963) using gamma rays and Swaminathan et al. (1962) using EMS got such mutants in T. compactum and T. dicoccum, respectively. In T. durum wheat such reports come from D' Amato et al. (1964), Scarascia-Mugnozza (1965, 1966 a, b, c), Bosini and Scarascia-Mugnozza (1967). According to Scarascia-Mugnozza (1970) who has reviewed mutation work on lodging resistance, some of these mutants are used to establish new varieties, released or to be released.

Better mutants in respect of one or more agronomic characters have been obtained by many workers. Banerjee (1964) by X-irradiating UP 824, recovered two mutants with high protein content. Skvarenkov (1964) obtained 90 types of mutations, out of which 43 per cent were beneficial, including forms with such characters as, improvement in yield, earliness, straw length, overwintering capacity and gluten content. D' Amato et al. (1964) obtained 395 mutants promising for short straw, lodging resistance and increased fertility. Increasing fertility was obtained by Shkvarnivov et al. (1965) in about 23 per cent of the mutants. Campelli variety of durum wheat has been extensively used in mutation induction. Scarascia-Mugnozza (1966 a, b, c) found mutants in this variety which had shorter-straw, lodging resistance and higher yields. Mexican varieties Sonora 64, Sonora 63 and Lerma Rojo 64 treated by Varughese and Swaminathan (1966) yielded amber grain variants, Sharbatli Sonora released as a variety.
is the result of such mutants. Similar reports have been made by Tavcar and Kendjelic (1965), Konzak et al. (1966), Singh et al. (1967), Vighisi (1968), Korotkova (1968), Edward et al. (1969), Bogyajajjii. (1969 a, b).

Gaul (1963) has outlined various ways of utilizing the mutants. The use of mutants in the hybridization programmes can prove encouraging, since by this technique a beneficial mutation can be incorporated into a new genetic background. The crosses of mutants can be made with the mother variety, the other variety or the other mutants. Interseeding of mutants has yielded transgressive segregates for polygenically controlled characters (Jastweit, 1966; Gaul 1965; Hagberg, 1959). Transgressive segregates can also be produced by crossing two different varieties having same mutant phenotype. Hence the genotypic background could play an important role in the expression of mutations (Gaul, 1967; Mikaelson, 1967).

Further it is easier to incorporate a desirable character from a mutant of adapted variety, than from an unadapted wild relative of the crop (Sigurbjornsson, 1970).

Transgressive segregates in wheat have been obtained by Scarascia-Mugnozza et al. (1966) by crossing short straw durum mutants. Konzak (1966) also used the mutants of bread wheat in hybridization and study of the inheritance of useful induced mutants. Bagnara (1967) studied a diallel set including parents and F1's; involving Campelli, its radiation-induced mutants Cp048, CpB132, CpB144 and CpCB2, and the American variety Lakota for seven quantitative characters. The four mutant lines different
from Capelli in respect of almost all the characters and from each other in the case of some of them. The average degree of dominance varied from partial to complete dominance for different characters except number of spikelets which showed over-dominance and a low heritability. The chances of obtaining lines by selection amongst segregating material appeared to be particularly promising for length of the main ear, number of spikelets and number of internodes.

The results obtained by Kaimura et al. (1967) from crosses of two R$_6$ white-chaffed short culmed plants with the original parent indicated that short culm mutation was polygenic. Bozzini and Scarascia-Mugnozza (1967) crossed short strawed mutants with the mother strain, 'Capelli' and in the F$_2$ the plant height distribution indicated monofactorial, dominant behaviour which was confirmed in crosses with other durum lines and varieties.

The crosses between mutant lines can also exhibit hybrid vigour. The indications of exploiting this phenomenon have been given by Scheibe and Micke (1967) and Micke (1969a, b).

Crossing mutants with a variety other than the mother line could also be useful. Gaul et al. (1968) in barley attempted crosses with genotypes different from the mother line and this way it was possible to select modified mutants. The range of modification in the expression of mutation increased with the increasing genetic differences between the mother line of the mutant and the cross parent used.

