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MEAN AND VARIABILITY STUDIES IN M_1 AND M_2 GENERATIONS OF SUNFLOWER (*Helianthus annuus* L.)

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SUMMARY

The experiment was carried out to induce variability in the sunflower varieties Morden and CO 4 (TNAUSUF 7) by a physical mutagen, *i.e.*, gamma rays. The LD_{50} value was fixed at 15 kR for both varieties based on germination percentage. Progressive decreases in germination and survival with increase in gamma ray dose were recorded in the M_1 generation. Stimulatory and inhibitory effects were noticed in quantitative characters with lower and higher doses, respectively. The mean expression and variability in quantitative characters increased considerably in the M_2 generation. The different mutagenic treatments showed an inconsistent relationship with respect to mutagen mean and variability. However, considerable increase in variance was observed in traits such as plant height, seed yield per plant and oil content. Regarding seed yield per plant, heritability and genetic advance were maximum at 20 kR and 5 kR in the genotypes Morden and CO 4, respectively.

Key words: gamma irradiation, mean, variability, sunflower

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oil seed crops in India, after groundnut and rape seed mustard. Production of sunflower in India had increased six fold from 1970 to 1990 due to the introduction of high-yielding varieties and hybrids. Presently, the area under cultivation exceeds 1.30 million hectares with a production of 0.70 million tons (Damodaran and Hedge, 2002). Even though the progress achieved is quite high in terms of area and production, the productivity (549 kg/ha) seems to be the lowest in the world. The present study was undertaken in order to create variability for the improvement of sunflower seed yield through mutation breeding. The mean, variability, heritability, genetic advance and dispersion were studied.

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MATERIALS AND METHODS

The promising sunflower varieties Morden and CO 4 (TNAUSUF 7) were selected to study the effect of gamma rays on the induction of mean expression and variability in biometric characters. Well-dried, viable seeds from genetically pure materials of Morden and CO 4 obtained from the department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore, were used in this study. Gamma irradiation was done in the gamma chamber installed at the Tamil Nadu Agricultural University, Coimbatore. The seeds were exposed to gamma irradiation from cobalt 60 (^{60}Co) gamma source for the required duration.

LD_{50} values were compared in the M_1 generation and control in a randomized block design with two replications. A total of 100 seeds were sown in each treatment. All plants in the first generation, in each treatment, were observed for the following parameters: germination on the 15th day, survival on the 30th day, days to first flower, plant height, head diameter, 100-seed weight, days to maturity, seed yield per plant and oil content. Seeds obtained from M_1 plants in each treatment were advanced to raise the M_2 generation as progeny rows. Each plant was raised in one row of 3 m length with the spacing of 60 × 30 cm during Rabi/summer, season 2002-2003. The above biometric characters were recorded and individual plant data were used for statistical analysis. Data for each character in all treatments were analyzed separately by an appropriate analysis. Mean analysis of variance, coefficient of variation, heritability, genetic advance and genetic advance as percentage of the mean were calculated.

RESULTS AND DISCUSSION

In the present study, biological effects of the mutagenic treatments were determined from observations made on germination and survival percentages in the M_1 generation. Progressive decrease in germination with increase in gamma ray dose was observed in both genotypes (Table 1). The reduction was more pronounced at higher doses of gamma rays. Increasing doses of mutagen causing a progressive increase in biological damage measured in terms of reduction in germination and plant survival in the M_1 generation have been reported in some leguminous crops also (Sjodin, 1962; Gregory, 1968; Nerkar, 1976). Similar dose-dependent relationship in reducing germination has been observed in the irradiated material of sunflower (Vranceanu and Iuoras, 1990; Marcelo *et al.*, 1998; Jambhulkar and Joshua, 1999) with regard to morphological traits while stimulatory effect was observed with lower doses of mutagen for days to first flower and 100-seed weight. The characters days to first flower, head diameter, days to maturity and seed yield per plant showed a positive shift from the control to the 15 kR dose. Such a stimulatory effect has been reported in a wide variety of crop plants (Davis, 1979). Pronounced inhibitory effects were noticed with higher doses in most cases. Such

Table 1: Effect of gamma rays on various characters based on mean performance in the M_1 generation (Angular transformed values within brackets)

