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Assessing of genetic variability, heritability and genetic advance in faba bean (*Vicia faba* L.) under sodic soil

Amit Kumar Chaudhary, Shiva Nath, Suraj Kumar Hitaishi and Akriti dutt

Abstract
The present investigation was undertaken with the objectives of genetic variability, heritability, and genetic advance in faba bean (*Vicia faba* L.) under sodic soil. The experiment was conducted at Genetics and Plant Breeding Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during *Rabi*, 2018-19. The experimental materials of faba bean for this investigation comprised of 65 entries (45 F_1's, 18 parents along with two check varieties *viz.*, Vikrant and HFB 1) for fourteen characters under salt-affected soil in Randomized Block Design with three replications. The soil type of the experimental site was sandy loam, low in organic carbon, nitrogen, and phosphorus and rich in potash (EC-3.2dSm^{-1}; ESP-45% and pH-9.2). The analysis of variance revealed that all the treatments were highly significant for the yields and its contributing traits indicated sufficient variation among the treatment/materials under study. In general, PCV were higher than the GCV for all characters under salt-affected soil indicates the influence of the environment. High heritability coupled with high genetic advance were observed for leaf nitrogen, grain yield per plant, chlorophyll content, biological yield per plant, and number of pods per plant indicates that presence of additive gene action. Hence, emphasis should be given to select these quantitative traits to enhance the yield potential of faba bean (*Vicia faba* L.) under salt-affected soil.

Keywords: Genetic variability, heritability, genetic advance, faba bean, sodic soil

Introduction
Faba bean (*Vicia faba* L.) is one of the most established legume crops grown by man food, feed, forage, and soil improvement. It can in reality be an exceptionally beneficial crop, being fit for fixing air nitrogen and indicating improved weed and infection control in subsequent crops (Preissel *et al.*, 2015) [12] alongside cold/frost (Sallam *et al.*, 2015) [14], and saltiness tolerance, consequently assisting with combatting environmental change. It is the world's fourth most significant legume crop and it is picking up significance as a grain legume for protein security around the world (Kumar, 2016 and Kaur *et al.*, 2014) [9, 3]. The major faba bean growing nations are China (1.80 Mt), Ethiopia (0.93 Mt), Australia (0.37Mt), Germany (0.19 Mt), France (0.19 Mt), Egypt (0.11 Mt), and Sudan (0.11 Mt). China is the leading producer with 37% share of the world's total faba bean production (FAOSTAT, 2019) [4]. It has been sorted as an underutilized legume crop of potential value in India. Faba bean entered India through Mesopotamia most likely after the coming of the Arabian spice shipping lane which appeared around 3000 B.C. It is a *Rabi* season crop in India and has been accounted for to be developed inconsistently in Bihar and connecting states where its raw pods are eaten as a vegetable. It adds to human sustenance because of its higher protein content and other fundamental supplements. Immature faba bean is utilized as a quality vegetable, numerous antioxidants, and essential vitamins including carbohydrates and proteins (Sheelamary, 2015) [16]. Low realized yield and yield instability is the major challenges faba bean breeding programs. Probably, the non-availability of high yielding varieties with quality pods constitutes the major limiting factor of this crop. This indicated the need for variability studies in faba bean to exploit its potential against malnutrition and hidden hunger. The line x tester analysis method introduced by Kempthorne (1957) [8] is one of the powerful tools available to estimate the combining ability analyses to help in the identification of desirable parents and crosses for their further exploitation in the breeding program. Assessments of genetic parameters indicate the relative importance of the various types of gene effects affecting the total variation of a plant character. Genetic gain from the selection depends upon the extent of genetic variability and magnitude of genetic variance from these variations (Fikreselassie, 2012) [5]. Johnson, Robinson, and Comstock (1955) [6] announced the huge significance varieties for quantitative and yield ability

in any breeding program before such varieties can be introduced to a given neighborhood condition. Past investigations (Alghamdi, 2007) [1] demonstrated that huge contrasts were seen among different genotypes through genetic variability studies between yield and yield components in faba bean genotypes. Keeping this in view, the present investigation was carried out to genetic variability, heritability, and genetic advance in faba bean (*Vicia faba* L.) under sodic soil.

