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New Delhi-12.  
June 14:1966.

18th

Dear Shri Jaiswal,

I enclose herewith an article entitled 'the use of induced mutations in rice improvement' for the Special Number of Indian Farming. I shall send you the figures on my return from tour. I would like 100 reprints of this article as well as the one on National Demonstrations which has already been sent to you.

With kind regards,

Yours sincerely,

*M.S.*  
(M.S. Swaminathan.)

Shri P.L. Jaiswal,  
Editor,  
I.C.A.R., Krishi Bhavan,  
New Delhi.

Enc: article.

MSS:nji

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# The Use of Induced Mutations in Rice Improvement

By

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## INTRODUCTION:

The growing degree of sophistication in the control of the processes leading to the artificial transmutation of genes establishes beyond doubt that mutation breeding would soon become, even more than before, a very valuable tool in accelerating the pace of progress in plant breeding. Breeding of indica rices is in an interesting phase today. A decade ago, it was widely held that only japonica varieties of rice are capable of responding well to the application of large doses of fertilizers. This belief underwent a remarkable change after the development in Taiwan of Taichung Native-I, Dee-geo-woo-gen, and I-geo-tze, three early maturing, nitrogen responsive, photo-insensitive, semi-dwarf indica varieties. The genetic factor for dwarfing arose as a spontaneous mutation in Dee-geo-woo-gen and Taichung Native-I was developed by crossing this strain with Tsai-Yuan-Chung. These dwarf indica strains have established that fertilizer response is conditioned more by morphological characters than by physiological ones. Because of their high fertilizer responsiveness and yielding ability indica strains for the first time started replacing japonicas in Taiwan.

To get high yields, an efficient management of soil fertility and water application is essential. When conditions for plant growth are thus improved, conditions for the spread of pathogens and pests become coincidentally favourable. This is the reason why diseases like bacterial blight have

assumed greater importance in I.A.D.P. districts like Sahabad in Bihar than in areas where the practice of fertilizer application has not become wide spread. Thus, all varieties may develop diseases to a greater extent when grown under conditions of high soil fertility. Certain varieties like Taichung Native-I, are, however, relatively more susceptible to diseases like bacterial leaf blight and Tungro virus (this latter disease is fortunately not found in India so far). Varietal diversification and rapid replacement of varieties would hence be essential if rice yields are to be pitched at levels exceeding 6 tons per hectare over many years. For developing an assembly-line of new strains as well as for rectifying solitary or specific defects of otherwise good strains, the rice breeder should take advantage of all the experimental tools now available including mutation breeding.

Mutagens available:

When mutation breeding work was initiated in rice in India by Drs. K. Ramiah, N. Parthasarathy and S. Ramanujam, over 3 decades ago, the mutagen commonly employed was X-rays. Now, a wide range of physical and chemical mutagens are available for creating new variation in rice varieties. Among those found very effective are neutrons, gamma rays and X-rays among physical mutagens and ethyl methane sulphonate (EMS), diethyl sulphate (DES) and nitroso-methyl urea (NMU) among chemicals. In plants like barley, nitroso-methyl urea has been found to be the most potent mutagen (Fig.1) and hence this chemical and a few others like Nitroso-ethyl urea have been termed by Rapoport of U.S.S.R. as "Super-mutagens". Experiments carried out at the Indian Agricultural Research Institute indicate that EMS and NMU are very effective in rice strains also.