**Nature and Magnitude of Induced Polygenic Variation**

The pioneer work on the induced micro-mutations was done
by Gregory (1955) in peanuts, who concludes that the value of irradiation in the field of plant breeding depends on the extent to which genetic variation is induced. The usefulness of such variation will depend upon the magnitude and distribution of the induced variation (Gregory, 1956). Gregory (1965, 1966) gave experimental evidence in support of Fisher's hypothesis and recorded that the frequency of observed changes increased exponentially with decreasing magnitude of change. He based his conclusions on the fact that the number of plus and minus mutations in the polygene system to be nearly equal, and that it is the magnitude of the phenotypic effect of a mutation which gives minus effects and not its unidirectional character. His observations are contrary to previous reports by workers like Sakai and Suzuki (1964) who asserted that in rice, the polygenes mutated unidirectionally towards minus side. However, Brock (1965) has also criticised such views.

**Effect on mean:** The mean values for quantitative characters in irradiated populations are in most instances lower than in untreated control populations (Scossiroli, 1970). Bhatia and Swaminathan (1962) reported that the means for tiller number and plant height were lower in the irradiated populations and they differed to greater extent in the second generation than in the third generation after treatment. The distribution of plants was skewed in a negative direction. Gaul and Aastveit (1966) and Gaul (1967) also got left-skewed curves for kernel yield in irradiated material. Borojevic (1965, 1966a, b) while reporting experiments from M₂ to M₇ generations observed that the mean values for various
quantitative characters decreased than the controls. Syed et al. (1968), Bahl et al. (1968) also obtained similar results for various characters. For a larger number of characters in the same population such effects have also been noted by Scossiroli (1966a, b) and Scossiroli et al. (1966). In experiments of Borojevic (1965) the means for kernel number in the $M_1$ and $M_2$ generations were lower but in the $M_3$ generation were higher than those of the controls. The rise in mean was probably due to selection against morphological variants in the irradiated material.

Shifts in the means following induction of mutations have been extensively discussed by Brock and Latter (1961) and Brock (1965). On the basis of experiments on subterranean clover and Arabidopsis thaliana, they put forth the theory that random mutations would be expected to increase the variance and shift the mean away from the direction of previous selection. Goud (1967 a) confirmed this hypothesis in wheat, and reported that in the variety NP 876 originally bold grained, the size of grains was reduced while in the small grained variety NP 870, the size of grains increased after irradiation as compared with the control. Goud (1967 b, 1967 c ) studying tiller number and grain yield noted that the shift was in positive direction in low tillering and in the negative direction in high tillering varieties and concluded that the polygenic mutations tend to follow a trend opposite to that of the previous selection history of the variety. Similar results were reported in wheat and Brassica by Swaminathan (1965b). The results obtained by Gaul and Aastveit (1966), however,
contradicted the hypothesis of Brock (1965) while studying two wheat varieties in respect of culm length. Khadr (1970) got still different results and observed that neither EMS nor irradiation caused any significant shift in the means of seed weight, width and length.

The differences between the means of treated and untreated populations decrease in subsequent generations (Scoiarioli, 1970). Borojevic and Borojevic (1968) reported that the mean values increased sharply in $M_2$ but were still below those of controls; in the $M_3$ a slight decrease was observed; in the $M_4$ no change; and in the $M_5$ the mean values were near to those of the control in all the seven varieties of wheat.

