1. INTRODUCTION

Wheat (*Triticum aestivum* L.em. Thell), an important food grain crop in India, belongs to the family Poaceae of the tribe Triticeae and sub-tribe Triticinae. Wheat is represented by three ploidy levels i.e. diploid (*2n=2x=14*), tetraploid (*2n=4x=28*) and hexaploid (*2n=6x=42*). The commercial wheats include the common bread wheat (*Triticum aestivum*), macaroni wheat (*T. durum*) and emmer wheat (*T. dicoccum*). Wheat along with rice, corn and sorghum (including millets) constitute four most important food crops and in India, wheat is the second major food crop, next only to rice and its cultivation extends from about 9°N (Palani hills in Tamil Nadu, South India) to 35°N (Srinagar valley in Jammu and Kashmir in North India). Among the cultivated species of wheat, *T. aestivum* (common bread wheat) is the most important and covers about 80% of total wheat growing area in India and accounts for 30% of total food production.

In India, the total wheat production which was about 12 million tonnes per annum in early 1960’s increased to over 63.1 m. tonnes during the crop year 1994-95, produced under an area of approximately 23.3 m.ha of land (Anonymous, 1995). The increase in production, since the adoption of semidwarf varieties, has been attributed both to the genetic potential and yielding ability of new varieties and to the more intensive crop husbandry.

In recent years, there has been a stagnation in productivity in newly released varieties of wheat in comparison to the improvement made in earlier released varieties. This may be attributed to (i) lack of improvement in the genetic yield potential, and (ii) susceptibility to diseases. There are at least 12 important wheat diseases in India, among which the black (stem) rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks and Henn); brown (leaf) rust
(P. recondita Rob ex Desm. f. sp. tritici Eriks and Henn); and yellow (stripe) rust (P. striiformis Westend f. sp. tritici) are ranked the most destructive. The grain yield losses due to severe rust epidemic may reach up to 80-100% (Roelfs et al., 1992). Chemotherapeutic agents are reported to control rusts, however, these are beyond the means of wheat growers in India.

The utilization of alien genetic variation is a well accepted method for wheat improvement, particularly for development of disease resistant cultivars. However, in India, this technique has not been fully exploited systematically. Desirable characters including disease resistance from many of the 300 or more species within the Triticeae can be transferred to wheat by simple backcross, while in other cases embryo rescue or chromosome pairing control mutants could be employed. Subsequent selections, in backcross progeny, are made keeping in mind to retain desirable genes while reducing the number of deleterious characters from the donor parent. Markers can be used to verify and to follow the alien chromosome/chromosomal segment/gene/gene complex during backcrosses and selection.

