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INCREASED GENETIC VARIABILITY IN THE M2 GENERATION OF THREE GAMMA-IRRADIATED BROAD BEAN (*VICIA FABA* L.) VARIETIES

M. H. KASIM, S. R. A. SHAMSI* and S. A. SOFAJY

Department of Biology, College of Science, University of Mosul, Mosul, Iraq.

Abstract

To test the effectiveness of gamma radiation for the induction of quantitative variations, dry seeds of three broad bean varieties (Sinjar, Egyptian and French) were exposed to 100,250,500,750 and 1000R dosages from a Co^{60} source. In M_1 generation all varieties exhibited earliness of flowering and increase in stem length; though response to the different doses was different in the three varieties.

Analysis of M_2 revealed that Sinjar had highest genetic variability followed by Egyptian and French as regards the flowering time. A dose of 500R was most effective in Sinjar, 100R in Egyptian and 250R in the French variety. On the contrary, for the stem length, the order of increase in variability was French, Sinjar and Egyptian; 750R being most effective in French, 100R in Egyptian and 1000R in Sinjar. In all the varieties there was no relationship between the magnitude of irradiation and the amount of induced genetic variance. The ranges of predicted heritability estimates for both these characters were relatively higher in Egyptian as compared with other varieties. This additional variability, in so far as it is genetic would provide an opportunity for improvement of broad bean by selection.

Introduction

Broad bean is an important commercial crop of Iraq. It is grown as a forage crop as well as for the seeds. In addition to local Sinjar variety, French and Egyptian varieties have also been introduced for increased yield. Results on the varied response of these three varieties to gamma irradiation as regards their germination and survival have been reported earlier (Shamsi *et al.* 1977).

This paper presents an assessment of the genetic variability obtained in M_2 generation of these varieties which can be utilized in any future breeding programme.

Materials and Methods

Certified seeds of three broad bean varieties i.e., Sinjar, Egyptian and French were irradiated at 100, 250, 500, 750, 1000, 3000 and 5000R from a Co^{60} source at Atomic Energy Centre, Baghdad and stored at 5°C for two weeks before use. Irradiated seeds along with the control for each variety were germinated in sub-irrigated (24 cm, diameter) plastic sieves at a day time temperature of 25-30°C in the greenhouse on 26th February, 1975. Ten seedlings per treatment per variety were selected for uniformity of size and grown to maturity in Long Ashton nutrient solution (Hewitt, 1966) in water culture medium, taking all the necessary precautions. Seedlings from exposures higher than 1000R remained stunted for a long time and were discarded. During the entire period from germination to maturity, each plant was examined for desirable variations in characters and data on days to flower (i.e.,

* Department of Botany, University of the Punjab, Lahore—Pakistan.

number of days from date of sowing till the date of opening of the first flower) and the plant height (i.e., shoot length in cm. from plant base to the apex before harvesting) were recorded for each plant.

Individual plants of M_1 were allowed to reproduce by self-fertilization and the seeds produced per treatment per variety were bulked. These seeds were germinated in laboratory and seedlings transplanted in the field on 19th October, 1975 (beginning of the growing season in Iraq) to obtain M_2. Plant to plant distance was 30 cm. and inter-row distance was 50 cm. All the treatments within a variety were randomized and the varieties were grown in adjoining plots. Data similar to M_1 were collected.

Data on the number of days to flowering and the stem length (cm) in M_1 and M_2 generations were used for the estimation of means and variances.

Results and Discussion

M_1 generation

Egyptian and Sinjar varieties exhibited earliness in flowering time almost at all dose levels (Table 1) while French only at 750 and 1000R. However, in all these treatments flowering time was not significantly different from the respective control and only indicated the trends.

Stem length exhibited a marked and significant increase at all dose levels in the Sinjar variety (Table 2). Increase in stem length in variety French was significant only at 500R but variety Egyptian was not significantly different from the control at any dose.

TABLE 1. Flowering time (days) in the M1 generation in three broad bean varieties grown from pre-sowing gamma irradiated seeds in the greenhouse.