Variety	Treatment	Germination percentage	Survival percentage	Days to first flower	Plant height	Head diameter	100-seed weight	Days to maturity	Seed yield per plant	Oil content
Morden	Control	90.50 (76.47)	91.00 (74.56)	53.03 (48.56)	69.63	8.48	3.73	83.03 (82.41)	7.15	30.93 (27.65)
	5kR	75.00 (64.23)	72.50 (62.58)	51.94 (48.56)	61.66	8.20	3.92	81.94 (78.56)	6.58	28.57 (26.53)
	10kR	66.00 (54.48)	63.00 (52.48)	52.31 (50.16)	56.73	8.29	4.10	82.31 (79.64)	6.63	30.17 (28.46)
	15kR	55.00 (46.64)	51.50 (43.59)	53.03 (50.16)	58.04	8.90	3.29	83.03 (81.54)	8.38	29.99 (26.84)
	20kR	41.00 (35.42)	37.50 (31.54)	52.73 (49.86)	57.96	8.39	3.60	82.73 (80.46)	6.71	32.15 (30.46)
	25kR	25.00 (20.46)	21.50 (17.56)	52.96 (51.46)	47.36	6.94	3.58	82.67 (81.54)	6.01	25.88 (23.46)
CO 4	Control	95.00 (79.65)	95.00 (78.56)	57.08 (53.46)	118.89	14.75	4.60	87.08 (84.62)	11.57	31.77 (28.45)
	5kR	87.50 (78.14)	85.00 (75.48)	56.90 (53.87)	115.39	11.05	4.65	86.90 (83.65)	14.35	32.32 (30.45)
	10kR	71.00 (65.40)	64.50 (63.48)	57.12 (54.68)	104.88	11.91	4.69	87.12 (85.10)	11.02	30.62 (28.61)
	15kR	57.50 (48.25)	52.50 (46.87)	56.31 (53.46)	99.32	9.70	4.35	86.31 (84.59)	10.94	31.07 (28.42)
	20kR	43.50 (38.64)	41.00 (36.64)	56.83 (53.21)	95.49	10.07	3.75	86.83 (86.32)	14.12	29.42 (26.87)
	25kR	37.00 (30.10)	33.50 (28.67)	56.53(54.21)	76.32	7.53	4.07	86.53 (86.37)	16.02	35.02 (33.45)
	SE_d	6.551	6.83	0.74	9.39	1.70	0.44	0.74	1.51	2.28
	CD	13.10	13.66	1.63	20.67	3.76	0.98	1.63	3.33	5.03

Table 2: Variability parameters for various characters in the M_2 generation

Treatment	Days to first flower					Plant height					Head diameter				
	Mean	GV (%)	GCV (%)	H^2	GA over mean	Mean (cm)	GV (%)	GCV (%)	H^2	GA over mean	Mean (cm)	GV (%)	GCV (%)	H^2	GA over mean
Morden															
5kR	50.43	5.62	4.70	44.81	6.48	102.31	149.15	11.94	28.08	13.03	9.65	5.11	23.43	48.94	33.77
10kR	51.54	3.30	3.52	32.29	0.18	98.40	68.31	8.40	15.17	0.03	9.93	5.11	21.76	48.94	3.22
15kR	51.07	8.11	5.58	53.99	15.56	110.67	496.55	20.13	56.52	11.07	10.35	5.99	25.74	52.89	34.23
20kR	54.34	8.96	5.51	56.45	15.78	142.29	120.44	7.71	23.97	4.14	8.86	4.33	22.76	44.80	31.01
25kR	51.14	3.81	3.82	35.55	10.24	116.77	334.87	15.67	46.72	8.91	8.89	5.24	25.74	49.55	33.23
Control	52.12					110.17					9.11				
CO 4															
5kR	53.10	4.60	4.04	33.93	4.85	175.30	137.63	6.69	28.68	7.38	10.58	4.69	24.47	44.36	28.09
10kR	53.23	5.27	4.31	37.00	5.40	153.10	480.93	14.32	58.42	22.55	9.32	3.09	18.86	34.42	22.79
15kR	53.18	3.71	3.62	29.25	4.03	177.46	198.53	7.94	36.71	9.91	8.60	1.59	14.65	21.26	13.92
20kR	54.02	7.63	5.11	45.99	7.15	172.92	153.41	7.16	30.95	8.21	8.80	2.77	18.91	32.02	22.04
25kR	53.43	6.68	4.84	42.71	6.51	163.34	429.11	12.68	55.63	19.49	9.34	4.67	23.12	44.25	31.68
Control	53.92					186.03					11.02				

Table 2: Variability parameters for various characters in the M_2 generation (continued...)