**Effect on variance:** The estimates of variability have been found to be larger in irradiated than in non-irradiated populations. In general, the hierarchical analysis have been employed (Scoiarioli, 1962 a, Borojevic 1965, Palenzona 1965, Scoiarioli et al., 1966, Gregory, 1968) for the estimation of components of variation. The estimation of induced genetic variation have generally been based on the estimation of genetic variances and broad sense heritabilities determined in early generation (Rawlings et al., 1958 in Soybeans; Gregory 1955, 1961 in Peanuts, Goud 1967c in wheat). Frey and his students at Iowa have used standard unit heritabilities (Frey, 1965). The genetic nature of induced variation have also been studied by using diallel analysis of mutants (Lawrence 1965, Gregory 1968) and by an estimation of covariances among relatives in generations directly following radiation (Gregory, 1968). Aastveit and Gaul
(1967) extended Mather's technique in the irradiated populations and stressed that by growing several generations simultaneously, the components of variance, $D$ and $H$ can be estimated. He, however, favoured parent-progeny correlation method as generally the material is studied in different years. Since from plant-breeding point of view, only additive genetic variance is important in self-pollinated crops, to achieve selection responses, refinement in existing techniques for partitioning of genetic variance into its components, is still needed.

A number of experiments on the induced mutations in diploid, tetraploid and hexaploid wheats have been undertaken at the Institute of Genetics, Pavia University, Italy and the results of such studies conducted by Scossiroli et al. (1960, 1961); Scossiroli (1962 b, 1965, 1966); Scossiroli and Pallelgrini-Scossiroli (1962, 1965); and Palenzona (1965, 1964) as reviewed by Scossiroli (1965) indicated that there was consistent reduction in the mean differences between the treated and untreated populations in the subsequent generations; the mean of irradiated one being smaller. The genetic variability for most of the traits considered was found to be larger in the irradiated populations as compared to the control ones. There were genotype-environment interactions when the same generation was grown in autumn or in spring. It has also been found that the larger increase of genetic variability is detectable in the latest generation — $N_0$ studied after treatment. The amount of increase of genetic variability estimated was larger in the tetraploid species ($T. durum$) than in the hexaploid.
species (T. aestivum) for some character, while it was the opposite for other.

In hexaploid bread wheat, Bhatia and Swaminathan (1962) found that the phenotypic variability for tiller number and plant height was greater in X and β-ray irradiated populations than the untreated control. Increased genetic variability for culm length, length of last internode, length of spike rachis, number of spikelets and number of grains, was found by Bagnara (1965) after the seed irradiation of Cappelli variety of durum wheat. Borojevic (1965) irradiated the seeds of variety 'Mara' (T. vulgare aestivum) and showed from the analysis of variance of the M₂ and M₃ generations, that irradiation increased variability for kernel number. The between line variability increased while within line variability decreased in the M₄ generation. The heritability estimates showed that the increase of variability was due to an increase in its genetic component beginning with the M₂ and M₃ generations. Scossiroli (1966 a) reported that increase in genetic variation was higher for some traits in the tetraploid and for other in the hexaploid species and suggested that artificial selection may make use of the induced variability. Considerable variation for protein content was induced in variety NP 824 as reported by Banerjee and Swaminathan (1966). Increase in variance was observed for culm length by Gaul and Aastveit (1966). Gaul (1966 a) observed that most of the variability was negative but occasional lines outyielded the controls and in progenies produced by M₂, genetic variance was greater than in the selected controls. Borojevic (1966 a) in irradiation experiments on bread wheat, reported
results from M<sub>2</sub>-M<sub>7</sub> generations and observed increased variability for plant height and number of grains. From 15 per cent increase of grain number over control in line 341, she concluded that the induced variability was brought about by an increase in its genetic component. Marked increases in genetic variability for various characters have also been reported by many workers like Bazzini et al. (1967), Goud (1967 c), Bahl et al. (1968), Mihaljev (1968), Trujillo-Figuera (1968), Popovic et al. (1968) and Khadr (1970).

From practical point of view, the mutation breeding seems to be an attractive method since it can produce less disruptive fresh variability into well adapted varieties. However, mean values for characters not subjected to selection also move away from the direction of previous selection. Hence, selection must be applied simultaneously for all economic characters if they are to be maintained at the desired levels (Rana, 1965).