Materials and methods

The present investigation was carried out during Nov. 2017-18 and 2018-19 at Genetics and Plant Breeding Research Form, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.). The experimental material was based on a line x tester set of 45 hybrids (F_1's) developed by the crossing of 15 lines (females) with 3 testers (males). The fifteen lines *viz.*; HB 11-32, HB 11-15, HB 12-34, HB 11-12, HB 14-20, HB 14-74, HB 14-21, HB 12-42, HB 14-48, NDF 8, HB 82, HB-28, HB 74, HB 90, HB 184 with 3 testers (males) *viz.*, HB 12-8, HB 12-37 and NDFB 14. The 45 F_1's along with their parents including two checks; *viz.*, Vikrant, and HFB-1 were evaluated in Randomized Block Design with three replications during R*abi* 2018-19. Each plot was consisting of a single row of 4m length with inter and intra row spacing of 30 cm and 10 cm, respectively. The soil type of the experimental site was sandy loam, low in organic carbon, nitrogen, phosphorus and rich in potash (EC, 3.2dSm^{-1}; ESP, 45% and pH, 9.2). Uniform cultural practices were followed as per the recommended package of practices. Observations were made on the characters *viz.*, days to 50 per cent flowering, days to maturity, chlorophyll content, plant height (cm), number of branches per plant, pod length (cm), number of pods per plant, number of seeds per pod, biological yield per plant (g), harvest-index (%), 100-seed weight (g), protein content (%) and grain yield per plant (g). Analysis of variance was calculated on the method suggested by Panse and Sukhatme (1985) [13]. The phenotypic and genotypic coefficients of variation (PCV and GCV) were estimated as per Burton and Devane (1953) [2]. Heritability in the broad sense and genetic advance (in terms of percentage of mean) were computed according to Johnson *et al*. (1955) [6]. Recommended cultural practices were adopted to raise a worthy crop. The mean data of different traits were subjected to analyze by standard statistical and biometrical method for Line x Tester analysis.

Results and discussion

The mean squares due to treatments were highly significant for all the fourteen characters which showed significant differences, indicating the presence of sufficient variability in the materials. The variances due to replications were found significant for seven characters *viz.*, chlorophyll content, leaf nitrogen, plant height, number of branches per plant, biological yield per plant, protein content, and grain yield per plant and non-significant for the rest of the characters (Table 1). The success of selection in improving plant characters depends mainly on the presence of substantial genetic variability and the nature of heritability and gene action. The genetic variability is the raw material of plant breeding programs on which selection acts to evolve superior genotypes. The phenotypic, genotypic, and environmental coefficients of variation can be used for assessing and comparing the nature and magnitude of variability existing for different characters in the breeding materials. Heritability in broad-sense quantifies the proportion of heritable genetic variance to total phenotypic variance, while heritability in narrow-sense represents the ratio of fixable additive genetic variance to total phenotypic variance. Estimates of heritability help in estimating expected progress through selection. The genetic advance in per cent of mean indicates the expected selection response by taking into account the existing genetic variability and heritability of the character (Table 2).

