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EFFECT OF GAMMA RADIATION OF MACRO MUTATIONS, EFFECTIVENESS AND EFFICIENCY UNDER M_2 GENERATION IN PEA (*Pisum sativum* L.)

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ABSTRACT

The present investigation was undertaken to study the spectrum of macro mutants, effectiveness and efficiency of different doses of gamma rays in pea variety (Arkel). The seeds were treated with gamma rays viz., 00kR (dry control), 05kR, 10kR, 15kR, 20kR, 25kR, 30kR, 35kR, 40kR (dry seeds) and presoaked seeds of the same was exposed to 00kR (wet control), 05kR, 10kR, 15kR, 20kR (kilo Roentgen) biological damage was calculated in M_1 and M_2 generation based on lethality (L) and pollen sterility. The irradiated seeds were sown in the M_1 field their respective controls and harvested in bulk to raise the M_2 generation in Randomized Block Design (RBD) with three replications. The spectrum of macro mutants i.e., plant stature (tall, dwarf, small dwarf), maturity (early, late), pod shape (bold, long, short), seed colour (brown, light white, light green) and seed shape (small, bold, wrinkled) were observed in M_2 generation. The usefulness of any mutagen in plant breeding depends not only on its effectiveness but also upon if efficiency. Mutagenic effectiveness is a measure of the frequency of mutations induced by unit mutagen dose, whereas mutagenic efficiency is measure of proportion of mutations in relation of undesirable changes like lethality and sterility are used for gamma rays. A result of the indicated positive relationship in M_2 generation with macro mutation, effectiveness and efficiency was found to be highest at lowest doses.

KEY WORDS: G*amma radiation, pea, macro mutation, effectiveness, efficiency.*

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the important leguminous crops on India. The crop however, has sufficient genetic variability; it suffers from severe susceptibility to biotic stress. Plant type, which is directly related to yield potential and disease resistance has not been fully exploited in case of pea (Moot & McNeil, 1995). A crop plant can be improved in productivity resistance to biotic and abiotic stress when the genetic variability for the specific traits is available in the considered population or species. Induced mutagenesis has been successfully used to generate variability. Portioning for isolating mutants with desirable characters of economic importance such as superior dwarf plant types, synchronous maturity, high grain yield, pad shape, larger seed size and seed colour etc. (Kharkwal *et al*. 2004). As genetic

variability is essential for any crop improvement programme, the creation and management of genetic variability becomes central base to crop breeding. Experimentally induced mutations provide an important source of variability. However gamma rays act on genetic material by ionization leading to more of chromosomal rather than point mutations and gamma rays are successfully used in plant breeding programme because of its simple application, good penetration reproducibility and high mutation frequency and less disposal problems. The practical utility of induced mutations for the improvement of quantitatively inherited characters in pea is well recognized.

They have been extensively used to find out sensitivity of crop plants to mutagens and to elucidate effectiveness and efficiency of mutagen (Gustafsson, 1940). Effectiveness refers to the ability of mutagen to induce desirable mutations (Awnirdra *et al.* 2001) and therefore, it is a measure of mutation rate relative to doses. Efficiency, on the other hand, gives an idea of the proportion of mutations in relation to other associated undesirable biological effects such as grass chromosomal aberrations; lethality and sterility induce by the mutagen.

The higher efficiency of a mutagen indicates relatively less biological damage (plant survival, pollen sterility etc.) in relation to the mutagens induced (Shah *et al*. 2008; Kharkwal, 1998). Selection of effective and efficiency mutagen is very essential to recover high frequency of the desirable mutations in a mutation breeding studies. The present investigation was undertaken to study the frequency and spectrum of macro mutations along with the mutagenic effectiveness and efficiency of different doses of gamma rays in M_1 and M_2 generation.

MATERIALS AND METHODS

The experimental seeds of pea variety Arkel was treated with physical mutagen *viz*., gamma rays, 00kR (dry control) 05kR, 10kR, 15kR, 20kR, 25kR, 30kR, 35kR, 40kR (dry seeds) and pre-soaked seeds of the same was exposed to 00kR (wet control), 05kR, 10kR, 15kR, 20kR (Kilo Roentgen) in different of doses from ^{60}CO Source at National Botanical of Research Institute, Lucknow (U.P.). The treated seeds along with control (untreated seeds were used and sown immediately in the field with a spacing of 40x10 cm in a without replication to raise the M_1 generation. Surviving plants with sufficient seeds in different treatments including control were harvested and threshed individually and their seed yield was recorded. M_2 generation was raised on M_1 plant basis following plant to progeny method in a randomized black design with three replication during the *rabi* season of November in the year 2012-13 at Field Experimental Centre, Department of genetics and plant breeding, SHIATS Allahabad (U.P.). All the recommended agronomic practices were carried out during the growth period of the crop M_2 generation was screened for spectrum micro mutation observed before maturity time whereas viable mutation and morphological mutations were observed throughout the life period of the plants. Different kinds of morphological mutation affecting different features of the plant stature (Tall, dwarf and semi dwarf), Maturity (Early and late), pod shape (Blood, long & Short) seed colour (Brown, light white and light green) and seed shape (small, bold and wrinkled) were grouped according to the modified classification proposed by (Blixt, 1972). Mutagenic effectiveness and efficiency was calculated on the basis of formulae suggested by (Konzak *et al*. 1965).

