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Analysis of Genetic Variability, Heritability and Genetic Advance in *Phaseolus vulgaris* L.

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A B S T R A C T

French bean *(Phaseolus vulgaris* L.) belongs to the family Fabaceae. It is also known as *rajmash*, *rajma (Hindi)*, haricot bean, kidney bean, common bean, snap bean or navy bean. It is also known as *Ghewada* in Marathi. It is native of South America Experimental genotype selected for the present investigation was French bean *Phaseolus vulgaris* L. The experimental seed material of French bean variety – *Varun* collected from Ganeshkhind, Dist: Pune, Maharashtra, India released by Mahatma Phule Agricultural University, Rahuri, Dist- Ahmednager Maharashtra, India. The fresh, aqueous solutions of the mutagen were prepared prior to treatments. The different concentrations used for the chemical mutagenic treatments were 0.1%, 0.15%, 0.20% and 0.25 of EMS. The seed samples were exposed to doses of 30kR, 40kR, 50kR and 60kR of Gamma rays. In the combination, Gamma rays and EMS were used like 30 kR+0.10%, 40 kR+0.15%, 50 kR+0.20% and 60 kR+0.25%. From each concentration/dose of mutagen about 25 plants from the progeny were randomly selected, harvested and collected seeds for further generations. The observations were recorded in M_2, M_3 and M_4 generations. These five quantitative characters were recorded at the time of harvesting of plants. The data of quantitative characters like plant height, number of pods per plant, length of pods, number of seeds per pod and weight of 100 seeds were studied.

Introduction

French bean (*Phaseolus vulgaris* L.) belongs to the family Fabaceae. It is also known as *rajmash*, *rajma (Hindi)*, haricot bean, kidney bean, common bean, snap bean or navy bean.

It is also known as *Ghewada* in Marathi. It is native of South America. It is domesticated in various countries like Mexico, Peru and Colombia since 8000 years. It is widely cultivated in tropics, sub tropics and temperate regions. It is also cultivated in India and part of the tropical Asia.

The plant of French bean is erect, semi-erect, prostrate or climbing type with tap root system and which is annual crop. It is consumed as immature tender fruits and green grains as vegetables. French bean is one of the oldest sources of human food. It is used as pulse in India as well as green fodder with it other crops like Sorghum, Pearls, Millets and Maize. It forms a palatable fodder when mixed with cereals. The French bean can be said as a versatile crop because of the following reasons:

It is the most suitable crop of marginal farmers in the arid and semi-arid regions. It needs low inputs and less care after cultivation. As it is leguminous crop help in soil enrichment by the atmospheric nitrogen fixation and increase in micro flora. It is uses in multi cropping pattern with other crops due to less harvesting period. It has medicinal properties. As it is a good source and highly demanded vegetable. It provides good test as well as nutritious value.

They contain carbohydrates; proteins, vitamin C, calcium, iron and phosphorus provide good nutritional quality. It is low in fat and high fiber content. It is drought tolerance and highly adapted in poor and erratic rains condition. The pulses are belongs to the family Fabaceae which is also known as food legumes. Pulses are second important group of the crops after cereals. Pulses are the most important crops of Indian Agriculture. The member of Fabaceae family includes the economically important legume like pulses, oil seed, forage and fodder crops and also shrubs and tropical or subtropical trees. These pulses are chickpea, pigeon pea, lentil, moonbeam, urdbean, field pea, grass pea, French bean, common bean and horse gram. The split grains of these pulses are known as dal which is excellent source of high quality of proteins, amino acids, fatty acids, fibers, minerals and vitamins. The pulses are rich in plant proteins and cereals are rich in carbohydrates, which are an excellent combination for a balanced human diet. Legumes are more superior to cereals as sources of micronutrients. Pulses are being consumed due to presence of various amino acids. As a rich source of proteins, legumes also provide a nutritional fodder for cattle.

Materials and Methods

The experimental seed material of French bean variety – *Varun* collected from Ganeshkhind, Dist: Pune, Maharashtra, India released by Mahatma Phule Agricultural University, Rahuri, Dist-Ahmednager Maharashtra, India.

The following Physical and Chemical mutagens were used for the present research studies.

