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Studies of Genetic Parameters in Exotic Collections of Fava Bean (*Vicia fava* L.)

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A B S T R A C T

The present investigation "Studies of genetic parameters in exotic collections of fava bean (*Vicia fava* L.)" was carried out to assess the extent of genetic variability, nature of association, direct and indirect effects of yield contributing characters of seed yield per plant in forty-six genotypes of fava bean at Vegetable Research Farm, Chandra ShekharAzad University of Agriculture and Technology, Kanpur (U.P.) during *Rabi* 2019-20. The analysis of variance revealed highly significant differences among the forty-six fava bean genotypes for seed yield per plant traits indicating the presence of sufficient variability for all the traits under the study. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) recorded for characters like, number of clusters per plant, 100 seed weight, pod length and number of branches per plant. All the traits indicating the presence of high degree of variability and better scope for further crop improvement. The moderate PCV and GCV were observed for number of seeds per pod, plant height and number of pods per plant. High heritability coupled with high genetic advance as per cent of mean was recorded for days to maturity, number of clusters per plant, 100 seed weight, seed yield per plant, days to 50 per cent flowering, number of pods per plant and number of seeds per pod. For all the traits indicating less influence of environment on the expression of these characters and they may be governed by additive gene action so simple selection can be practiced for improvement of these traits along with seed yield. The high significant and positive association of seed yield per plant with 100 seed weight and number of clusters per plant indicates that these characters should be given emphasis while selecting plants for improvement of seed yield. Path analysis revealed that, the characters like 100 seed weight, number of clusters per plant and days to maturity had direct effect on seed yield per plant, indicating a true relationship between them. Therefore, simultaneous selection for above traits is suggested for the improvement of seed yield per plant in fava bean.

Introduction

Broad bean, horse bean, winter bean, windsor bean, pigeon bean, and generally known as bakla and kala matar in India are all names for the fava bean. Bionomically, fava pods belong to the fabaceae family, in the genus: *Vicia* scientifically called (*Vicia fava* L.; 2n = 2x = 12, 14) (Singh *et al.*, 2013). It is a tough plant that can withstand cold temperatures. The only bean cultivated as a winter

crop is the fava bean. It is widely assumed that it originated in North Africa and the South Caspian Sea (Tanno and Willcox, 2006), and that Arab traders brought it to India. Fava beans play a significant role in global agriculture due to its superior yield performance when compared to other grain legumes. It can also be utilized as a break crop in areas where grain monoculture is prevalent. Because of its biological nitrogen fixation capacity and improved weed and disease control in succeeding crops, it is a highly profitable crop (Preissel *et al.,* 2015).

The fava bean is a small annual, glabrous herb with erect stem, growing to the height of upto 6 feet plant. The fava bean features big white flowers that grow in clusters on short pedicles, honeybees play a role as pollinators. The pod of the fava bean is a light, green beaded fruit that matures to a blackish-brown colour (Lindemann and Glover, 2003).

The green pod of the fava bean is consumed as a vegetable, while the dry seed is utilized as a grain legume. The seeds of the fava bean are high in protein (16%), carbohydrate (6 %), fat (1%) and dietary fiber (32%). Fava bean has the highest crude protein content as well as the largest production of protein per hectare among the most widely farmed crops. It contains 18 gm of carbohydrate, 8 gm of protein, 0.7gm of total fat, 0.08 mg of thiamine, 12.0 mg of ascorbic acid, 50 mg of calcium, 25 mg of sodium, 332 mg of potassium, 0.1 gm. of saturated fat and 1.4 mg of iron per 100 gm of edible amount (fdc.nal.usda.gov, 2019).

Fava bean was recognized by the Indian Council of Agriculture Research (ICAR) as a viable grain legume crop and was included in the AICRP programme. The fava bean is classified as the eighth most important grain legume by the Consultative Group on International Agricultural Research (CGIAR) (Sharifi, 2015).

The fava bean is used in a variety of ways to soften stiff limbs, including as an ingredient and as a topical therapy. The seeds of the fava bean are a good source of L-DOPA, which is a precursor to dopamine and is used to treat Parkinson's disease. It has anti-oxidant properties as well. For chronic disease prevention and health enhancement, the fava bean is a good dietary source of natural antioxidants (Oomah *et al.,* 2006).