Triticale (X Triticosecale Wittmack), is the product of a cross between wheat (Triticum sps.) and rye (Secale sps.). The production of triticales begins with the crossing of either tetraploid (Triticum durum L.) or hexaploid (T. aestivum Thell.) wheat X diploid rye (Secale cereale L.) and followed by doubling of the resulting haploid hybrid by treating with colchicine, thus creating a fertile amphidiploid. This procedure results in primary hexaploid (AABBRR) and octoploid (AABBRRDD) triticales, respectively. Intensive breeding work with triticale did not start, however, before the middle of this century. In the early 1950’s breeding began on the hexaploid level, combining tetraploid wheat with diploid rye, and it started almost simultaneously in Hungary, USSR, Spain and Canada, and later, in the mid sixties in Mexico. Since then, hexaploid triticale has been treated as a man made new cereal crop with great potential,
particularly in marginal growing areas and especially for third world 
agriculture. In a report of the National Research Council of the USA, triticale 
is described as a "Potentially important addition to the global armory of 
weapons for combating hunger as world population rises" (NRC, 1989). 
Intercrossing between primary triticales within their own ploidy levels was 
the generally accepted method of breeding from the 1930's until the mid 1950's. 
This method of crossing resulted in some improvements in plant type, however, 
the yield and stability of best triticales were still significantly below that of 
wheat. Hexaploid triticales have proved to be more promising as they possess 
a number of advantages of practical interest to the breeders e.g. increased 
protein content and quality, resistance to certain fungal diseases, and long 
spikes with more spikelets per spike and florets per spikelet. However, the 
use of triticales in the form of commercial varieties is hampered by poor seed 
setting, different degree of seed shrivelling, relatively tall plants and 
susceptibility to lodging, ear brittleness, poor threshability and late maturity. 
In the mid 1960's, Kiss and Pissarev had initiated crosses between hexaploid 
triticales and hexaploid wheat. The resulted secondary triticales from the above 
cross were shown to possess a variety of R/D chromosome substitutions 
ranging from that of pure hexaploid wheat (AABBDD) to pure hexaploid triticale 
(AABBRR), along with 126 intermediate types. This crossing procedure resulted 
in spectacular progress in the improvement of triticale. However, the 
improvement in secondary triticales are not always due to presence of R/D 
substitutions, since modification of rye chromosomes in triticale, due to 
reduction or loss of telomeric heterochromatin are found common in 
recombined and advanced triticale lines. Such modification seem to determine 
to a large extent the meiotic stability and agronomic characters in triticale. 
Identification of rye chromosomes in triticale is very much easier with the 
discovery of Giemsa C-banding technique, however, this technique cannot be 
applied for identification of modified rye chromosomes. The chromosome
composition in triticales having modified rye chromosomes, can easily be studied by crossing them with wheat ditelos.

After the discovery of artificial induction of mutations in plants, various kinds of physical and chemical mutagens have been and are being applied in induced mutagenesis. Both fundamental and applied aspects of mutagenesis have been studied and mutations have been used in various ways in plant improvement. Mutation induction research began to flourish in several countries when the main interest was concentrated in practical plant breeding and aimed at the development of improved crop varieties through the use of induced mutations by 1950. The mutation method in agricultural species has shown valuable results both with regard to the direct release of new mutant varieties and the use of induced mutants in recombination work. Induction of mutations is a proven supplement to conventional breeding to confer specific improvement in a variety without significantly altering its otherwise acceptable phenotypes.

Recent experience and induced success in plant breeding has clearly shown that the mastering of mutation breeding techniques may become crucial to further success in the breeding of cereal crops. There are two main reasons for this. One is that in cereals, the breeding intensity has been so great that for some ecological reasons it will be increasingly difficult to achieve further progress, drawn solely from germplasm already existing and readily available. Secondly, other agronomical characteristics, such as disease resistance, are also becoming increasingly difficult to locate naturally, and even if they are found, the problems of incorporating these traits into high-performance genotypes may present formidable difficulties. In addition to these, rapid and alarming erosion of genetic resources is also one of the main reason for the plant breeder to pay attention on induced mutations.
The importance of induced mutations in plant breeding programmes has generated considerable interest in India and elsewhere and, it is evident that so far more than 800 new varieties, of which 300 of them are cereals, have been released worldwide for commercial use (Gupta, 1995). Mutation breeding now has been recognized as an established method for plant improvement and the increasing number of mutant varieties proves that breeders have begun to recognize mutation induction as a practical tool and have started to exploit its potential. In order to induce and utilize useful mutations in plant breeding, a systematic study of induced mutations is necessary in a given crop variety. A knowledge of mutagen specificity and varietal response is a pre-requisite for effective utilization of mutation techniques. Mutagens differ in their mechanism and mode of action in the biological system. By applying mutagenesis together with an appropriate selection method, one can obtain genotypes with quantitative differences in disease resistance, which are very difficult to extract from alien/related material via cross breeding. Effective and efficient treatments are essential for economical use of mutagens as tools for the mutation of heritable changes both in qualitative and quantitative character of plants. The probability of isolating mutations of economic interest would be high in population with higher frequency and spectrum of mutations. The enhancement of mutation frequency and spectrum, in turn, depends on our having basic information on the mutagenic sensitivity of varied genotypes, effectiveness and efficiency of mutagens and the vigour of the diplontic and haplontic sieves operating in the plant. Investigations into the effects of ionizing radiations and chemical mutagens in inducing macro-mutations have received much attention owing to their utmost importance in plant breeding.