### Methods of Treatment and Handling

In order to recover as many as of the mutations induced as possible in the succeeding generations, it is necessary to minimise the possibility of eliminating the loss of cells carrying mutations through cell competition. Fortunately, the dormant rice seed which is exposed to treatment has 8 to 10 initials which will give rise to tillers. By collecting the seeds from each of this primary group of tillers separately and studying their progenies, it would be possible to avoid the dilution of the mutation frequency. Also, treating seeds after dehusking enhances the effectiveness of the mutagen and helps to obtain very high frequencies of mutations (Tables 1 and 2). The frequencies given in Tables 1 and 2 are the highest so far realised in rice varieties. As a precautionary measure for avoiding contamination with foreign pollen, it would be advisable to self all the treated plants by placing envelopes or bags over the inflorescences. In addition, to treating seeds, it is possible to treat growing plants to small doses of radiation over their entire life cycle in a Gamma Garden (Fig.2). Such chronic irradiation helps to overcome some of the limitations imposed by the competition for further growth occurring among the cells of a treated meristem. Varieties of indica have more than one gene governing several traits and in such cases repeated or recurrent irradiation of the treated material has an unmasking effect on the external manifestation of the characters controlled by duplicate factors.

#### Types of mutations induced:

A wide spectrum of mutations can<sup>be</sup> induced in rice by adopting suitable treatment and handling procedures.

with the theoretical knowledge gained on the frequency and spectrum of mutations induced by different mutagens and treatment methods, it is essential that studies on the maximisation of the induced mutation frequencies are initiated in rice on the model of the work already done in barley and wheat. Such studies should be carried out in varieties of japonica, indica and javanica.

b. Induction of mutations for specific characters:

This work will be principally for rectifying specific defects in otherwise desirable varieties. Mutations for desirable morphological characters like the plant type which is best suited for making good use of solar energy as well as the fertilizer applied, should be looked for. Among physiological characters, mutations for photoperiodic insensitivity, earliness (100 to 120 days from seeding to maturity) and tolerance to salinity are the problems worthy of investigation. Among diseases, resistance to blast and to bacterial blight were recommended for investigation.

c. Use of radiations for special purposes:

i) Increasing recombination and breaking undesirable linkage: For increasing recombination of genetic factors in Japonica and Indica crosses and for breaking undesirable linkages such as the association that appears to exist between photosensitivity and seed dormancy radiation techniques may be useful.

ii) Induction and irradiation of haploids: Irradiation of haploids followed by colchicine treatment will be another promising approach worthy of investigation in rice.

Induced mutations of practical value:

The recent work done in India at the Central Rice Research Institute, Cuttack, the Atomic Energy Establishment Trombay, the Bose Research Institute, Calcutta and the Indian Agricultural Research Institute, New Delhi, has

given rise to many valuable mutations. Thus, an early mutant isolated in Trombay in the variety G.E.B. 24 is not only 3 weeks earlier than the parent, but has also more grains per panicle (260 as compared to 180 in G.E.B.24) and higher yield (10 to 19 percent more than the control). At the I.A.R.I., Dr. S.V.S. Shastri and his colleagues isolated several dwarf mutants in the fine grain variety, N.P.130, in material treated with gamma rays and E.M.S. Some of the desirable features of these mutants were (a) reduction in height from 150 cm in the parent to 100 cm in the mutant, (b) thicker stem, (c) dark green leaves which are more efficient in the utilization of sunlight, (d) a non-lodging habit under high fertility conditions. The yields obtained with these mutants in trials conducted in different parts of Bihar, U.P and Punjab during 1965 indicated that some of these dwarf mutants could be cultivated with profit in soils fertilized with 100 Kg N/ha (See Table 3). The great attraction of these mutations is that they have fine, Basmati-type of grain. As can be seen from the data in Table 3, the dwarf mutants, S 1, 3, 4, 12 and 13, are uniformly superior at all the centres.

Some recent research carried out at the I.A.R.I. under contract with the International Atomic Energy Agency has led to the isolation of several interesting mutants in Taichung Native-I and Taichung-65. In the former variety, attention has been paid to the isolation of mutations with earliness and resistance to bacterial leaf blight, while in the latter mutants with non-gluginous grains are being developed. The progenies of the treated material of these two strains grown at the Paddy Breeding Station, Coimbatore and the Central Rice Research Institute, Cuttack, contain a wide array of useful types.