The magnitude of the PCV was higher than the corresponding GCV for all the traits. The high (>20%) PCV and GCV were not estimated for any characters. The moderate phenotypic and genotypic coefficient of variation (10-20%) were estimated for number of branches per plant (PCV=19.38%, GCV=15.37%), grain yield per plant (PCV=16.07%, GCV=14.63%), number of pods per plant (PCV=16.03%, GCV=13.43%), biological yield per plant (PCV=14.74%, GCV=13.08%), leaf nitrogen (PCV=13.14%, GCV=12.61%), chlorophyll content (PCV=12.70%, GCV=11.33%). Shrifi (2015) [15] also reported moderate PCV and GCV for pods per plant which could be due to variation in genetic material and environmental conditions. The moderate estimates of PCV and low estimates of GCV were recorded for pod length (PCV=16.57%, GCV=9.35%), number of seeds per pod (PCV=12.34%, GCV=7.92%) and harvest index (PCV=10.68%, GCV=9.08%). The low estimates (<10%) PCV and GCV recorded for protein content, 100-seed weight, days to 50% flowering, plant height, days to maturity. Kalia (2003) [7] and Peksen (2007) [8] also reported similar findings. Moreover, the differences between PCV and GCV were very narrow which indicated the importance of genetic variance in the inheritance of the studied characters. Little environmental effect on the expression of these characters. It is interesting to note that the differences between GCV and PCV values were at minimum implying the least influence of environment and additive gene action and effects indicating that genotypes can be improved and selected for these characters.

The scale of PCV, GCV and genetic advanced (GA) in per cent of mean

S. N.	PCV, GCV and GA in per cent of mean	Scale/Rate
1.	High	>20%
2.	Moderate	10-20%
3.	Low	<10%

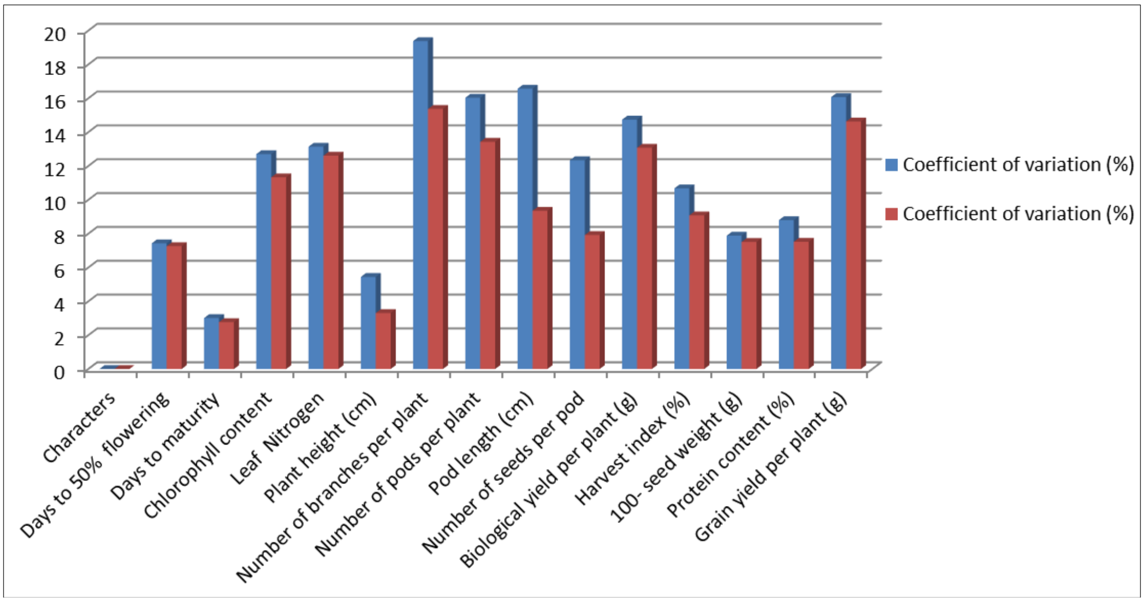

Fig 1: Phenotypic and Genotypic Coefficient of variation (PCV and GCV) in faba bean