Fresh pods and immature seeds of the Fava bean contain anti-nutritional elements such as polyphenols, which add a beany flavour (Bjerg *et al.,* 1988) and are known to produce astringency. The vicine and co-vicine found in fava bean seeds cause haemolytic anaemia by oxidising erythrocytes. Heat treatment in boiling water, as well as pre-soaking, can diminish the action of anti-nutritional agents (Batra *et al.,* 1990).

The fava bean is a self-pollinating crop that is somewhat allogamous (5-20 per cent). The presence of sufficient variety in a crop's fundamental genetic material is a need for starting a systemic breeding programme for agricultural improvement.

Using numerous genetic factors such as heritability, the study of such variability among diverse germplasm of a crop aids breeders in identifying the most prospective genotypes. Genetic progress and genetic coefficient of variation are two terms that are used interchangeably.

Because many economic characteristics are quantitative in nature and heavily impacted by the environment, the nature of both genetic and non-genetic variation governs the progress of any breeding effort. As a result, the overall variability must be divided into heritable and non-heritable components.

The study of interrelationships between distinct characteristics is beneficial because the choice of one trait might have a direct impact on the performance of another, which is important when selecting the components of complicated characters like yield. Correlation studies, on the other hand, do not provide an exact picture of the direct impact of each of the component features on the yield. When it

comes to splitting the correlation coefficient into direct and indirect effects, the path coefficient comes in handy.

Materials and Methods

The materials for present investigation comprised of forty-five fava bean genotypes and one varietal check i.e., Vikrant were grown in a randomized complete block design (Federer,1956) during *Rabi* 2019–20 at Vegetable Research Farm, of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.), with recommended agronomical package of practices. Each genotype was sown in three row of 3 m length by adopting a spacing of 30 cm between rows and 10 cm between plants in the replication. The technique of random sampling was adopted for the observation of 10 quantitative characters namely Days to 50 per cent flowering days to maturity, plant height (cm), number of branches per plant, number of clusters per plant, pod length (cm), number of pods per plant, number of seeds per pod, 100-seed weight (g) and seed yield per plant (g).

The experimental data thus recorded on these characters were subjected to statistical and biometrical analysis for analysis of variance and variability (Fisher, 1925), estimation of coefficients of variation (Burton, 1952), heritability and Genetic advance (Burton and Devane, 1953), estimation of correlation coefficients (Searle, 1961) and path coefficient analysis (Dewey and Lu, 1959).

Correlation studies provide information on the nature and magnitude of the association of different component characters with seed yield. It also helps us to understand the nature of interrelationship among the component traits themselves. Ultimately this could help the breeder to design selection strategies to improve seed yield.

The analysis of path coefficient was undertaken with a view to understand the underlying causes of given effects and the relationship between a component character and dependent character as measured by genotypic and phenotypic correlation coefficient and was subdivided into direct effect of these characters. Path Coefficient Analysis was carried out by the method modified by Dewey and Lu (1959) from the technique originally proposed by Wright (1921). Path coefficient were obtained by simultaneous equations which express basic relationship between correlation and path analysis.

Results and Discussion

Analysis of Variance

The analysis of variance (ANOVA) for ten characters is presented in Table 1. It is revealed that there were highly significant differences among the treatments for all the characters under study, showing wide range of variation in 46 genotypes of fava bean. The perusal of Table 3 revealed that the high phenotypic coefficient of variance (PCV) was exhibited by number of clusters per plant (44.26%), 100 seed weight (22.65%), pod length (21.60 %), number of branches per plant (21.34 %). Moderate phenotypic coefficient of variance was noticed in number of seeds per pod (16.58%), plant height (12.53%) and number of pods per plant (11.68%) while seed yield per plant (7.84%), days to 50 per cent flowering (6.01%) and days to maturity (4.84 %) express low value of PCV. The perusal of Table 4 revealed that high genotypic coefficient of variance (GCV) was exhibited by number of clusters per plant (43.63 %) and 100 seed weight (22.16%). Moderate genotypic coefficient of variance (GCV) was noticed in pod length (15.11%), number of branches per plant (14.14 %), number of seeds per pod (14.01%) and number of pods per plant (10.09%). Plant height (9.64%), seed yield per plant (7.12 %), days to 50 % flowering (5.39%) and days to maturity (4.78%) expressed low value of GCV.