Sophisticated mutation research in rice is only in its infancy. We can confidently hope that the knowledge now being gathered would enable us to take advantage of this tool more effectively and extensively in future rice breeding research.

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TABLE 1

## Chlorophyll mutation frequency in Taichung Native - 1

Dosage	M2 Plant Progeny			M2 Spike Progeny		
	Total number of plants	Number of plants segregating	% of chlorophyll mutants	Total number of plants	Number of plants segregating	% of chlorophyll mutants
<u>Gamma-rays</u>						
10Kr	91	37	40.6	412	142	34.4
20Kr	125	55	44.0	544	192	35.2
30Kr	92	52	56.5	333	148	44.4
40Kr	24	18	75.0	126	69	54.7
<u>EMS</u>						
1/500	125	41	32.8	625	87	13.9
1/400	125	48	38.4	620	97	15.6
1/300	125	63	50.4	548	228	55.1
1/200	93	51	54.8	442	178	40.2
1/100	35	24	68.5	176	80	45.4
<u>Gamma + EMS</u>						
20Kr + 1/500	50	36	72.0	169	78	46.4
30Kr + 1/300	22	18	81.8	60	34	56.6

TABLE 2

Chlorophyll mutation frequency in  
Taichung - 65

Dosage	Total No. of plants	M2 Plant Progeny		M2 Spike Progeny		
		No. of plants segre- gating	% of chloro- phyll mutants	Total No. of spikes	No. of spikes segre- gating	% of chloro- phyll mutants
<u>Gamma-rays</u>						
10Kr	85	29	34.1	372	79	21.2
20Kr	100	36	36.0	370	83	23.8
30Kr	32	14	43.8	133	36	27.1
<u>EMS</u>						
1/500	100	21	21.0	478	53	11.1
1/400	100	24	24.0	462	57	12.3
1/300	100	29	29.0	390	61	15.6
1/200	44	18	40.9	145	36	24.8

Table 3.

Yield of dwarf mutants of N.P. 130 during the year 1965-66  
at different centres.

Rank	Nagina		Pusa		Faizabad		Kanke		Kapurthala	
	Culture No.	Yield in kg. per hectare.	Culture No.	Yield in kg. per hectare.	Culture No.	Yield in kg. per hectare.	Culture No.	Yield in kg. per hectare.	Culture No.	Yield in kg. per hectare.
1	S 13	2864	S 11	3744	S 4	2984	S 4	3296	S 12	6203
2	S 1	2808	S 3	3704	S 13	2885	S 12	3252	S 13	5977
3	S 10	2628	S 1	3629	S 11	2806	S 2	3185	S 4	5948
4	S 3	2610	S 4	3526	S 12	2786	S 1	3162	S 1	5920
5	S 2	2538	S 12	3509	S 1	2740	S 3	3117	S 3	5778
6	S 9	2563	S 14	3472	S 10	2670	S 10	3072	S 7	5750
7	S 14	2467	S 10	3252	<u>T 3</u>	2667	S 11	2826	S 8	5637
8	CH 4	2467	S 13	3003	S 2	2656	S 13	2646	S 11	5551
9	S 11	2449	S 2	2980	S 3	2627	S 5	2422	S 2	5410
10	S 6	2431	<u>N136</u>	2706	S 14	2595	<u>CH-1007</u>	2377	S 5	5297
11	S 12	2341	S 6	2224	<u>T 21</u>	2524	S 8	2355	S 9	5070
12	S 4	2332	S 5	2124	S 7	2119	S 9	2198	S 10	5042
13	S 8	2287	S 9	2124	S 8	2000	S 6	2130	S 6	4759
14	T 21	2287	S 7	2029	S 6	1897	S 7	2108	S 14	4674
15	S 7	2269	S 8	1965	S 9	1798	S 14	2063	<u>Bas 217</u>	4674
16	S 5	2245	<u>N.P.130</u>	1950	S 5	1722	-	-	-	-

Varieties underlined are the control checks in the trials.