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EFFECT OF MUTAGENS ON CHARACTER ASSOCIATION IN SESAME (*SESAMUM INDICUM* L.)

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Abstract

Three diverse sesame genotypes *viz*., Rama, SI 1666 and IC 21706 were treated with both physical (γ-rays) and chemical (EMS) mutagens separately. Three doses of γ-rays (200 Gy, 400 Gy and 600 Gy) and four doses of EMS (0.5%, 1.0%, 1.5% and 2.0%) were applied to each of the three genotypes. Correlation coefficients of morphological characters were computed in M_3 generation, while in M_4 generation biochemical characters namely oil, fatty acids and protein were subsumed in correlation study along with seed yield. The correlation coefficients in M_3 generation evinced that plant height, number of branches per plant, capsules per plant, capsule length and number of seeds per capsule were important yield components in the mutants. Suggestion has been made to accentuate these five characters during selection in M_3 generation. Correlation coefficients between seed yield and biochemical characters in M_4 generation revealed that mutation refurbished association of seed yield with linoleic acid, stearic acid, palmitic acid and between linoleic acid and oleic acid, linoleic acid and palmitic acid, stearic acid and oleic acid from negative (control) to positive direction. Along with seed yield, oil content, oleic acid and linoleic acid were epitomized to be considered as important selection criteria for evolving high yielding variety with more oil content and good oil profile in mutant population.

Introduction

Seed yield is a multifacet trait, which is dependent on interrelated characters. The components that determine the yield are best indices for selection. Therefore, knowledge of relationship between important yield traits and seed yield may help the researcher to identify suitable donors for a potential and successful breeding programme (Kumaresan & Nadrajan, 2002). The estimation of character associations could identify the relative importance of independent characters contributing to dependent ones and suggest upon the character(s) that may be useful as indicator for one or more of other characters. In other words, character associations between yield components can be used as the best guide for successful yield improvement by indirect selection.

Seed yield being a complex and polygenic trait, is an ultimate expression of different factors. The knowledge of interrelationship among various developmental and productive traits is necessary for fostering an effective breeding programme. Knowledge of the association of component traits with yield may greatly succour in a precise selection for the improvement of yield. Selection based on yield components is expedient if different yield related traits have been well documented (Panse, 1957; Poehlman, 1991; Singh & Kakar, 1997; Sarwar *et al*., 2005).

Along with the seed yield, amelioration of oil content (%) or different fatty acids are considered as important breeding objectives in oilseed crops. It is interesting to know the association of biochemical characters to formulate the breeding strategy which would improve not only seed yield but also oil content or important unsaturated fatty acid components of oil. The objective of the present analysis was conceived to investigate whether or not physical radiation and chemical mutagen disturbed the normal relationship between different characters during mutation breeding. Henceforth an attempt was made to assess the correlation coefficients between seed yield and biochemical characters *viz*., oil content, fatty acid composition and protein content which were worked out both in control and mutant populations.

Materials and Methods

Three diverse sesame (*Sesamum indicum* L.) genotypes *viz*. Rama, SI 1666 and IC 21706 were taken for the study. One physical mutagen *viz*. gamma (γ)-rays and one chemical mutagen *viz*. ethyl methane sulphonate (EMS) were used to induce mutation.

Physical mutagen: Dry seeds (10-12% moisture content) of each of the three genotypes were exposed to 200 Gy, 400 Gy and 600 Gy doses of gamma-rays. For gamma-rays (^{60}Co) the irradiation was done at the rate of 30 Gy/min in the gamma garden of Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore, West Bengal, India. For each dose 300 seeds were treated.

Chemical mutagen: EMS having the concentrations of 0.5%, 1.0%, 1.5% and 2.0% was used in phosphate buffer of neutral pH. Six hours treatment with intermittent shaking was done for each dose of EMS treatment. The treated seeds were laved under running tap water and sown immediately in the field after surface drying with filter paper. For each EMS dose 150 seeds were used.

Seven treatments including both physical and chemical mutagens along with control were used for each genotype as detailed below:

T_1 = Control, T_2 = 200 Gy γ-rays, T_3 = 400 Gy γ-rays, T_4 = 600 Gy γ-rays,
T_5 = 0.5% EMS, T_6 = 1.0% EMS, T_7 = 1.5% EMS, T_8 = 2.0% EMS.