1. Physical Mutagen – Gamma Rays

2. Chemical Mutagen – Ethyl Methane-sulphonate (EMS)

3. Combination of Gamma Rays and Ethyl Methanesulphonate (EMS)

Mode of Treatment

Gamma rays

Healthy, uniform size and dry seeds of the French bean variety – *Varun* were packed in polythene bags and sealed for the Gamma radiation. Electromagnetic, ionizing radiations were applied from Co^{60} source of irradiation. Gamma radiation was carried out at Nuclear Chemistry Division, Department of Chemistry, University of Pune, Ganeshkhind, and Pune - 411007. The seed samples were exposed to doses of 30kR, 40kR, 50kR and 60kR of Gamma rays.

Ethyl Methanesulphonate (EMS)

Ethyl Methanesulphonate (EMS) was obtained from Spectro chem. Pvt. Ltd. Mumbai (India) with a molecular weight 124.16 g/mol and its density 1.20 g/cm^3 to determine the lethal dose (LD_{50}) at suitable concentration of mutagen for the further study.

Chemical mutagenic treatments were administered at room temperature of 25 ± 2°C. Healthy and dry seeds of the French bean variety– *Varun* having uniform size were selected for the treatment. Seeds were surface sterilized with 0.1% mercuric chloride solution for about one to two minutes than washed thoroughly and soaked in distilled water for 6 hours for pre -soaking of seeds, which were made the seed coat permeable for the mutagenic treatment.

The fresh, aqueous solutions of the mutagen were prepared prior to treatments. The different concentrations used for the chemical mutagenic treatments were 0.1%, 0.15%, 0.20% and 0.25%. After the pre - soaking seeds were immersed in the mutagenic solution for 4 hours with continuous shaking. The volume of the chemical solution used was five times more than that of the seeds to facilitate uniform absorption.

Seeds soaked in distilled water for 6 hours served as control. Immediately after the completion of treatment, the seeds were washed thoroughly under running tap water for 3 to 4 times. Later on they were subjected to post - soaking in distilled water for 4 hours.

Combination of Gamma Rays and Ethyl Methanesulphonate (EMS)

For the combination treatments Gamma rays irradiated seed samples were used. After the physical mutagenic treatment, chemical mutagenic treatment of EMS was conducted on the same seed samples. In the combination, Gamma rays and EMS was used like 30 kR+0.10%, 40 kR+0.15%, 50 kR+0.20% and 60 kR+0.25%. For each treatment, a batch of 500 seeds was used. From each treatment 100 seeds were plotted between the folds of filter paper and kept in dark at room temperature, which was used to record the germination percentage and seedling injury. Another 100 seeds were kept in filter paper and germinated in petriplates after three days to raise the root tips required to study cytological preparations for the mitotic index and screening of chromosomal abnormalities. The remaining lots of 300 seeds of each treatment along with control (untreated seeds) were sown in research field by Complete Randomized Block Design (CRBD) with three replications in order to raise the M_1 generation.

Coefficient of variation

The genotypic and phenotypic coefficient of variations was calculated following the formulae given by Burton and De Vane (1953).

$$GCV = \frac{\sqrt{\sigma^2 g}}{\overline{X}} \times 100$$

$$PCV = \frac{\sqrt{\sigma^2 p}}{\overline{X}} \times 100$$

Where,

$\sigma^2 g$ = Genotypic variance for the character
$\sigma^2 p$ = Phenotypic variance for the character
X = Mean for the character

Broad sense heritability

Heritability in broad sense was estimated for various characters as suggested by (Hanson *et al.*, 1956).

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

$\sigma^2 g$ = Genotypic variance
$\sigma^2 p$ = Phenotypic variance

Genetic Advance (GA)

Genetic advance (at 5% selection intensity) was calculated by the formula suggested by the (Johnson *et al*., 1955).

$$G.A = K \frac{\sigma^2 g}{\sigma^2 p} \times \sigma^2 p$$

Where,

$\sigma^2 g$ = Genotypic variance
$\sigma^2 p$ = Phenotypic variance
K = Selection differential as defined by Lush (1949),
(At 5% selection intensity, the value of K = 2.06).

Results and Discussion

Experimental observations

Analysis of Genetic Variability, Heritability and Genetic Advance: (Table Nos.1 to 9)

In *Phaseolus vulgaris* L. statistical analysis of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance (GA) has been computed for the quantitative traits like Plant height, Number of pods per plant, Length of pod, Number of seeds per pod and 100 seeds weight. Calculation of heritability and genetic advance for different traits in French bean populations were carried out to enable selection of desired genotypes. Induced variability was calculated in following treatments of Gamma rays, EMS and Combination of both treatments in seven different yield-contributing traits of French bean in the M_2 M_3 and M_4 generations.

