Chapter 1
Introduction and aim of the investigation
1. INTRODUCTION AND AIM OF THE INVESTIGATION

1.1 Introduction

Plant breeding is an act of developing genetic variability, selection of useful genotypes followed by evaluation of agronomic performance of the selected genotypes and their multiplication. For a long time naturally occurring genetic variability was used for the improvement of crops either by selection or hybridization. Population of crop species with little genetic variability can be improved to a limited extent by these conventional breeding methods. The pioneering experiments of Muller (1927) and Stadler (1930) generated a new era of plant breeding by setting the tone for employing induced mutations in crop improvement. Mutation breeding is considered to be an additional technique to the conventional method and a number of mutagens are now being used to produce variability with the aim of inducing mutations in crop species. Direct use of mutants offer the best possible advantage of utilizing mutations in plant breeding and saves nearly half of the time required to evolve a new variety through cross breeding methods (Gaul, 1961a). The achievements in mutation breeding provide a conclusive evidence that induced mutations can increase grain yield and improve plant characters like disease resistance and protein quantity and quality (Gustafsson, 1947; Gaul, 1961; Sigurbjornsson and Micke, 1969, 1974; Micke, 1995; Agrawal, 2005; Shewry, 2007).

Mutation breeding increases the genetic variability of the quantitative characters and induces point mutation that confers a desired character to a variety. No selection or hybridization can bring a significant genetic advance in a population in which too little genetic variability is present. Apart from different ways of creating genetic variability, induced mutations can greatly enhance the mutation frequency
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through the use of various mutagenic agents. While different ionizing radiations are
still popular agents of induction of mutations, a number of chemicals have also been
found to be equally or more effective. Amongst the wide variety of chemical
mutagens employed in mutation breeding programmes, ethyl methane sulphonate
(EMS) has been found to be most effective (Ehrenberg et al., 1961; Swaminathan et
al., 1962; Gaul, 1964; Wang et al., 1993; Montalvan et al., 1998; Jabeen, 2002) and
was extensively used in rice breeding (Swaminathan et al., 1971; Tsukada et al.,
1975; Rao, 1977; Borah and Goswami, 1995). Diethyl sulphate is also one of the
chemicals belonging to the same category of mutagens (Heslot, 1977) as EMS. Since
EMS is widely applied in inducing mutations in cereal crops, a scope for application
of dES in rice breeding programmes cannot be ruled out. Therefore, in the present
study Diethyl sulphate (dES) was selected as a potent mutagen in inducing both
micro- and macro- mutations in rice.

Rice is the most important food crop of about half of the world’s population. It
possesses very low percentage of crude fiber, tannin and easily digestible proteins.
Rice is mainly produced by Eastern countries. India is one of the largest rice
producers of the world, which contribute about 22 percent of total rice production
(Kumar and Rosegrant, 1996). Out of the total 128 million hectares of cultivated land,
in India rice is cultivated in nearly about 44 million hectares of land which contribute
around 14, 83, 65,000 tons of rice grains annually (World rice statistics, IRRI,
Philippines, 2009).
During the last ten years there are some ups and down in the rice production in India (World rice statistics, IRRI, Philippines, 2009). In the year 2001 there was maximum rice production (140.02 million tons) followed by minimum rice production (107.74 million tons) in 2002. As per world’s rice statistics, India’s contribution in rice production in 2008 is 22.41 percent. But the average rice production per hectare is 3.37 ton which is lower than world’s average i.e. 4.25 ton per hectare. Though the adoption of high yielding varieties have contributed in increasing rice production, in India the production per unit hectare is not satisfactory as compared to the rice production in some other countries such as in USA, Australia, Spain, Greece and Japan.
Table No.1: Land under rice cultivation and its production in India 
(1995 to 2008)

<table>
<thead>
<tr>
<th>Year</th>
<th>Land under rice cultivation (In hectares)</th>
<th>Production (In tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>42,300,000</td>
<td>115,482,000</td>
</tr>
<tr>
<td>1996</td>
<td>43,283,000</td>
<td>122,607,000</td>
</tr>
<tr>
<td>1997</td>
<td>43,420,000</td>
<td>123,822,000</td>
</tr>
<tr>
<td>1998</td>
<td>44,600,000</td>
<td>129,133,000</td>
</tr>
<tr>
<td>1999</td>
<td>45,160,000</td>
<td>134,533,000</td>
</tr>
<tr>
<td>2000</td>
<td>44,361,000</td>
<td>127,483,000</td>
</tr>
<tr>
<td>2001</td>
<td>44,600,000</td>
<td>140,024,000</td>
</tr>
<tr>
<td>2002</td>
<td>40,400,000</td>
<td>107,741,000</td>
</tr>
<tr>
<td>2003</td>
<td>42,400,000</td>
<td>132,808,000</td>
</tr>
<tr>
<td>2004</td>
<td>42,300,000</td>
<td>124,707,000</td>
</tr>
<tr>
<td>2005</td>
<td>43,400,000</td>
<td>137,699,000</td>
</tr>
<tr>
<td>2006</td>
<td>44,000,000</td>
<td>140,039,000</td>
</tr>
<tr>
<td>2007</td>
<td>43,770,000</td>
<td>145,050,000</td>
</tr>
<tr>
<td>2008</td>
<td>44,000,000</td>
<td>148,365,000</td>
</tr>
</tbody>
</table>