The seeds were planted at the end of February, 2004 at Agricultural Experimental Farm of Calcutta University, Baruipur, West Bengal, India representing alluvial part of coastal South Bengal having the latitude and longitude of 22°21′56″ N and 88°26′14″ E, respectively. The plants thus raised from treated seeds were designated as M_1 plants and subsequently M_2, M_3 and M_4 plants were grown. Based on family means ten selected families of each genotype were advanced to M_3. In M_3 ten progeny rows were raised with a single row of respective controls for each treatment. Seeds were sown in the 4th week of February, 2006 in randomized block design with three replications. Treatment randomization was done keeping the progeny rows/families of each treatment serially i.e., one to ten. Row-to-row and plant-to-plant distance were maintained at 35 cm and 10 cm, respectively. Normal cultural practices were followed. In M_3 generation observations were recorded for eleven agronomic characters namely days to 1st flowering, flower duration, plant height (cm), number of branches per plant, number of capsules per plant, capsule length (cm), internode length (cm), number of seeds per capsule, 1000-seed weight (g), days to maturity and seed yield per plant (g). Based on yield and its component means ten families were selected irrespective of treatments from each genotype. Thus a total of 30 families representing ten from each genotype were advanced to M_4. Seeds of three plants from each of the selected families were bulked and sown along with their respective controls in randomized block design with three replications in the 4th week of February, 2007. Ten superior mutants were selected on the basis of seed yield and its components and biochemical analysis was carried out in these ten mutants. The oil content, fatty acid composition and protein content of these ten mutants were investigated further.

Association analysis of different morphological characters with seed yield per plant and their interrelationships were investigated in M_3 generation and in M_4 generation the relationship of seed yield with biochemical characters were estimated. Correlation coefficients were computed following the method suggested by Panse & Sukhatme (1961).

Results and Discussion

Effect of mutagens on correlation coefficients of yield and its component characters: The results evinced that number of capsules per plant exhibited highly significant and positive correlation coefficient with seed yield consistently in control population of all the three genotypes (Tables 1, 2 and 3). Interestingly, mutant population exhibited change of relationship in a few correlated characters. It was observed that seed yield was positively and significantly correlated with plant height, number of branches per plant, number of capsules per plant, capsule length and number of seeds per capsule consistently in the mutated population of three genotypes, while flower duration, 1000-seed weight and days to maturity were also significantly and positively correlated with seed yield per plant but not consistently in the treated population of three genotypes. Among the correlated characters highest magnitude of positive correlation coefficient was found between seed yield per plant and number of capsules per plant professing that number of capsules per plant was most important yield contributing character in both normal and mutant populations irrespective of the genotypes (Tables 1, 2 and 3). Similar significant positive correlation of seed yield per plant with number of capsules per plant in mutated population was also reported by Hassan *et al*., (2005) in chickpea; Govindarasu & Ramamoorthi (1998) and Sarwar *et al*., (2007) in sesame, while Geetha & Subramanian (1992), Anandakumar (1994), Arshad *et al*., (2003) and Atta *et al*., (2008) observed similar correlation in normal population. On the other hand, Ramanathan & Rathinam (1983) observed negative association between number of pods and pod yield in M_3 generation due to the induction of EMS in two varieties of groundnut.

Combining all, it affirmed that plant height, number of branches per plant, number of capsules per plant, capsule length and number of seeds per capsule were important yield contributing characters consistently in all mutant populations. The interrelationships of these characters depicted that number of capsules per plant was significantly and positively correlated with plant height in mutant population. Similarly, number of branches per plant and number of capsules per plant were significantly and positively interrelated. Such positive trend in correlation coefficients was also found in plant height and capsule length, plant height and number of seeds per capsule, capsule length and number of seeds per capsule. The results, therefore, inferred that number of capsules per plant would like to produce correlated response in plant height and number of branches per plant. During selection procedure, a plant breeder always seeks minimum number of characters, which are effective in improving yield, as it becomes complicated to handle more number of characters. Therefore, number of capsules per plant should be considered as most important selection criteria for improving yield. Selection for more number of capsules per plant would obviously result in plant types with more seed yield. Along with capsules per plant, plant height, number of branches per plant, capsule length and number of seeds per capsule were observed to be important yield components in the mutagen treated population. Thus restructuring or selection of plants with more number of capsules per plant, plant height, number of branches per plant, capsule length and number of seeds per capsule would likely to aid in evolving varieties with high yield.

Table 1. Phenotypic correlation coefficients of yield components in mutant (M) and control (C) populations of Rama in M_3 generation.