Treament	100 seed weight					Days to maturity					Seed yield per plant					Oil content				
	Mean (g)	GV (%)	GCV (%)	H^2	GA over mean	Mean	GV (%)	GCV (%)	H^2	GA over mean	Mean (g)	GV (%)	GCV (%)	H^2	GA over mean	Mean (%)	GV (%)	GCV (%)	H^2	GA over mean
Morden																				
5kR	3.78	2.02	37.62	70.31	64.97	82.74	3.13	2.14	30.51	2.43	6.26	10.74	30.56	26.26	12.27	29.78	8.30	9.67	24.71	9.90
10kR	4.36	1.44	27.51	62.83	14.21	81.44	8.11	3.50	53.23	8.15	8.28	15.54	31.90	34.01	19.93	30.13	22.01	15.57	46.54	9.58
15kR	3.98	1.05	25.79	55.29	57.10	82.75	1.93	1.68	21.33	4.83	12.36	15.54	31.90	34.01	19.93	28.96	7.57	9.50	23.04	8.82
20kR	3.68	1.44	32.63	62.88	67.51	82.09	3.44	2.26	32.60	7.41	10.55	26.97	49.22	47.21	29.94	34.16	43.44	19.30	63.21	22.28
25kR	3.77	1.49	32.40	63.60	67.52	82.33	1.81	1.63	20.26	4.60	5.64	10.84	58.33	26.44	22.93	25.56	20.51	17.72	44.79	18.25
Control	3.20					81.71					5.68					28.64				
CO 4																				
5kR	4.78	0.61	16.39	30.72	18.71	86.90	4.50	2.44	50.09	3.56	13.19	48.34	52.69	61.28	48.98	32.21	9.58	9.61	27.30	10.34
10kR	4.40	0.53	16.56	27.78	17.98	86.80	4.49	2.44	50.05	3.56	8.15	5.10	27.72	14.31	21.60	32.69	26.30	15.69	50.77	23.02
15kR	4.46	1.24	24.91	47.22	35.27	87.57	3.39	2.10	43.08	2.84	7.40	6.00	33.10	16.42	27.63	32.02	1.34	3.61	4.98	1.66
20kR	4.48	0.65	18.04	32.08	21.05	86.76	3.17	2.05	41.42	2.72	8.97	6.83	29.14	18.28	25.66	33.94	10.15	9.38	28.46	10.31
25kR	4.87	2.18	30.35	61.24	48.92	87.43	2.86	1.93	38.98	2.49	7.44	6.00	32.91	16.42	27.48	35.90	14.74	10.69	36.63	13.33
Control	4.64					87.37					12.48					31.58				

inhibitory effects in quantitative characters have been reported in groundnut (Habib *et al*., 1979; Dorairaj, 1979) and sesame (Rajan, 1969; Prabhakar, 1985).

In the M_2 generation of Morden, there was an increase in the mean value of most treatments for characters such as plant height, head diameter, 100-seed weight, days to maturity, seed yield per plant and oil content. Such a shift in positive direction is contrary to the generalized view where a negative shift is usually expected. However, the mean of a treated population showing a significant increase over control has been reported by Khan (1983, 1984 and 1988) in mung bean. Days to first flower, plant height, head diameter and seed yield per plant showed a negative shift in mean values in CO 4. Increases in induced variance due to the increase in mutagen dose occurred in both genotypes, Morden and CO 4, for days to first flower, plant height and seed yield per plant. However, the present study revealed that linear relationship between dose and genotypic variance was not maintained for all the characters in the genotypes studied. Similarly, the magnitude of increase in variance also differed for different traits and was inconsistent with varying doses of the mutagen in one and the same genotype. The traits such as plant height, head diameter, seed yield per plant and oil content showed maximum variances for the treatments in both varieties.