**Induced Mutations in Different Genetic Backgrounds**

The differences in the genetic background can change radiosensitivity which can influence the rate and spectrum of mutations, as has been shown by many workers - Gustafsson (1944, 1947 and 1965), Gustafsson and Tedin (1954), Nilan (1956), Smith (1961), Konzak et al. (1961), Sparrow et al. (1965), Popovic et al. (1966 a,b), Mackey (1961), Shkvarnikov et al. (1965) and Jenken (1965). As different genotypes have different radiosensitivity, the choice of parent material (Mackey, 1960 a,b) is certainly to have decisive part in mutation breeding. A variety otherwise good but lacking only in some traits can be a
good material for mutation induction, as against an inferior
variety which might be a waste of resources because the genotype
may still remain unfit and unable to compete with the otherwise
promising varieties (Scarascia-Mugnozza, 1969). The specificity
of the genotype might be more important than the specificity
of different mutagens used (Enken, 1967). The role of different
genotypes, in mutational events will become more relevant when
the action of various mutagens on different genetic backgrounds
and on different loci of value becomes more clear.

The origin and the previous selection history of a variety
has also been known to influence the recovery of mutations. The
varieties of hybrid origin as compared to established cultivars
have shown a wide spectrum and higher rate of mutations (Zoz and
that the varieties, NP 876, NP 870 and NP 863 had characteristic
response to irradiation with regard to tillering. The low tillering
variety NP 876 showed an incidence of polygenic mutations in a
positive direction, whereas the medium tillering variety NP 870
showed no change in mean but the high tillering variety NP 863
showed a negative shift in the mean. But the results of Gaul
and Aastvæit (1966) contradict this hypothesis and they showed
that the random mutations result in a change of the mean in a
direction which is correlated with vitality reduction. Borojevic
and Borojevic (1968) also could not detect any differences in the
responses of different genotypes to irradiation treatments.
However, several workers have demonstrated that it is difficult
to induce improvement in the direction in which the parental material has been bred (Konzak, 1956; Mackey, 1949; Brock, 1965 and Favret, 1965).

In crops like wheat, where different ploidy levels exist, some investigations have been done on such levels. Most of these studies have been on macro-mutations. Irrespective to the nature of ploidy, the polyploid species in most genera are more resistant to radiations than the corresponding diploids (Swaminathan, 1965 c; Donini et al. 1964). Phenotypic expression of the induced mutations is affected in the polyploid by presence of duplicate loci exerting buffering effect. The extent to this buffering for a given trait varies even at an intra-specific level (Swaminathan, 1965 c). Borojevic (1964) got different frequency of mutations between varieties of T. aestivum vulgare. The closely related varieties are known to show similarity in frequency and spectra (Enken, 1966 a) but the results of Puhalskij (1965), however, are different who recorded greater similarity in the radiosensitivity among certain varieties belonging to the species of different ploidy in Triticum genus than among varieties of the same species. For quantitative characters, the studies of Gonzalez and Frey (1968) in oats and Grossioli (1965) in wheat showed that the differences in the ploidy level were not so important as the genotype at the same level of ploidy. Gregory (1960) and Emery et al. (1965) indicated that the characters showing greater variability in the background genotype are more easily improved and they yield better mutational improvement.
Most of the experiments, on induced polygenic variation, in the past, have been on pure-homozygous backgrounds at same or different ploidy levels, but more recently the importance of radiation in increasing recombination rates and the possibility of adding induced variability to that inherent in a cross, have been realized and the heterozygous genotypic backgrounds in different crop plants have been exposed to mutagens. The importance of exposing hybrid backgrounds to mutagens was first suggested by Gregory (1956, 1961). Gregory (1956) postulated that the variation induced by irradiation might be cumulative with that of hybridization and this way emphasized the possibility of hybridization and the induced mutations as a method of increasing variability. Gregory (1961) found in peanuts that in terms of genetic standard deviations there was more variation generated in both irradiated parents (1.28) and the irradiated hybrids (1.48), than in the unirradiated hybrids (1.00). Subsequently Krull and Frey (1961), Khadr and Frey (1965) in oats, Weber and Fehr (1967) in soybeans, Jalili and Yamaguchi (1965) and Saini and Sharma (1970) in rice, Kepler and Siegert (1965) in barley, have studied the effect of radiation on hybrid and homozygous genetic backgrounds. The experimental evidence on the irradiation of hybrids shows that if the independent variability from irradiation of parental types and that from only hybridization are added, the variability got from the irradiated hybrid was only 71 to 77 per cent (Gregory, 1961; Khadr and Frey, 1965 and Khadr, 1970).
On the radiation induced variability in the hybrid and pure genetic backgrounds only limited studies have been conducted in wheat. The only report available in this direction is by Khadr (1970). He studied seed weight and its components (length and breadth of seed) in hexaploid wheat following irradiation, EMS and hybridization. He observed that in the hybrid genetic background ($F_2$ of 'Giza 150' and 'Sonora 64'), the expression of irradiation-induced variability was somewhat depressed. The variations resulting from EMS and hybridization were to a great extent independent and cumulative (mean ratio of actual and predicted variances being 91\%) and in contrast irradiation-induced variation (mean ratio of variances only 71\%), was not cumulative with that of hybridization.