$$\text{Mutagenic Effectiveness} = \frac{\text{Mutation state on the basis of } M_1 \text{ plant progenies (Mp)}}{\text{Dose in Kilo roentgens (kR)}}$$

$$\text{Mutagenic efficiency} = \frac{\text{Mutation rate on the basis of } M_1 \text{ plant progenies (Mp) or M2 population (Ms)}}{\text{\% Lethality (Plant survival) or \% pollen sterility}}$$

Mutagenic Effectiveness and Efficiency: The effectiveness and efficiency of Mutagenic treatment in mutation breeding of crop plant have been discussed by several workers (Nilan *et al*. 1965; Kawai, 1975; Kawai, 1986). In this study of the effectiveness and efficiency of mutagenic treatments the use one and the some genotype throughout experiments in most important. The term effectiveness however is often used also for biological effects such as seedling growth reduction and chromosome injuries. The effectiveness of treatment with a mutagen is expressed as the magnitude of the effects produced after a particular dose of the mutagen or as the relative doses that produce equivalent effects under different treatments. (Nilan *et al*. 1965) defined the effectiveness of radiations by mutation rate in relation to dose and the efficiency of radiation by the mutation rate in relation to biological effects.

RESULTS AND DISCUSSIONS

Spectrum of Macro-mutations is generally used to evaluate the genetic effects of various gamma treatments. Different types of morphological macro-mutations *viz*., Plant stature (tall, dwarf, Semi dwarf), Maturity (early, late), Pod shape (bold, long, short), Seed colour (brown, light white, light green), Seed shape (small, bold, wrinkled) observed in mutagenic treated populations of the Arkel variety (table 1). Among different types of morphological mutations, the most frequent types were early maturity followed by tall plants and long pod shape indicating high mutability of the gene for the character. The high frequency of mean mutations in different treatment was found under 40kR dry dose (7.318%) followed by 35kR dry dose (6.371%), 30kR dry dose (5.755%) and 15kR dry dose (5.248%) white the minimum (0.360%) was under dose 10kR presoaked treatment. Various types of morphological mutant were induced by different mutagenic treatment with respect to plant stature, maturity, pod shape, seed colour and seed characteristics in M_2 generation. Theoretically, each gene which has any agronomic importance can mute. Hence, a wide spectrum of viable mutations can be expected in mutation experiments. As mention earlier, the probable cause of these macro mutations may be chromosomal aberrations, small deficiencies or duplication and most probably point or gene mutation (Singh *et al*. 1982; Kharkwal *et al*. 2004).

Dose dependent increase in frequency of macro mutations was observed in the variety indicating positive relationship between dose of mutagenic treatment and frequency of morphological mutation. Dose dependent increase in frequency of macro mutations was observed in the variety indicating positive relationship between dose of mutagenic treatment and frequency of morphological mutations. Similar differential induction of macro mutations in different doses of mutagen as well as in the variety have been reported earlier by many workers (Blixt *et al*.1964; Nerker, 1976; Kharkwal, 2000; Srivastava *et al*. 2008; Singh, 2007; Mishra, 2004; Bolbhat *et al*. 2012).

In M_2 generation, mutagenic effectiveness and efficiency of the mutagen exhibited inverse relationship with increasing dose. Mutagenic effectiveness is a measure of the frequency of mutation induced by unit mutagen does where as mutagenic efficiency is the measure of proportion of mutations is relation to undesirable changes like pollen sterility, meiotic aberrations and plant survival. The efficiency of mutagenic agents not only depends on the biological system but also on physiological damage, chromosomal aberrations and sterility induced due to mutation. The efficiency of any mutagen would therefore depend on its effectiveness and efficiency. The lower efficiency of certain mutagens may be attributed to the use of low doses corresponding to their mutation induction (Sarkar, 1985; Kharkwal, 2000).

Table 1. Spectrum of macro mutations in M_2 generation of pea (cv. Arkel) under different mutagenic treatments in rabi (2012-13).