Gregory (1955) reported that radiation could be used as a potent source of inducing variability in groundnut. Increasing genetic variability for yield and other quantitative characters has been reported by Giriraj *et al.* (1990) in sunflower. In the present study, low variability was induced for characters such as days to first flower, days to maturity and oil content. The low variance may be due to restricted heterozygosity in the mutated genes governing these traits in the M_2 generation which may produce greater variability in later generation.

The trend observed for genotypic variance was maintained for heritability also. However, genetic advance as percentage of mean showed slight deviations. High heritability and genetic advance was observed for 100-seed weight for all the treatments. However, moderate heritability and genetic advance were observed for all other characters under study. Heritability and genetic advance as percentage of mean were maximum at 20 kR for seed yield per plant as well as for oil content, days to first flower, head diameter and 100-seed weight. In CO 4, the heritability and genetic advance as percentage of mean were maximum at 5 kR for seed yield per plant and other traits such as head diameter and days to maturity. The high heritability and genetic advance was observed at 10 kR in CO 4 for oil content, plant height and days to maturity (Table 2). The increased heritability and genetic advance in the treated populations in the present study are in conformity with results obtained for other oilseeds crops such as sesame (Chavan and Chopde, 1982), mustard (Labana *et al.,* 1980) and groundnut (Mathur *et al.,* 2000). Hence, selection will be applied in the populations treated with 20 kR in Morden and 5 kR and 10kR in CO 4 to obtain high seed- and oil-yielding progenies. The mutants iso-

lated with increased mean values, high heritability and genetic advance may be useful in crop improvement programs.

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ESTUDIOS DE MEDIA Y VARIABILIDAD EN GENERACIONES M_1 Y M_2 DE GIRASOL (*Helianthus annuus* L.)

RESUMEN

Se condujo un experimento para inducir variabilidad en las variedades de girasol Morden y CO 4 (TNAUSUF 7) a través de mutagénesis física (rayos gamma). Se fijó el valor de LD_{50} en quince kR para ambas variedades de acuerdo con el porcentaje de germinación. Se registró la disminución progresiva de la germinación y supervivencia con el incremento en la dosis de rayos gamma en la generación M_1. Los efectos estimulante e inhibitorio se detectaron en caracteres cuantitativos en menores y mayores dosis, respectivamente. Tanto la expresión media como la variabilidad para caracteres cuantitativos se incrementaron considerablemente en la generación M_2. Diferentes tratamientos mutagénicos mostraron una relación inconsistente entre el agente mutagénico y la media y la variabilidad. Sin embargo, se observó un incremento considerable en la variabilidad para caracteres como altura de planta, rendimiento de semilla por planta y contenido de aceite. La heredabilidad y avance genético fueron máximas a 20 kR y 5 kR en los genotipos Morden y CO 4, respectivamente, para rendimiento de semilla por planta.

ÉTUDE DES MOYENNES ET DES VARIABILITÉS DES GÉNÉRATIONS M_1 ET M_2 DE TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

Une expérience a été mise en oeuvre dans le but d'induire de la variabilité au sein des variétés de tournesol Morden et CO 4 (TNAUSUF 7) à l'aide de la mutagenèse physique causée par l'irradiation gamma. La DL_{50} était fixée à 15 kR pour les deux variétés sur la base du pourcentage de germination. Une diminution progressive du taux de germination et de survie a été observée en génération M_1 lorsque la dose d'irradiation gamma augmentait. Des effets stimulants ou inhibiteurs ont été observés sur les caractères quantitatifs aux doses plus faibles et plus fortes, respectivement. L'expression moyenne des caractères et leur variabilité a augmenté considérablement en génération M_2. Aucune relation n'a pu être mise en évidence entre les différents traitements et les réponses obtenues en terme de moyenne et de variabilité. Cependant, il a été observé une augmentation considérable de la variance pour des caractères tels que la hauteur de plante, la production de grains par plante et la teneur en huile. L'héritabilité et le progrès génétique maximaux pour la production de grains par plante ont été obtenus pour les doses de 20 kR et de 5 kR pour les génotypes Morden et CO 4, respectivement.