Mutation breeding in common bread wheat, in the past was aimed to improve protein content. The research work on induced mutagenesis in wheat
has received renewed interest in India due to the success achieved in this
crop in recent years including the development of varieties with short straw,
amber coloured grain and disease resistance both in durum and bread wheats.

As the synthesis of new triticale plant is a laborious procedure it is not
surprising that the number of different wheat X rye combinations available
among the present triticale material is limited and that the triticales have a
narrow genetic base, because they are derived from a limited number of primary
triticales. This narrow spectrum of natural variability has been the major
impediment to its improvement. Enlargement of genetic variability in triticales
is thus urgently needed to develop suitable plant types. Triticale lacks the
natural resources of genetic diversity which exists for other cereals in the
form of their wild, primitive, evolutionary related counterparts. Since, the
 genetic pool of hexaploid triticale is narrow, therefore, it is utmost important
to enrich the genetic background and to widen useful variability of this cereal
crop. Triticale, a relatively recent in its origin, it may also provides an ample
opportunity to induce mutations of novel types of desirable nature. In triticale,
there is no information on varieties realized by means of mutation techniques
although there is much research done concerning improvement of several
agronomic traits.

Therefore, in view of the above, the present study is undertaken with
the following objectives.

A. Incorporation of alien genes imparting resistance against wheat rusts:

i) Transfer of seven specific rust resistance genes (Sr26, Sr27, Sr31, Lr24,
Lr26, Lr28 and Yr9), derived from four hexaploid wheat stocks (Veery'S',
Darf/3Ag/Kite, W 3353, CS 2D/2M 3/8), to two Indian hexaploid wheat
cultivars (HD 2009, HD 2380), by simple backcrossing.
ii) Transfer of *Secale cereale* and *Agropyron elongatum* derived (in Chinese Spring wheat background) stem rust resistance genes (*Sr25, Sr31*), leaf rust resistance genes (*Lr19, Lr26*) and yellow rust resistance gene (*Yr9*), to two Indian wheat cultivars (HD 2009, HD 2380) by manipulating 5B system of wheat by using homozygous recessive *ph* mutant.

iii) Evaluation of newly constituted lines for rust reactions and agronomic characters.

iv) Confirmation of transfer of rust resistance gene(s) through a study of morphological markers, estimation of nuclear DNA, various biochemical parameters and rust inheritance.

v) To make rust resistant stocks available in good wheat genetic background.

B. A study on improvement of hexaploid triticales and hexaploid wheats through reciprocal crosses.

C. Cytogenetical investigations in triticale:

i) To identify the rye chromosome constitution in hexaploid triticales by Giemsa C-banding technique.

ii) Confirmation of Giemsa C-banding results by studying the chromosome associations in *F₁* hybrids, derived from crosses between triticale and wheat di-telos for D-genome chromosomes.

iii) To find out the role of specific R/D substitutions and/or modified rye chromosomes on seed characters like kernel shrivelling and seed setting.

iv) To estimate the nuclear DNA and heterochromatin contents and to analyse the relationship between them with meiotic instability.

D. Induced mutations in wheat (2x, 4x, 6x) and triticale (6x) :

i) To study the effect of individual and combination treatments of gamma rays and EMS on various biological and cytological parameters in *M₁* generation.
ii) Isolation of chlorophyll, morphological and agronomically desirable mutants including rust resistant mutants in $M_2$ generation, and a study of their breeding behaviour and genetics in $M_2$ and $M_3$ generations.

iii) To carry out a study involving the induced variability for different quantitative characters in wheat ($4x$, $6x$) and triticale, both in $M_2$ and $M_3$ generations.