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MORPHOLOGICAL MUTANTS OF GARLIC[1]

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ABSTRACT

Cloves of garlic (*Allium sativum* Linn.) were exposed to gamma rays with various doses and different concentrations of ethylmethane sulphonate (EMS), diethyl sulphate (dES) and ethylane imine (EI). In the second and third generations, 16 types of morphological mutants were recorded with varied frequencies. Of all the mutagens used, gamma rays were found to be the most effective in inducing the maximum number of mutations followed by EI, EMS and dES in that order.

INTRODUCTION

The ionizing radiations and chemical mutagens are now being used to induce mutations in economically important plants. Some important horticultural and crop plants are propagated exclusively by vegetative means. In such plants, mutation breeding offers a good possibility in inducing desirable variations. Many workers (e.g., Baur, 1957 ; Nybom, 1961 and Broertjes, 1977) have successfully induced the desirable mutations in vegetatively propagated plants, using ionizing radiations. However, there are only a few reports on the use of chemical mutagens (Nybom and Koch, 1965). Hence, a detailed mutation study was undertaken in garlic which is vegetatively propagated, using EMS, dES and EI in addition to gamma rays. The present paper deals with morphological mutations induced by these mutagens.

MATERIAL AND METHODS

Cloves of *Allium sativum* L. were irradiated in ^{60}Co source at the Indian Agricultural Researh Institute, New Delhi with doses 500, 600 and 700 R. The dose rate was 1.0 kR/minute. Cloves were also treated with EMS, dES and EI for 18 hours at $20 \pm 2°C$ temperature. The following concentrations were used :

EMS —0.3%, 0.5%, 0.75%
dES —0.075%, 0.15%, 0.3%
EI —0.2%, 0.35%, 0.5%

In case of dES treatment, an hourly change of mutagenic solution was given due to its short life period. The chemical mutagen treatment was followed by thorough washing and post-soaking in deionised distilled water for 3 hours. Soon after the treatment, cloves were sown in the experimental field. After the harvest of first generation plants, garlic bulbs were cured, dried and stored in a well ventilated chamber. The second (VR_2 and VM_2) and third (VR_3 and VM_3) generations were raised from the cloves obtained from the bulbs of the first and second generations, respectively. Morphological mutations were scored in both the generations.

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RESULTS

Various kinds of viable mutations were obtained in VR_3, VR_3 and VM_3 and VM_3 generations of gamma irradiation and chemically treated populations, respectively. The frequency of viable mutations varied with the dose of concentration of the mutagen. The data on the mutation frequency and spectrum are presented in Tables I and II.

In VR_2 and VR_3 generations, the frequency of viable mutations was observed to be increased up to 600 R dose and then it decreased at 700 R. The maximum frequency of 15.29 and 14.20 was found at 600 R in VR_2 and VR_3 generations, respectively. In case of chemical mutagens, the frequency of viable mutations increased with an increase in the concentration of mutagen. In VM_2 generation, it ranged from 2.40 to 4.72, 1.19 to 4.20 and 2.20 to 6.11 with EMS, dES and EI, respectively.

Tables I and II indicate that of all the mutagens, gamma rays induced the maximum frequency of mutations at relatively lower doses. As regards the spectrum of mutations, the gamma ray treatment also showed a broad spectrum of morphological mutations.

In case of chemical mutagens, the maximum frequency (6.11) of mutations and the broadest spectrum were recorded with 0.5% EI treatment, while the population treated with dES exhibited relatively a narrow spectrum with a less frequency of mutations.

Various types of mutants obtained were as follows :

(1) *Tall :* These mutants were taller as compared to the control plants and other mutant types. In these mutants, the number of cloves and weight of the bulb were also more than those of contiol.

(2) *Dwarf :* These mutants were characterised by extremely less height as compared to that of control and other mutant types.

(3) *Axillary shoot :* It was observed in a few plants of second generation that the arrangement of leaves was initially distichous and all of them emerged from a single spathe. But soon afterwoids, a new serial shoot or shoots with a separate spathe were formed in the axil of an old leaf or leaves, and each newly formed aerial shoot grew independently of the old aerial shoot.

(4) *Equal sheath :* In control plants, the leaves were alternate with the sheathing leaf bases but in these mutants, due to the equal length of the spathe of leaves, the latter appeared to emerge from the top of the spathe of sheathing bases at the same level.

(5) *Thick leaf :* These mutants were characterised by extra thick leaves.

(6) *Broad leaf :* There were some plants in VR_2 and VM_2 generations, which had broad leaves.

(7) *Needlelike leaves :* The mutants were characterised by needlelike leaves.