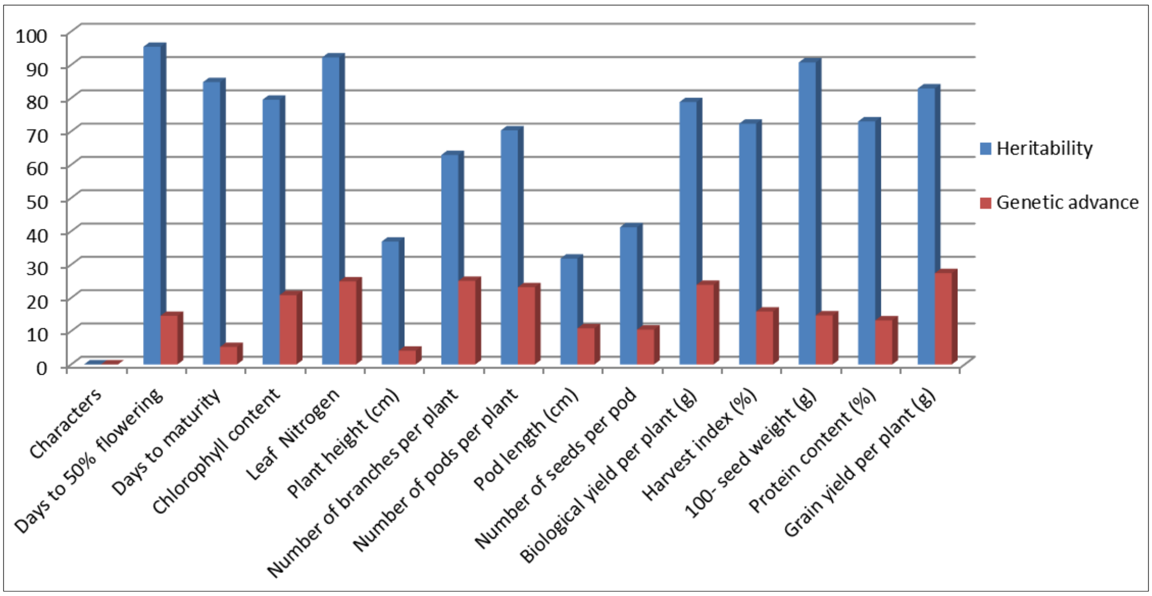

Fig 2: Heritability and genetic advance in faba bean

The proportion of genetic variability which is transmitted from parents to offspring is reflected by heritability. High estimates of broad-sense heritability (>75%) were recorded for the days to 50% flowering, leaf nitrogen, 100-seed weight, days to maturity, grain yield per plant, chlorophyll content, biological yield per plant, protein content, harvest index, number of pods per plant in crosses. Earlier research workers have also observed high heritability estimates in their respective studies by using different breeding material for days to 50% flowering (Sheelamary and Shivani, 2015) [16], plant height (Toker, 2004) [18], pod length (Shrifi, 2015) [15]. The moderate estimates of heritability (50-75%) were recorded for number of branches per plant and low estimates of broad-sense heritability (>50%) were recorded for number of seeds per pod, plant height, and pods length.

The scale of broad-sense heritability

S.N.	Heritability	Scale/Rate
1.	High	>75%
2.	Moderate	50-75%
3.	Low	<50%

The genetic advance in per cent of mean was found to be very high (>20%) for grain yield per plant (27.43%), number of branches per plant (25.11%), leaf nitrogen (24.95%), biological yield per plant (23.92%), number of pods per plant (23.20%), chlorophyll content (20.82%). Solieman and Ragheb (2014) have also reported high genetic advance for pods per plant, total yield per plant, pod weight, branches per plant, and plant height. Moderate genetic advance in per cent of mean (10-20%) was noted for harvest index (15.89%), 100-seed weight (14.73%), days to 50% flowering (14.60%), protein content (13.23%), pod length (10.87%), and number of seeds per pod (10.47%). On the other hand, low estimates (<10%) were noted for days to maturity and plant height. High heritability coupled with very high genetic advance in per cent of mean were observed for the characters like leaf nitrogen, grain yield per plant, chlorophyll content, biological yield per plant, and number of pods per plant. Whereas, characters namely, days to 50% flowering, nodes per plant, pod length, plant height, branches per plant, seeds per pod, days to maturity, seed yield per plant, 100-seed weight, showed the same results for heritability. High heritability coupled with the moderate genetic advance in per cent of mean was observed for days to 50% flowering, 100-seed weight, protein content, and harvest index. Low heritability with low genetic advance was observed for plant height. These observations are in agreement with the earlier reports of by, Alghamdi (2007) [1], Toker (2007) [18], and Mulualem (2013) [10].