Further studies in this direction are needed to have more clear concept of irradiation effects on hybrid and homozygous genetic backgrounds.

Response to Selection.

Gaul (1967) got higher mean kernel yield after three selection generations than the control. Further, Gaul and Ulonska (1967) reported that in barley, late selections seem to be more efficient than early flowering.

The appropriate generation to start with selection after irradiation has been under debate. Mackey (1961) mentioned that selection in $M_2$ is preferred for very easily detectable mutations and selection in $M_3$ may be better in other cases. Priadoencu et al.
(1962) stated that except where the first two generations show a marked variability, selection should be delayed until the third generation in wheat. However, Gaul (1964) could not draw a clearcut line regarding the generation of selection. Scossiroli et al. (1966) irradiated durum and aestivum wheats and concluded that the best way to obtain an improvement in a trait without loss of fitness is by induction of minor changes and the use of their additive effects, leaving time for natural or artificial selection to build up balanced genotypic conditions. Owing to the deleterious effects of radiation breeding work should only be started on advanced generations after treatment. This behaviour is also suggested by the behaviour of the induced genetic variability, as a consequence of the delayed appearance of phenotypic differences due to segregation and recombination of induced micro-mutations. For optimal use of the induced variability, they emphasize that it is necessary to know the best sampling procedure among the progeny spikes of any plant. Yoshida (1962, 1965) and Yoshida et al. (1969) have extensively discussed theoretical basis for choosing generations and the selection procedure e.g. 'one-plant-one grain, two-grain or three-grain methods'. The results of extensive studies carried out by Scossiroli (1968a, b) on X-irradiated durum and bread wheats, in which he compared the selection experiments started in M$_2$ or M$_3$ for plant height, culm number, number of spikelets and seeds in the main spike, indicated that selection delayed to M$_3$ is more efficient because of a wider array of genotypes as a
consequence of repeated recombination. The results of Palenmona (1966) also showed that selection started in the \( R_5 \) generation was more effective than that started in the \( R_2 \) for both 20 and 10 per cent selection pressures. Scossiroli (1966c) got greater response in the \( R_5 \)-generation of durum, Cappelli, exposed to X-rays than in untreated plants. The greatest response was for plant height which was correlated with the response for number of spikelets in the main spike, number of grains and number of headed stems but this correlated response was not observed in unirradiated plants. Selection progress of the four characters differed according to the variability prior to selection.