Phenotypic and Genotypic Coefficient of Variation

In *Phaseolus vulgaris* L. studied the different seven characters has been observed in population after three mutagenic treatments and computed their phenotypic coefficients of variation and genotypic coefficients of variation of M2, M3 and M4 generations. The genetic parameters like PCV and GCV of different characters and their wide range for plant height, days to maturity, days to flowering, number of pods per plant, length of pod, number of seeds per pod and 100 seeds weight were calculated for M_2, M_3 and M_4 generations.

The character like plant height obtained highest value of (13.800) PCV after treatment of Combination in M_3 generation and lowest value (4.512) recorded after Gamma rays treatment in M_2 generation. The GCV was calculated for the plant height and the trend was to be found quite similar to the PCV. PCV and GCV were calculated for the parameter like number of pods per plants. It was found that the PCV value (19.38) to be highest after treatment of EMS mutagen and lowest value was (6.533) after Gamma rays treatment and similar trend was found for GCV.

For the other parameter like length of pod showed the highest value (17.83) for PCV and (17.21) for GCV after treatment of Gamma rays and the lowest value (9.27) for PCV and (7.01) for GCV after treatment of Gamma rays. The PCV and GCV calculated for parameter number of seed per pod showed maximum PCV (13.68) and GCV

(12.86) for Combination treatment and minimum value for PCV (8.05) and GCV (5.08) for gamma rays treatment in M_2 generation. For the other parameter like days to maturity highest PCV (17.57) and GCV (11.43) was observed in Combination treatments, whereas lowest PCV (2.01) was in EMS treatment and GCV (0.51) was observed in Combination treatments of M_3 generation.

The difference between PCV and GCV values was higher for parameter like number of pods per plants and length of pod was observed in present investigation of French bean. The similar result was reported by (Yucel *et al*., 2006) due to influence of environment on the expression of character. The high value of PCV for number pods per plant was reported by (Trehan *et al.,* 1970; Arora, 1991). The similar result was reported by many researchers like (Damarany 1994; Umaharan *et al.,* 1997; Ubi *et al.,*) according to them, these characters may be under genetic control rather than environmental influence, therefore the improvement of these character can be achieved through selection pattern (Oyiga and Uguru, 2011) The PCV and GCV values was moderate for plant height, days to flower and days to maturity in French bean.

Similar result was observed by (Lesley, 2005) indicated that selection for these character was less effective when compared to high PCV and GCV. The higher PCV and GCV for number of Pods per plants and length of pod was found in variation of French bean. The similar result was reported by (Rajaravindran and Das, 1997; Resmi, 1998 and (Vardhan and Savithramma,1998) many researchers have obtained same results like Arulbalachandran *et al.* (2010) in Black gram, (Anbu Selvam *et al*., 2010) in Black gram. (Wani, 2011) in Chickpea, (Azad, 2012) in Mungbean and (Shinde, 2013) in Cluster bean.

Heritability and Genetic Advance

Heritability estimates were very high for some characters observed in French bean after mutagenic treatments in M_2 M_3 and M_4 generations the values were especially high for 100 seed weight, plant height and length of pod. The similar result was reported by (Resmi, 1998; Thiyagarajana, 1989), (Vardhan and Savithramma, 1998), (Shree kumar *et al*., 1996), (Idahosa, 2010) and (Singh, 2001) according to them, if the heritability character is very high for e.g. 70% or more then selection for trait could be fairly easy because the relation between phenotypes and genotypes was relatively small contribution of environment to phenotype. There was also comparatively high genetic advance for plant height, days to maturity and days to flower were estimated in present investigation. (Gupta and Lodhi, 1979) reported the similar result, according to them, the plant height showed high estimate of genetic advance.

Heritability combined with genetic advance is more reliable index for selection of trait was reported by (Ubi *et al*., 2001) high heritability and high GA was estimated for character like Plant height, number of pods, days to maturity and 100 seed weight in present work.

The similar finding was reported by (Nehru *et al*, 2009) and (Vinita Kumasi, 2003), (Ashok *et al*., 2003) suggested that the mass selection of plant breeding method of improvement characters controlled by additive gene action.