		Days to 1st flowering	Flower duration	Plant height	Number of branches/plant	Number of capsules/plant	Capsule length	Internode length	Number of seeds/capsule	1000-seed weight	Days to maturity	Seed yield /plant
Days to 1st	M	1.000	0.356**	0.105	0.092	-0.072	-0.120	-0.189	-0.193	0.222*	0.119	-0.057
flowering	C	1.000	0.464**	-0.346**	0.160	0.204	-0.043	0.080	0.235*	-0.229*	0.167	0.351**
Flower	M		1.000	0.185	0.246*	0.335**	0.059	0.041	0.068	0.298**	0.724**	0.370**
duration	C		1.000	-0.069	0.311**	0.697**	0.402**	0.219*	-0.198	-0.463**	0.146	0.723**
Plant	M			1.000	0.478**	0.604**	0.293**	0.001	0.270*	0.180	0.067	.590**
height	C			1.000	0.279*	0.267*	-0.008	-0.083	0.141	-0.534**	-0.064	0.227*
Number of	M				1.000	0.800**	0.202	-0.187	0.188	0.067	0.218	0.745**
branches/plant	C				1.000	0.271*	-0.183	0.053	-0.083	-0.408**	0.180	0.136
Number of	M					1.000	0.396**	0.083	0.430**	0.094	0.246*	0.973**
capsules/plant	C					1.000	0.181	-0.201	-0.299**	-0.841**	-0.224*	0.777**
Capsule	M						1.000	0.253*	0.845**	0.135	-0.082	0.508**
length	C						1.000	-0.028	0.269*	-0.003	0.378**	0.432**
Internode	M							1.000	0.289**	0.009	-0.027	0.131
length	C							1.000	-0.242*	0.047	0.171	-0.186
Number of	M								1.000	0.190	-0.069	0.569**
seeds/capsule	C								1.000	0.128	0.077	0.203
1000-seed	M									1.000	0.163	0.223*
weight	C									1.000	0.198	-0.628**
Days to	M										1.000	0.238*
maturity	C										1.000	0.057
Seed yield	M											1.000
/plant	C											1.000

*, ** Significant at 5% and 1% level, respectively

Table 2. Phenotypic correlation coefficients of yield components in mutant (M) and control (C) populations of SI 1666 in M_3 generation.

		Days to 1st flowering	Flower duration	Plant height	Number of branches/plant	Number of capsules/plant	Capsule length	Internode length	Number of seeds/capsule	1000-seed weight	Days to maturity	Seed yield /plant
Days to 1st	M	1.000	0.190	0.186	0.115	0.123	0.067	-0.022	0.088	0.019	0.203	0.120
flowering	C	1.000	-0.267*	-0.046	0.050	-0.158	0.068	0.135	0.257*	-0.074	-0.455**	-0.076
Flower	M		1.000	0.508**	0.326**	0.551**	0.141	-0.239*	0.157	0.067	0.330**	0.518**
duration	C		1.000	-0.116	-0.523**	-0.134	-0.046	-0.202	-0.184	-0.453**	0.004	-0.266*
Plant	M			1.000	0.276*	0.599**	0.574**	-0.210	0.640**	0.172	0.109	0.628**
height	C			1.000	0.160	-0.125	0.086	-0.338**	0.070	0.061	0.396**	-0.097
Number of	M				1.000	0.274*	0.154	-0.479**	0.153	0.012	0.090	0.253*
branches/plant	C				1.000	0.575**	-0.465**	0.177	-0.155	0.526**	0.106	0.614**
Number of	M					1.000	0.568**	-0.195	0.580**	0.158	0.272*	0.991**
capsules/plant	C					1.000	-0.526**	0.238*	-0.387**	0.266*	0.097	0.948**
Capsule	M						1.000	-0.053	0.907**	0.142	0.037	0.618**
length	C						1.000	0.101	0.832**	-0.566**	-0.313**	-0.315**
Internode	M							1.000	-0.068	-0.036	-0.140	-0.188
length	C							1.000	0.359**	-0.318**	-0.714**	0.350**
Number of	M								1.000	0.113	0.032	0.633**
seeds/capsule	C								1.000	-0.472**	-0.561**	-0.092
1000-seed	M									1.000	-0.349**	0.229*
weight	C									1.000	0.393**	0.228*
Days to	M										1.000	0.215
maturity	C										1.000	-0.058
Seed yield	M											1.000
/plant	C											1.000

*, ** Significant at 5% and 1% level, respectively

Table 3. Phenotypic correlation coefficients of yield components in mutant (M) and control (C) populations of IC 21706 in M_3 generation.