(8) *Dark green :* These mutant plants were with dark green colour and leathery leaves.

(9) *Spreading leaves :* In this type, the leaves were found to be much diverging from the spathe of the aerial leaves.

(10) *Compact leaves :* In VR_2 and VM_2 generations, some plants were observed with compactly arranged leaves.

(11) *Luxuriant :* Some plants were found with vigorous growth in VR_2 and VM_2 generations. Though the height of the mutants did not

TABLE I

FREQUENCY AND SPECTRUM OF VIABLE MUTATIONS IN VR_2 AND VM_2 GENERATIONS

Treatments	No. of Plants scored	No. of mutants observed	Total mutation frequency	Relative frequency of viable mutations															
				Tall	Dwarf	Axillary shoot	Equal sheath	Thick leaf	Broad leaf	Needle-like leaves	Dark green	Spreading leaves	Compact leaves	Luxuriant	Curvy	Bent shoot	Early maturing	Pink tunicated	Flat bulb
Gamma rays																			
500 R ..	422	57	11.13	2.36	1.18	0.71	1.65	1.18	0.94	..	0.47	0.71	1.18	0.94	1.18	0.71	..	0.47	0.23
600 R ..	425	65	15.29	3.52	1.88	0.94	1.41	1.17	..	0.70	..	1.64	1.17	1.41	0.94	0.47	..	0.70	0.47
700 R ..	286	33	11.53	2.44	2.09	..	..	1.74	..	1.39	..	2.09	..	..	1.04	0.69	..	1.39	1.04
EMS																			
0.3 % ..	499	12	2.40	0.40	..	..	0.80	0.40	..	..	..	0.60	0.30	..	0.20	0.20	0.60	..	..
0.5 % ..	451	16	3.54	0.88	..	..	0.66	0.22	0.44	..	..	1.10	0.44	0.22	..	0.22	0.22	0.22	0.22
0.75 % ..	402	18	4.72	0.49	0.74	..	0.24	0.49	0.74	..	..	0.99	0.24	..	0.49	..	..	..	..
dES																			
0.75 % ..	417	5	1.19	..	0.23	..	0.47	..	..	0.23	..	0.23	0.23	..	..	..	..	..	..
0.15 % ..	366	8	2.18	0.54	0.27	..	0.54	..	..	..	..	0.27	0.27	0.54	..	0.81	..	..	..
0.3 % ..	217	9	4.20	0.93	1.40	..	0.46	..	..	..	1.86	0.46	0.93	..	..	..	..	..	..
EI																			
0.2 % ..	498	11	2.20	0.80	0.40	..	..	..	..	0.20	..	..	0.20	..	0.20	..	0.20	0.20	0.20
0.35 % ..	439	16	3.64	..	0.68	0.22	0.45	0.22	..	..	..	0.91	0.22	0.45	0.68	..	0.22	0.22	0.22
0.5 % ..	425	26	6.11	0.70	0.94	0.47	0.47	1.41	0.70	0.23	0.23	..	0.47	..	0.23	..	0.70	1.41	0.23

TABLE II

FREQUENCY AND SPECTRUM OF VIABLE MUTATIONS IN VR_3 AND VM_3 GENERATIONS

Treatments	No. of plants scored	No. of mutants observed	Total mutation frequency	Relative frequency of viable mutation															
				Tall	Dwarf	Axillary shoot	Equal sheath	Thick leaf	Broad leaf	Needle-like leaves	Dark green	Spreading leaves	Compact leaves	Luxuriant	Curvy	Bent shoot	Early maturing	Pink tunicated	Flat bulb
Gamma rays																			
500 R ..	848	85	10.02	1.76	0.94	0.58	1.41	0.94	0.70	..	0.35	0.47	0.82	0.70	0.82	0.58	..	0.35	0.23
600 R ..	845	120	14.20	3.19	1.77	0.82	1.18	1.06	..	0.59	..	1.42	0.94	1.18	0.82	0.35	..	0.59	0.35
700 R ..	690	64	9.27	2.02	1.73	..	..	1.44	..	1.15	..	1.73	..	..	0.86	0.57	..	1.15	0.86
EMS																			
0.30 % ..	877	15	1.71	0.22	..	..	0.45	0.22	..	..	..	0.22	0.11	..	0.11	0.11	0.22	..	..
0.5 % ..	780	26	3.07	0.51	..	..	0.57	0.12	0.38	..	..	0.64	0.38	..	0.25	0.25	0.12	0.12	0.18
0.75 % ..	688	28	4.06	0.43	0.58	..	0.28	0.43	0·72	..	..	0.72	0.14	..	0.72	..	..	..	..
dES																			
0.075 % ..	750	8	1.06	..	0.26	..	0.40	..	..	0.13	..	0.13	0.13	..	..	..	..	..	..
0.15 % ..	600	9	1.50	0.50	0.16	..	0.50	..	..	..	..	0.16	0.16	0.50	..	0.66	..	..	..
0.3 % ..	477	15	3.14	0.83	1.04	..	0.62	..	..	..	1.67	0.41	0.83	..	..	..	..	..	..
EI																			
0.2 % ..	793	14	1.76	0.75	0.12	..	..	..	..	0.25	..	..	0.12	..	0.12	..	0.12	0.12	0.12
0.35 % ..	749	25	3.33	..	0.66	0.13	0.40	0.13	..	..	..	0.80	0.13	0.40	0.66	..	0.13	0.13	0.13
0.5 % ..	690	34	4.92	0.57	0.86	0.43	0.43	1.15	0.57	0.14	0.14	..	0.43	..	0.14	..	0.57	0.15	0.14