The total land under rice cultivation and its production in India is shown in the Table No. 1. In India during 1998 the total rice production was 129.13 million tons in a gross land of 44.6 million hectares. After ten years it has been increased up to 148.36 million tons which is an increase of 19.23 million tons (World Rice Statistics, IRRI, Philippines, 2009)

Although a large number of high yielding varieties were developed through cross breeding in India, cultivation of such varieties for a considerable period of time...
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In farmers field generate homozygosity leading to inbreeding depression. As a result gradual decrease in productivity and other improved characters of such varieties discourage the farmers to adopt them continuously. This problem of segregation of characters can be overcome by practicing mutation breeding, as it induces desired characters, leaving no chances of segregation of characters.

In comparison to other plant proteins, rice protein has the highest nutritional value in terms of available aminogram, digestibility, biological value and protein efficiency ratio. These plant proteins can be improved by plant breeding methods, since gene mutation can significantly increase the level of nutritionally limiting amino acids of the seed protein which was shown first in maize (Mertz et al., 1964; Nelson et al., 1965). A number of attempts have been made by different workers to improve the quality and quantity of protein contents in different crops through induced mutations (Kikushi, 1994; Sadimanatara et al., 1997). Verghese and Swaminathan (1966), Dumanovic et al. (1970) worked to improve the protein quantity and quality in wheat. Gottschalk and Muller (1970) in pea and Walther et al. (1975) in barely undertook similar work. In comparison to other crops, the mutation breeding technique for the improvement of rice protein has not been fully explored. However some positive results as reported by Siddiq et al. (1970); Tanaka (1975); Borah and Goswami (1981); Kaul et al. (1989); Kumamoru et al. (1997) and Pimentei et al. (2000); Sun et al. (2004); Shewry (2007) have shown that protein content in rice is amenable to mutagen inducible changes.

Initially the low recovery of desired mutants in mutation breeding techniques limited the interest of workers. The persistent efforts made by plant breeders in mutation research for about last forty years added valuable informations on various aspects of mutation breeding. In the year 1969 about 77 cultivars were produced
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through induced mutations (Mieke, 1995). During the period 1970 to 1999 more than 2000 mutant varieties belong to different crop species were developed and released for cultivation in different countries of the world (Mieke, 1999; Maluszynski et al., 2000). A number of beneficial mutations have been induced in barely (Gustafsson, 1953), peanuts (Gregory, 1956a), rice (Rutger, 1983; Chakraborty, 1995; Sahadev Singh et al., 1995; Kumar and Mani, 1997; Maluszynski et al., 2000; Myint et al., 2005; Yamaguchi et al., 2005). A number of rice varieties have been released through mutation breeding such as ‘Reimei’, ‘Miyama’, ‘Mutsuhonami’ in Japan, ‘Nucleoryza’ in Hungary, ‘Jagannath’, IIT-48, IIT-60, P-500-28, ADT-15, TR-17, ‘Padmini’ in India with improved agronomic and yielding characters. Mutation research in rice by using radiation was carried out by Ichijima (1934), Mashima and Kawai (1958) in Japan; Beachel (1957) in USA and Ramaiah and Parthasarathi (1938); Borah and Rao (1958); Ram and Zaman (1972a, b); Agrawal et al. (2005); Elayaraja et al. (2005); Maity et al. (2005) in India. But during this period due emphasis was not given on various chemical mutagens. As far as the use of chemical mutagens in rice is concerned, the research work of Sukanya Bai et al. (1957) on the effect of acenapthene on rice was among the earliest. Induction of beneficial mutation using ethyl methane sulphonate (EMS) has appeared in literature (Mikaelsen et al., 1971; Swaminathan et al., 1971; Reddy and Reddy, 1973; Tsukada et al., 1975; Kaul, 1978; Borah and Goswami, 1981; Maekawa et al., 1989; Santoshilal et al., 1997; Jabeen and Mirza, 2002; Agrawal et al., 2005; Luan et al., 2007). On the other hand the application of diethyl sulphate (dES) as an effective beneficial mutagen is very limited. So it is pertinent to study the possible application of diethyl sulphate as an effective beneficial mutagen in inducing mutations in the positive direction.
1.2 Aim of the investigation

Considerations as detailed above lead to undertake this investigation in rice by treating presoaked seeds of the cultivar 'Kolagoria' with ten different concentrations of diethyl sulphate (dES). This thesis presents the results on the various facets of the induced mutations in rice and their usefulness as evidenced by the effect of diethyl sulphate (dES) on the genetic apparatus of rice plant.