In respect of micro-mutations, the work has shown that there is immense scope for increasing the number of tillers, number of grains per ear, the weight of grain and protein content as stated by Swaminathan (1965d). Borjevic (1966c) studied the irradiated \( T. vulgar e \) var. Lutescens "Mara" for seven generations and reported that mean number of grains was lower in the control than in \( M_5 \) produced from the best spikes of the \( M_2 \) generation. In the \( M_7 \), 6 lines and 3 lines treated with thermal neutrons and X-rays, respectively produced more grains than the control. Line 341, which exceeded the control for mean grain number in the \( M_4 \) and \( M_5 \) was found to carry about 15 per cent more grains per spike. Banerjee and Swaminathan (1968) obtained, in the irradiated variety NP 824, after three years of selection, two 'high protein' lines and thus indicated that scope existed for altering the
protein content in grain without any coincident change in yield or morphological characters. Gaul (1966a) also got considerable number of lines outyielding the control through positive selection. Selections carried out by Goud (1967a) for spike number and 100-grain weight in irradiated populations were effective. Scossirolli (1968a) made family selections (20% pressure) and mass selection (20 and 10% pressure) from $R_2$ and $R_3$ generations in the irradiated Cappelli for plant height, number of stems and number of spikelets in the main spike, with the aim of increasing the average of the population. He did not find any response in the control populations but definite responses were obtained from the irradiated plants; mass selection at the 10 per cent pressure was the most efficient. Bahl et al. (1968) irradiated two wheat varieties, and found that in the study of $M_2$ generation, there was no particular advantage in selecting bulks of $M_1$ from the main vs. side tillers. Similarly, for $M_3$ generation bulks originating from such of the $M_2$ plants whose yields were higher than the mean of the control did not show any advantage over the bulks from all the plants irrespective of their individual yield levels. The expected genetic advance on the basis of heritability in the $M_3$ generation could be realized in the experiments of Borojevic (1965), for kernels per spike in the thermal neutrons irradiated populations. Selections by Borojevic (1965, 1966a) and Borojevic and Borojevic (1969) showed that for yield, selection in subsequent generations to $M_2$ showed responses for a few generations, but the yields of the selected lines stabilized approximately at the control value by about $M_5$. 
... generation and no further response was achieved through M. Estimates of residual genetic variability in these lines indicated that part of the induced variation remained in the population but that it was not responding to selection. The results, in respect of selection responses in the treated populations, obtained by several workers seem encouraging e.g. Gregory (1955) and Loesch (1964) in peanuts; Koo (1962), Gonzales and Frey (1965), Khadr and Frey (1965), Joshi and Frey (1967), Joshi and Frey (1969) in oats; Pernai al. (1961) in soybeans; Gaul and Mittelstenheid (1961), Gaul (1963, 1966b), Aastveit (1965) in barley; and Bhatia (1963), Trujillo-Figueroa (1963), Mugurov (1966), Wagner (1969), Robben and Trujillo-Figueroa (1969) in wheat.

Brock (1967 b) indicated that effective selection responses should be possible in either direction, provided that absolute limits had not been reached in the parental genome. For an unselected character, the mean could depend on its previous selection, on its response to mutation and its correlation (due to linkage or pleiotropy of induced mutation) with the character under selection, and, therefore, with the selection applied to this character. This had been demonstrated experimentally by Brock (1967 a) and in other words it can be stated that selection responses could be achieved without any major alternations of other characters, provided that selection pressure is maintained for all important characters.

Selection for one character in the induced quantitative variability are known to have some effect on the constellations of other characters, and this has been asserted by many workers.
Scarascia-Mugnozza (1966a) while selecting for straw-shortening, noticed additional changes in grain quality and maturity time in durum wheat. Borojevic (1967) studied awned mutant lines derived from a single M\textsubscript{3} plant, induced in awnless variety, which differed significantly from one another for plant height and tiller number. Goud (1968) applied selection in varieties NP 876 and NP 870, treated with gamma-rays and EMS. Selection for grain weight was exercised in NP 876 before treatment with the mutagens but selection for high tillering after treatment resulted in a reduction in grain weight. Kaizuma et al. (1967) performed selection for short culm up to R\textsubscript{0} generation and asserted that a simple correlation existed between culm length and yield in mutant lines. Bhatia and Swaminathan (1962) performed selection with the goal of increasing tiller number in the X and \gamma-ray irradiated wheat and observed that an increase by selection of tillers bearing ears is followed by an increase in yield. Brady and Prendergast (1968) reported that phenotypes with favourable characteristics, such as strong straw and improved baking quality obtained after selection were usually associated with a lower yield. Moreover, irradiation increased susceptibility to stem rust.