		Days to 1st flowering	Flower duration	Plant height	Number of branches/plant	Number of capsules/plant	Capsule length	Internode length	Number of seeds/capsule	1000-seed weight	Days to maturity	Seed yield /plant
Days to 1st	M	1.000	0.095	0.167	-0.031	0.045	-0.090	-0.092	-0.001	0.054	0.123	0.045
flowering	C	1.000	-0.238*	-0.270*	-0.387**	0.058	-0.259*	0.490**	-0.286**	0.711**	-0.375**	0.178
Flower	M		1.000	0.054	0.035	0.017	0.242*	0.048	0.154	0.020	0.609**	0.032
duration	C		1.000	-0.327**	0.163	-0.012	-0.338**	-0.159	-0.215	-0.416**	0.860**	-0.236*
Plant	M			1.000	0.149	0.504**	0.434**	0.064	0.485**	-0.029	-0.224*	0.545**
height	C			1.000	0.291**	-0.188	0.088	0.235*	0.173	-0.411**	-0.212	-0.203
Number of	M				1.000	0.597**	0.014	-0.160	0.026	-0.104	0.049	0.566**
branches/plant	C				1.000	0.318**	0.070	-0.274*	0.219*	-0.483**	0.342**	0.153
Number of	M					1.000	0.157	-0.018	0.140	0.030	-0.217	0.981**
capsules/plant	C					1.000	0.192	-0.230*	0.164	0.267*	0.244*	0.881**
Capsule	M						1.000	0.468**	0.858**	0.355**	-0.147	0.291**
length	C						1.000	-0.168	0.527**	-0.207	-0.370**	0.292**
Internode	M							1.000	0.457**	0.475**	-0.088	0.076
length	C							1.000	0.107	0.370**	-0.180	0.016
Number of	M								1.000	0.351**	-0.167	0.285*
seeds/capsule	C								1.000	-0.119	-0.066	0.485**
1000-seed	M									1.000	-0.076	0.167
weight	C									1.000	-0.368**	0.484**
Days to	M										1.000	0.733**
maturity	C										1.000	0.023
Seed yield	M											1.000
/plant	C											1.000

*, ** Significant at 5% and 1% level, respectively

Table 4. Phenotypic correlation coefficients between seed yield and biochemical characters in mutant (M) and control populations in M_4 generation.

		Oil content (%)	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Arachidic acid (%)	Protein content (%)	Seed yield (g)
Oil content (%)	M	1.000	-0.207	0.222	0.233	0.199	0.093	-0.947**	0.464*
	C	1.000	-0.852**	-0.861**	0.881**	-0.026	0.045	-0.917**	0.644**
Palmitic acid (%)	M		1.000	-0.097	-0.134	0.545	0.089	0.180	0.271
	C		1.000	0.990	-0.998**	-0.043	0.854**	0.572**	-0.949**
Stearic acid (%)	M			1.000	0.634**	0.428*	-0.078	-0.233	0.410*
	C			1.000	-0.999**	0.530**	0.864**	10.587**	-0.943**
Oleic acid (%)	M				1.000	0.029	-0.352	-0.088	0.323
	C				1.000	-0.495*	-0.884**	-0.620**	0.929**
Linoleic acid (%)	M					1.000	-0.124	-0.265	0.377
	C					1.000	0.030	-0.375	-0.782**
Arachidic acid (%)	M						1.000	0.026	-0.291
	C						1.000	0.915**	-0.647**
Protein content (%)	M							1.000	-0.330
	C							1.000	-0.285
Seed yield (g)	M								1.000
	C								1.000

*,** Significant at 5% and 1% level, respectively

Effect of mutagens on correlation coefficients between seed yield and biochemical characters: The data revealed that the oil yield was significantly and positively correlated with seed yield but negatively correlated with protein content in both mutant and control populations (Table 4). The present report corroborates the findings of Başalma (2008) in winter rapeseed. A contrasting relationship between oil content and seed yield as well as protein content and seed yield were observed by Pahlavani (2005) in safflower. Sesame is cultivated chiefly for oil purpose in India. So, augmenting oil content against sacrifice of higher protein content would not be a disappointing proposition. Similar finding was also reported by Solanki & Gupta (2000) in sesame.

It is worth mentioning that the mutation distinctly spawned change of relationship between seed yield and some biochemical characters namely palmitic acid, stearic acid and linoleic acid as the correlation coefficients between seed yield with either of these unsaturated fatty acids were highly negative in control population but in mutant population the correlation coefficients were found to be significantly positive or positive (Table 4). Similar result was also observed in interrelationship between linoleic acid and palmitic acid as well as linoleic acid and oleic acid. Similarly, in control population stearic acid was correlated negatively and significantly with oleic acid but in mutant population a significant positive relationship subsisted. Thus mutation appeared to break the negative linkage between characters. This obviously is enviable situation as selection for higher seed yield in mutant population would lead to high stearic acid, oleic acid and linoleic acid along with more oil content. Again in mutant population stearic acid was interrelated significantly and positively with both oleic acid and linoleic acid. Thus selection for high stearic acid will ameliorate both oleic acid and linoleic acid through correlated response. It is to be emphasized here that oleic acid and linoleic acid are the two important and beneficial unsaturated fatty acids in sesame (Sengupta & Das, 2003). If oil quality is also improved concomitant with oil content and seed yield, then that would be most rewarding situation or in other words such varieties would be the most demanding varieties in sesame cultivation. The present mutant population appeared to bring about a break through in this direction. Thus the characters like seed yield, oil content, oleic acid and linoleic acid would be ideal selection criteria for further improvement of sesame.

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