differ much from that of control, the number of leaves and cloves was, however, more than that of control.

(12) *Curvy :* The aerial shoot of these mutants had a gradual curvature at one side giving curvy appearance to the plant.

(13) *Bent shoot :* In these mutants, the underground bulb was found to be horizontal in position and the spathe of the aerial shoot was bent sharply just above the neck of the bulb.

(14) *Early maturing :* These mutants matured early as compared to control and other mutant types, i.e., in 80-90 days while normal and other mutant plants matured in 125 140 days.

(15) *Pink tunicated :* These mutants had a pink coloured outer papery membrane (tunic) surrounding the bulb and cloves.

(16) *Flat bulb :* In normal plants, the cloves were formed in a concentric manner and the compound bulb was subglobular, while in these mutants the cloves were not formed at one side and due to this, there was unequal development of the compound bulb resulting in the flattening of the bulb.

Out of the 16 types of mutants, the high yielding tall and luxuriant mutants are of economic importance and other mutant types are of morphological interest.

DISCUSSION

In the present investigation, the frequency of viable mutations increased up to 600 R and then declined in case of gamma rays. However, in case of chemical mutagen treatments, the frequency increased with an increase in the concentration of EMS, dES and EI.

There are several reports of the induction of viable mutations in different vegetatively propagated plants by ionizing radiations (Breider, 1959 ; Nybom, 1961 ; Gupta and Samata, 1963 ; Broertjes and Alkema, 1970 ; Broertjes, 1977 ; Doorenbos and Karper, 1975). However, the reports on the induction of mutations with chemical mutagens in vegetatively propagated plants are very few (Ferwerda, 1964 ; Argos, 1965 ; Kaiker and Swarup, 1972 ; Sparrow *et al.*, 1974). Bowen (1965) immersed cuttings of *Chrysanthemum* in solutions of EMS and EI but the rate of sporting obtained was very low as compared to that of irradiation.

In the present investigation, the gamma rays were found to be the most effective in inducing mutations as compared to other mutagens. As regards chemical mutagens, EI was observed to induce more mutations as compared to EMS and dES. Nybom and Koch (1965) and Broertjes (1969) stated that in vegetatively propagated plants, ionizing radiations are more effective than those of chemical mutagens. Nybom and Koch (1965) tested a few chemical mutagens such as EMS, NNMG and NMUA on various vegetatively propagated plants. The result was, however, very insignificant and they ascribed this due to insufficient penetration and low chromosome breaking potency. Onazawa (1972) studied the effect of several chemical mutagens including EMS and EI applied on growing plants of barley. He found that EI had comparatively higher penetration in the tissue of plants and was effective in inducing mutations. Sarsole (1966) reported that the treatment of grape vines with EMS solution porved to be a very efficient method for inducing mutations.

Nayar and Chauhan (1968) who treated sprouts of potato with EMS, obtained somatic mutations with very less frequency.

In garlic, gamma rays and EI were found to induce the broad spectrum with 15 kinds of mutations while the mutation spectrum of dES-treated population was relatively narrow with only 9 types of mutations. According to Arnason *et al.* (1962) and Nilan *et al.* (1964), radiations and chemical mutagens seem to induce different mutation spectra. Nawar *et al.* (1970) have shown that the mutagen-induced biological changes very greatly with different mutagens in living organisms.

In conclusion, it can be said that the gamma rays are most effective in inducing the maximum number as well as a broad spectrum of mutations as compared with the chemical mutagens in *Allium sativum.* This might be due to the high penetrating power and chromosome breaking potency of gamma rays.

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