Table 1: Analysis of variance for randomized block design for 14 characters in faba bean (*Vicia faba* L.) under sodic soil

S. N.	Characters	Sources of variation		
		Replications	Treatments	Error
	d.f.	2	64	128
1.	Days to 50% flowering	1.98	58.63**	0.93
2.	Days to maturity	0.00	42.64**	2.41
3.	Chlorophyll content	0.95**	2.17**	0.17
4.	Leaf Nitrogen	0.001*	0.007**	0.0002
5.	Plant height (cm)	203.44**	49.77**	18.05
6.	Number of branches per plant	0.79**	0.73**	0.12
7.	Number of pods per plant	6.46	31.17**	3.85
8.	Pod length (cm)	0.69	1.07**	0.44
9.	Number of seeds per pod	0.04	0.34**	0.11
10.	Biological yield per plant (g)	44.44*	134.08**	11.06
11.	Harvest index (%)	0.44	46.73**	5.30
12.	100- seed weight (g)	0.17	12.90**	0.43
13.	Protein content (%)	4.42*	10.18**	1.12
14.	Grain yield per plant (g)	6.94*	27.38**	1.77

*, ** Significant at 5% and 1% probability levels, respectively.

Table 2: Estimates of general mean, phenotypic (PCV), genotypic (GCV) coefficient of variation, heritability in broad sense (h^2_{bs}) and genetic advance in per cent of mean for 14 characters in faba bean (*Vicia faba* L.) under sodic soil

S. N.	Characters	General mean ±SE	Range		Coefficient of variation (%)		Heritability in broad sense (%)	Genetic advance in per cent of mean
			Parents	Crosses	PCV	GCV		
1.	Days to 50% flowering	60.43±0.558	58.67-71.00	54.33-63.33	7.43	7.26	95.40	14.60
2.	Days to maturity	132.02±0.897	126-140.95	124-139	3.01	2.77	84.80	5.25
3.	Chlorophyll content	7.20 ±0.239	6.14-9.47	4.89-9.21	12.70	11.33	79.50	20.82
4.	Leaf Nitrogen	0.39 ±0.008	0.34-0.47	0.26-0.53	13.14	12.61	92.20	24.95
5.	Plant height (cm)	98.33±2.453	90.15-105.42	91.55-105.66	5.44	3.31	36.90	4.14
6.	Number of branches per plant	2.93±0.200	2.53-4.40	2.13-3.93	19.38	15.37	62.90	25.11
7.	Number of pods per plant	22.55±1.133	15.31-24.86	15.80-29.06	16.03	13.43	70.30	23.20
8.	Pod length (cm)	4.87±0.385	3.43-6.44	3.95-6.59	16.57	9.35	31.80	10.87
9.	Number of seeds per pod	3.51±0.191	2.96-3.96	2.82-4.39	12.34	7.92	41.20	10.47
10.	Biological yield per plant (g)	49.19±1.920	36.74-62.66	39.83-63.45	14.74	13.08	78.80	23.92
11.	Harvest index (%)	40.91±1.330	34.47-46.38	32.66-50.49	10.68	9.08	72.30	15.89
12.	100- seed weight (g)	27.21±0.377	25.28-31.16	22.39-30.72	7.88	7.51	90.70	14.73
13.	Protein content (%)	23.15±0.610	19.32-26.68	18.33-26.47	8.80	7.52	73.00	13.23
14.	Grain yield per plant (g)	20.06±0.767	14.30-22.91	15.22-26.26	16.07	14.63	82.90	27.43

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