The perusal of Table 4 revealed that high genotypic coefficient of variance (GCV) was exhibited by number of clusters per plant (43.63 %) and 100 seed weight (22.16%). Moderate genotypic coefficient of variance (GCV) was noticed in pod length (15.11%), number of branches per plant (14.14 %), number of

seeds per pod (14.01%) and number of pods per plant (10.09%). Plant height (9.64%), seed yield per plant (7.12 %), days to 50 % flowering (5.39%) and days to maturity (4.78%) expressed low value of GCV.

The estimation of heritability in broad sense and genetic advance were estimated and laid out in Table 4. The value of heritability in broad sense were observed high for the characters days to maturity (97.62%), number of clusters per plant (97.15%), 100 seed weight (95.73%), seed yield per plant (82.55%), days to 50 % flowering (80.20%), number of pods per plant (74.67 %) and number of seeds per pod (71.46%). Moderate heritability was observed for plant height (59.25%), pod length (48.92%) and number of branches per plant (43.90%).

Genetic advance in per cent of mean 5% was observed highest in the character for number of clusters per plant (113.54%), followed by 100 seed weight (57.24 %), number of seeds per pod (31.28%), pod length (27.90%), number of branches per plant (24.74 %) and number of pods per plant (23.03%).While medium magnitude of genetic advance as per cent of mean was observed for plant height (19.60%), seed yield per plant (17.08%), days to 50 per cent flowering (12.74%) followed by days to maturity (12.48%).

Correlation Coefficient Analysis

Seed yield had positive and significant phenotypic and genotypic correlation with, 100 seed weight, and positive non-significant correlation with number of clusters per plant, number of seeds per pod while, negative and significant correlation with number of branches per plant. The above results were in consonance with the research work of Osman *et al.,* (2013) for number of seeds per pod, 100 seed weight Verma *et al.,* (2013) number of seeds per pod, biological yield and harvest index, Mulualem *et al.,* (2013) and Sharifi and Aminpane (2014) for number of clusters per plant, number of seeds per pod and 100 seed weight.

100 seed weight had positive and significant correlation with number of clusters per plant the similar results were also reported by Abdemulla (2002) for one or more characters. Number of seeds per pod had positive correlation with 100 seed weight.

Days to 50 per cent flowering had positive and significant correlation with days to maturity similar results earlier found by Badolay *et al.,* (2009) days to 50 percent flowering with days to maturity. Days to maturity had positive significant correlation with number of clusters per plant. Plant height had positive and significant correlation with number of pods per plant. Number of branches per plant had negative significant correlation with number of pods per plant, 100 seed weight, seed yield per plant. Number of clusters per plant had positive significant correlation with 100 seed weight while, negative significant correlation with number of seeds per pod. Pod length had negative non-significant correlation with seed yield per plant, number of pods per plant, 100 seed weight. Number of pods per plant had positive and non-significant correlation with 100 seed weight, number of seeds per pod while, negative non-significant correlation with seed yield per plant. Number of seeds per pod had positive non-significant correlation with 100 seed weight and seed yield per plant. These results were in close conformation with the studies of Cokkizgin *et al.,* (2013); Verma *et al.,* (2015); Tofiqi *et al.,* (2016); Kumar *et al.,* (2017) and Arya *et al.,* (2019).

Path Coefficient Analysis

The path analysis revealed that out of ten characters, three were showed positive and direct effect on grain yield at phenotypic level viz, 100 seed weight, number of clusters per plant and days to maturity. This indicates that selection for these traits in yield improvement programme will reflect to overall improvement of the grain yield. Similar results of high direct effect of grain yield were reported by Badolay *et al.,* (2009) for 100 seed weight, days to maturity, clusters per plant and Verma *et al.,* (2015) for 100 seeds weight.

Table.1 Analysis of variance (ANOVA) for ten characters in forty-six fava bean genotypes.