Treatments in Roentgen (R)	Varieties		
	Sinjar	Egyptian	French
0	51.4±2.418	43.4±1.392	51.1±1.958
100	49.0±2.745	42.9±1.140	51.5±2.721
250	45.4±2.583	42.7±0.667	52.4±2.428
500	50.4±2.993	41.2±0.490	51.4±2.548
750	49.4±2.247	41.8±0.680	50.3±2.463
1000	51.6±2.504	42.0±0.615	47.7±1.476

All treatment means are not significantly different from the control mean, (P 0.05).

TABLE 2. Stem length (cm) in the M_1 generation in the three broad bean varieties grown from pre-sowing gamma irradiated seeds in the greenhouse.

Treatments in Roentgen (R)	Varieties		
	Sinjar	Egyptian	French
0	66.0±3.256	79.9±3.545	69.4±3.436
100	91.0±2.955*	81.8±3.524	70.7±3.159
250	85.3±3.774*	80.8±4.714	75.6±2.446
500	81.2±4.844*	80.4±3.902	81.7±3.246*
750	87.8±2.149*	77.1±3.138	73.3±3.194
1000	86.5±5.212*	78.1±2.972	76.0±3.815

*Significantly different from control mean, (P=0.05).

M_2 generation

Flowering time of all the irradiated populations (except Sinjar at 1000R) in all the three varieties was lower than their respective controls (Table 3). This earliness in flowering was significant in Egyptian and French at all dose levels (except French at 100R) but only at 250 and 750R in the case of Sinjar variety. It may be noted that the trends in earliness of flowering exhibited in M_1 were also manifested in M_2.

The estimates of within-plot variance for control and irradiated treatments in the M_2 generation are also shown in the Table 3. In the non-irradiated controls, the within-plot variance is assumed to be mainly of environmental origin. Hence, it is possible to estimate the induced genetic variance in each of the irradiated treatments by computing the difference between their respective within-plot variances and within-plot variances of control. This derived variance component, "genetic variance" estimates the transmissible variation induced by radiation. This genetic variance was further used to determine the heritability of these characters in a broad sense.

Although, within-plot variances for flowering time in each variety were greater (range being 1.1-15) than that of their respective controls at all radiation levels but were statistically significant only at certain doses. (Table 3). Also, there was no relationship between the magnitude of irradiation and the amount of genetic variance in all the three varieties; the pattern being irregular like within-plot variance. Daly (1973) also reported similar results in *Arabidopsis thaliana*. Pooling together the genetic variability of all the irradiated populations of each variety separately, revealed that Sinjar had the highest genetic variability followed by Egyptian and French. Further, the specific radiation dose inducing the greatest amount of genetic variability was also different in different varieties; being 500R in Sinjar, 100R in Egyptian and 250R in the case of French. Higher variability created in Sinjar by gamma radiation might be due to its background genotype as suggested by Gregory (1955), Brock

TABLE 3. Analysis of flowering time distribution in the M_2 generation for three broad bean varieties grown in the field.

Treatments in Roentgen (R)	Varieties	Flowering time (days)	Within-plot variance	Gentic variance	Herita-bility
0	Sinjar	120.2±0.747	2.23	——	——
	Egyptian	123.3±0.653	3.41	——	——
	French	122.6±0.319	1.53	——	——
100	Sinjar	118.9±0.526	2.77	0.54	0.20
	Egyptian	118.8±1.017*	24.84**	21.43	0.86
	French	122.0±0.574	4.62**	3.09	0.67
250	Sinjar	109.5±1.289*	28.26**	26.03	0.92
	Egyptian	118.4±0.703*	7.41	4.00	0.54
	French	118.3±0.756*	7.43**	5.90	0.79
500	Sinjar	114.0±1.972	35.00**	32.77	0.94
	Egyptian	118.2±0.807*	7.17	3.76	0.52
	French	118.1±0.467*	3.06	1.53	0.50
750	Sinjar	114.6±0.713*	14.74	12.51	0.85
	Egyptian	114.8±1.171*	21.93**	18.52	0.84
	French	119.7±0.350*	1.72	0.19	0.11
1000	Sinjar	125.3±0.482*	3.73	1.50	0.40
	Egyptian	112.4±0.873*	17.53**	14.12	0.80
	French	117.3±0.563*	6.02**	4.49	0.75

*Significantly different from control mean, (P=0.05).
**Significantly greater than control variance, (P=0.05).