Table.1 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M2 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	4.512	6.53	9.27	8.05	2.59	4.72	2.19
GCV%	2.45	5.13	7.01	5.08	2.07	3.99	1.67
h2	29.49	61.77	57.20	39.88	64.06	71.39	58.11
GA%	1.00	0.83	1.21	0.43	2.14	2.60	1.64

Table.2 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M2 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	6.07	15.52	13.71	9.70	3.84	6.17	5.78
GCV%	4.64	13.41	13.35	8.49	3.70	5.23	5.56
h2	58.38	74.62	94.76	76.67	93.15	71.68	92.61
GA%	2.29	3.03	3.46	1.17	4.87	3.62	7.17

Table.3 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M2 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	13.85	10.57	10.24	13.68	3.50	9.80	2.85
GCV%	13.42	4.20	7.88	12.86	1.93	8.57	1.87
h2	93.99	15.80	59.26	88.31	3.38	76.48	42.97
GA%	7.53	0.31	1.19	1.48	1.33	4.84	1.53

Table.4 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M3 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	8.99	11.47	8.67	8.92	3.18	4.51	4.41
GCV%	5.10	9.61	7.47	7.43	2.21	2.45	4.41
h2	32.21	70.12	74.12	69.34	48.31	29.49	99.94
GA%	1.96	1.93	1.52	0.86	1.94	1.00	1.17

Table.5 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M3 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	6.00	17.97	18.59	9.97	4.13	3.86	4.35
GCV%	5.23	16.38	17.80	8.70	3.91	3.19	3.95
h2	76.04	83.05	91.65	76.10	89.58	68.28	82.31
GA%	2.82	4.42	4.58	1.21	4.98	2.05	4.68

Table.6 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M3 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	13.80	11.35	5.87	9.58	3.10	12.89	3.18
GCV%	13.40	8.25	4.66	8.10	0.51	11.76	1.94
h2	94.40	52.83	63.14	71.50	2.79	83.26	37.37
GA%	7.01	1.40	0.77	0.86	0.10	6.69	1.49

Table.7 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M4 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	5.84	11.77	8.68	12.76	5.16	3.86	4.74
GCV%	4.65	10.48	7.82	10.48	3.96	3.19	4.22
h2	63.51	79.16	81.07	67.42	58.75	68.28	79.18
GA%	2.64	2.41	1.69	1.34	3.74	2.05	4.74

Table.8 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M4 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	3.70	19.38	17.83	12.78	2.01	5.73	4.52
GCV%	3.06	18.89	17.21	12.04	1.66	2.28	4.44
h2	68.49	94.97	93.24	88.81	68.34	15.82	96.49
GA%	1.76	5.76	4.64	1.95	1.80	0.68	5.79

Table.9 Effect of gamma rays treatment on variability parameters of *Phaseolus vulgaris* L.in M4 generation

Variability parameters	Plant height	No.of per pods plant	Length of pod	No.of seeds per pods	Days to maturity	Days to flower	Weight of 100 seeds
PCV%	5.84	14.98	5.87	9.58	11.57	11.78	3.17
GCV%	4.65	11.17	4.66	8.10	11.43	11.06	2.30
h2	63.51	55.57	63.14	71.50	97.64	88.15	52.71
GA%	2.64	2.14	0.77	0.86	12.69	6.45	2.07

High heritability combined with the moderate GA was noticed in many characters. The heritability and GA has estimate the combine effects in the characters like days to maturity, days to flower, and number of pods per plant was estimated in present investigation of French bean. Similar result have been reported for days to flower (Lesley, 2005), (Manju and Screelathanakumari, 2002) and (Apte, 1987). Days to maturity (Lesley, 2005)

This combines process of heritability and GA of non-addictive gene action which might be epistemic and or dominance effect. Many researchers have obtained same results like (Arulbalachandran *et al.*, 2010) in Black gram, (Anbu Selvam *et al.*, 2010) in Black gram. Wani (2011) reported in Chickpea, Azad (2012) in Mungbean and (Shinde, 2013) in Cluster bean.

In conclusion, statistical analysis of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance (GA) for plant height, number of pods per plant, length of pods, number of seeds per pod and weight of 100 seeds were carried out. Estimates of heritability and genetic advance for different traits in French bean population were carried out to enable selection of desired genotypes. Induced variability was calculated in EMS, Gamma rays and Combination treatments in five different yield-contributing traits of French bean in the different generations.

A phenotypic coefficient of variation (PCV) was higher than its genotypic coefficients of variation (GCV) for the studied characters. This resemblance between PCV and GCV in almost all the characters suggests that the environment had effect on those characters expression. Higher heritability coupled with high genetic advance was observed for quantitative traits like Number of pods per plant, Length of pod, Number of seeds per pod, Plant height, Weight of 100 seeds. In modern plant breeding one of the major trends has been supporting the traditional methods by biochemical studies, so as to obtain a better value of a progeny in breeding.

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