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Pod Length(cm)	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Replication	2	10.19	46.98 **	11.10	0.18	1.09	0.57	3.75	0.24	5.76	3.28
Treatment	45	50.39**	104.59**	107.10 **	1.72 **	55.16 **	1.78 **	18.88 **	0.87 **	183.93 **	23.31 **
Error	90	3.83	0.84	19.97	0.51	0.53	0.46	1.91	0.10	2.69	1.53

Significant at 5 %

Significant at 1 %

Table.2 Mean, range & standard error difference among forty-six genotypes for then characters in fava bean.

S.No.	Characters	Grand mean	Range				SE(d)
			Minimum value	Genotype	Maximum value	Genotype	
1	Days to 50 % flowering	73.09	63.00	IC FB247	79.67	AREC16079	1.13
2	Days to maturity	122.90	103.33	L2014-100	139.00	IC FB245	0.53
3	Plant height (cm)	55.87	34.33	IC FB238	63.67	IC FB234	2.58
4	Number of branches per plant	4.49	3.00	AREC16079, AREC16071	6.00	L2014-119	0.41
5	Number of clusters per plant	9.78	4.00	L2014-005,	19.00	IC FB245	0.42
6	Pod Length(cm)	4.40	3.33	AREC16076, AREC16068, IC FB234, AREC16065, IC FB239, IC FB235, IC FB236	7.00	L2014-106	0.39
7	Number of pods per plant	23.55	16.00	IC FB242	28.00	L2014-095	0.80
8	Number of seeds per pod	3.61	2.00	AREC16078	4.33	L2014-106	0.18
9	100 seed weight (g)	35.07	18.67	L2014-005	47.67	L2014-099	0.95
10	Seed yield per plant (g)	37.83	28.67	L2014-121	42.33	L2014-010	0.71

Table.3 Phenotypic and genotypic coefficient of variation among forty-six genotypes for ten characters in fava bean.

S.No.	Characters	PCV (%)	GCV (%)
1.	Days to 50 % flowering	6.01	5.39
2.	Days to maturity	4.84	4.78
3.	Plant height (cm)	12.53	9.64
4.	Number of branches per plant	21.34	14.14
5.	Number of clusters per plant	44.26	43.63
6.	Pod Length(cm)	21.60	15.11
7.	Number of pods per plant	11.68	10.09
8.	Number of seeds per pod	16.58	14.01
9.	100 seed weight (g)	22.65	22.16
10.	Seed yield per plant (g)	7.84	7.12

Table.4 Heritability (h^2), genetic advance and genetic advance per cent over mean among forty-six genotypes for ten characters in fava bean

S.No.	Characters	Heritability (h^2) %	Genetic advance at 5%	Genetic advance as % of mean
1.	Days to 50 % flowering	80.20	9.31	12.74
2.	Days to maturity	97.62	15.33	12.48
3.	Plant height (cm)	59.25	10.95	19.60
4.	Number of branches per plant	43.90	1.11	24.74
5.	Number of clusters per plant	97.15	11.10	113.54
6.	Pod Length(cm)	48.92	1.22	27.90
7.	Number of pods per plant	74.67	5.42	23.03
8.	Number of seeds per pod	71.46	1.12	31.28
9.	100 seed weight (g)	95.73	20.07	57.24
10.	Seed yield per plant (g)	82.55	6.46	17.08

Table.5 Genotypic correlations coefficient among the seed yield and its contributing characters in Fava bean genotype.

Traits	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Pod Length(cm)	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Days to 50 % flowering	**1.000**	0.751**	-0.139	-0.059	-0.054	0.203*	0.048	0.111	0.005	-0.071
Days to maturity		**1.000**	-0.096	-0.056	0.192*	0.179*	0.094	-0.096	0.028	-0.028
Plant height (cm)			**1.000**	-0.111	-0.108	0.046	0.328**	0.150	0.011	-0.105
Number of branches per plant				**1.000**	0.020	0.062	-0.398**	0.099	-0.384**	-0.278**
Number of clusters per plant					**1.000**	-0.143	-0.047	-0.285**	0.191*	0.200*
Pod Length(cm)						**1.000**	-0.147	-0.106	-0.078	-0.127
Number of pods per plant							**1.000**	0.127	0.124	-0.082
Number of seeds per pod								**1.000**	0.137	0.047
100 seed weight (g)									**1.000**	0.774**

Table.6 Phenotypic correlation coefficient among the seed yield and its contributing characters in Fava bean genotypes.