(1971) and Ojomo & Chheda (1972) in other crops. Sinjar is a local variety not exposed to any extensive artificial selection, thus being more succeptible to irradiation treatments in contrast to the introduced French and Egyptian varieties. The predicted heritability estimates range was highest and rather narrow in the case of Egyptian variety (0.52-0.86) followed by Sinjar (0.20-0.94) and French (0.11-0.79).

Stem length increased in all the radiation treatments in French and Sinjar varieties (Table 4). In the French variety the increase was significant at all (except 100R) dose levels but in Sinjar only at 250 and 500R. The Egyptian variety also exhibited a slight non-significant increase at 250 and 500R doses. A critical examination of Tables 2 and 4 will reveal that the behaviour of the plants in all the vaieties in M_2 as regards height was essentially similar to that in M_1.

Within-plot variances in all the irradiated populations of all the varieties were higher than the control variances in the range of 3-38 times. In Egyptian and French increase being statistically significant at all dose levels (except Egyptian at 250R). The general pattern of genetic variance for stem length was also irregular like the flower-

TABLE 4. Analysis of stem length distribution in the M_2 generation for three broad bean varieties grown in the field.

Treatments in Roentgen (R)	Varieties	Stem length (cm)	Within-plot variance	Genetic variance	Herita-bility
0	Sinjar	77.6±2.926	42.80	——	——
	Egyptian	51.2±1.067	5.70	——	——
	French	55.7±1.328	24.68	——	——
100	Sinjar	84.4±2.348	126.80	84.00	0.66
	Egyptian	50.6±3.010	217.55**	211.85	0.97
	French	57.0±3.139	137.92**	113.24	0.82
250	Sinjar	97.2±3.240*	178.53	135.73	0.76
	Egyptian	52.1±1.187	21.13	15.43	0.73
	French	66.3±4.952*	318.73**	294.05	0.12
500	Sinjar	102.3±3.708*	123.75	80.95	0.65
	Egyptian	55.2±1.939	41.37**	35.67	0.86
	French	76.7±2.579*	93.10**	68.42	0.73
750	Sinjar	86.7±2.056	140.38	97.58	0.70
	Egyptian	47.9±2.487	99.00**	93.30	0.94
	French	69.5±5.702*	455.19**	430.51	0.94
1000	Sinjar	89.0±3.325	194.66	151.86	0.78
	Egyptian	50.2±2.631	159.18**	153.48	0.96
	French	70.0±2.454*	114.38**	89.70	0.78

*Significantly different from control mean, (P 0.05)..
**Significantly greater than control variances, (P 0.05).

ing time variance. However, French variety showed greatest genetic variability followed by Sinjar and Egyptian. The specific radiation dose inducing greatest amount of genetic variability was also different in different varieties and dissimilar to those from the flowering time (being 750R in French, 100R in Egyptian and 1000R in Sinjar). High degree of variability in French variety may be due to its lack of adaptation to the Iraqi enviornmental conditions. However, the ranges of predicted heritability estimates were higher and much narrower than those of the flowering time estimates in all the varieties; being 0.73-0.97 in Egyptian, 0.73-0.94 in French and 0.65-0.78 in the case of Sinjar variety.

The ranges of predicted heritability estimates (especially that of stem lengeth) shown by these broad bean varieties were much higher than those calculated for *Arabidopsis thaliana* by Daly (1973). This indicates that significant gains could be expected from selection. Whether, the predicted responses to selection can be realized will obviously depend upon breeding test, particularly since the heritability values may over-estimate the proportion of the total variance which can be utilized by selection.

The results show that in both the characters studied, the increase in variance was not proportional to the dose. Lack of a consistent dose-response relationship for gamma rays may be due to additional uncontrolled environmental variation, for the response to ionizing radiation is notably modified by environmental variables such as seed moisture and oxygen availability (Conger, *el al.* 1966). Daly in two separate studies (1960 & 1973) on the same plant has contested that the genetic alteration induced by gamma rays reflected by increased variance in quantitative traits was oxygen dependent. If oxygen was excluded from the water during post-irraditation treatment of seeds in the chilled water then the genetic variance was not proportional to the dose.

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