Mutation Types / Treatments	Plant stature			Maturity		Pod shape			Seed colour			Seed shape			Total frequency (%)
	Tall	Dwarf	Semi Dwarf	Early	Late	Bold	Long	Short	Brown	Light White	Light green	Small	Bold	Wrinkled	
Control (dry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05kR „	-	-	-	0.678	-	0.339	0.339	0.339	-	-	-	-	-	-	1.695
10 kR „	0.355	-	0.709	0.355	0.355	0.355	0.355	-	-	0.355	-	-	-	0.355	3.194
15 kR „	0.984	-	-	0.328	0.984	0.328	0.656	-	-	0.984	0.328	-	0.656	-	5.248
20 kR „	1.455	-	-	0.364	0.727	-	1.091	-	-	-	-	-	1.091	-	4.728
25 kR „	-	0.769	0.385	0.385	0.385	-	0.385	-	-	-	-	0.769	-	-	3.078
30 kR „	-	1.219	-	0.407	0.813	1.219	0.407	0.813	0.407	-	-	-	0.407	-	5.692
35 kR „	0.980	0.490	-	1.471	-	-	0.490	0.490	-	-	0.980	0.490	-	0.980	6.371
40 kR „	0.488	-	-	1.951	-	0.976	0.488	-	-	0.976	0.488	1.463	-	0.488	7.318
Wet control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05kR(Pre-soaked)	0.337	-	-	0.337	-	-	-	-	-	-	-	-	0.337	-	1.011
10 kR „	-	-	-	-	-	-	-	-	-	-	-	-	0.360	-	0.360
15 kR „	0.676	0.338	-	-	0.338	0.338	0.338	0.338	0.676	0.338	-	0.338	-	-	3.718
20 kR „	-	-	-	-	-	-	-	-	-	-	0.365	-	-	-	0.365
l	5.275	2.816	1.084	6.276	3.602	3.555	4.549	1.980	1.083	2.653	2.161	3.060	2.851	1.823	42.778

It is evident from the table 2, existing that highest effectiveness was found at 05kR presoaked (0.337) followed by 20kR dry (0.291) and 15kR dry (0.284), while lowest the effectiveness was found at the treatment of 25kR (0.123) dry. Mutagenic efficiency calculated on the basis of both percentage pollen sterility and percentage plant survival, most efficiency was exhibit 20kR dry (0.575 and 0.503) where as minimum efficiency of mutation was found at treatment of 35kR (0.122 and 0.083) dry seeds. Lower doses found most efficient which was similar to Paul and Singh (2005). The above findings are in accordance to the observations of several other workers, (Gautam *et al.* 1992); (Goverdhan & Lal, 2013); (Sharma, 1972); (Sharma *et al*. 2006). The spectrum of macro mutation, effectiveness and efficiency in different doses of gamma treated population suggesting of variety to the mutagenic treatment and was in conformity with earlier findings.

Table 2. Mutagenic effectiveness and efficiency of gamma rays in M_2 generation of pea cv. Arkel.

Mutation / Treatments	M_2 plants (Numbers)	No. of mutated family	Pollen sterility % (PS)	Lethality or Plant survival %	Mutation rate (%)	Effectiveness	Efficiency	
					M_2 plants (MS)	M_2 plants (MS/dose)	MS/PS %	MS/ Plant survival%
0.5kR (dry)	295	4	10.06	13.78	1.356	0.271	0.135	0.098
1.0 kR „	282	6	11.38	12.04	2.128	0.213	0.187	0.177
1.5 kR „	305	13	10.16	10.46	4.262	0.284	0.419	0.407
2.0 kR „	275	16	10.12	11.56	5.818	0.291	0.575	0.503
2.5 kR „	260	8	22.02	18.73	3.077	0.123	0.140	0.164
3.0 kR „	246	10	32.62	46.59	4.065	0.136	0.125	0.087
3.5 kR „	204	12	48.29	71.29	5.882	0.168	0.122	0.083
4.0 kR „	205	18	53.12	85.77	8.780	0.220	0.165	0.102
0.5kR(Pre-soaked)	297	5	13.45	11.27	1.684	0.337	0.125	0.149
1.0 kR „	278	7	15.18	21.21	2.518	0.252	0.166	0.119
1.5 kR „	296	8	18.85	40.12	2.703	0.180	0.145	0.067
2.0 kR „	274	13	19.57	53.70	4.745	0.237	0.242	0.088

CONCLUSIONS

In mutation breeding where large populations are handled, estimation of mutagenic effect for macro mutation, effectiveness and efficiency may help the breeders in identifying effective treated populations in early generation for reduction in cost of breeding and enhancing scope of selection.

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