Traits	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Pod Length(cm)	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Days to 50 % flowering	**1.000**	0.661**	-0.101	-0.017	-0.053	0.102	0.013	0.047	0.011	-0.045
Days to maturity		**1.000**	-0.071	-0.025	0.188*	0.108	0.092	-0.085	0.029	-0.020
Plant height (cm)			**1.000**	-0.029	-0.091	0.000	0.220**	0.145	0.015	-0.103
Number of branches per plant				**1.000**	0.030	0.105	-0.260**	-0.002	-0.257**	-0.233**
Number of clusters per plant					**1.000**	-0.097	-0.030	-0.254**	0.187*	0.164
Pod Length (cm)						**1.000**	-0.089	-0.016	-0.069	-0.118
Number of pods per plant							**1.000**	0.071	0.112	-0.046
Number of seeds per pod								**1.000**	0.123	0.035
100 seed weight (g)									**1.000**	0.698**

****Significant at 1 % * Significant at 5%**

Table.7 Direct and indirect effect of ten components traits on seed yield of fava bean as independent variable at phenotypic level.

Traits	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Pod Length(cm)	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Days to 50 % flowering	**-0.054**	0.001	0.009	0.002	-0.001	-0.007	-0.002	-0.001	0.007	-0.045
Days to maturity	-0.036	**0.002**	0.006	0.002	0.002	-0.007	-0.012	0.002	0.020	-0.020
Plant height (cm)	0.005	0.000	**-0.088**	0.003	-0.001	0.000	-0.028	-0.004	0.010	-0.103
Number of branches per plant	0.001	0.000	0.003	**-0.086**	0.000	-0.007	0.034	0.000	-0.177	-0.233**
Number of clusters per plant	0.003	0.000	0.008	-0.003	**0.011**	0.007	0.004	0.006	0.129	0.164
Pod Length(cm)	-0.006	0.000	0.000	-0.009	-0.001	**-0.067**	0.012	0.000	-0.048	-0.118
Number of pods per plant	-0.001	0.000	-0.019	0.022	0.000	0.006	**-0.129**	-0.002	0.077	-0.046
Number of seeds per pod	-0.003	0.000	-0.013	0.000	-0.003	0.001	-0.009	**-0.024**	0.085	0.035
100 seed weight (g)	-0.001	0.000	-0.001	0.022	0.002	0.005	-0.014	-0.003	**0.688**	0.698**

***Significant at 5 %**
****Significant at 1 %**
R SQUARE = 0.5261 RESIDUAL EFFECT = 0.6884
Bold values shows direct and normal values shows indirect effects

While the characters like number of seeds per pod, days to 50per cent flowering, pod length, number of branches per plant, plant height and number of pods per plant. These findings are in accordance with the reports of Chaubey *et al.,* (2012) for the number of seeds per pod, days to 50per cent flowering and pod length, Kumar *et al.,* (2017) for number of branches per plant and plant height. Even though the direct effect of these traits on grain yield was negative, these traits seem to be the potential traits in improving the grain yield as these exerts indirect effect via other component traits. Days to maturity showed negative indirect effect on seed yield per plant via days to 50 per cent flowering while, positive indirect effect showed via 100 seed weight. The character plant height recorded negative indirect effects on seed yield via number of pods per plant. The character number of branches per plant showed the positive indirect effects on seed yield per plant via number of pods per plant while, negative indirect effect on seed yield per plant via 100 seed weight. These results were in close conformation with the studies of Badolay *et al.,* (2009); Azarpour *et al.,* (2012); El-Shal and El-Sayad (2019).

Number of clusters per plant recorded positive

indirect effects on seed yield via 100 seed weight. The character pod length showed the negative indirect effects on seed yield through 100 seed weight. Number of pods per plant showed the positive indirect effects on seed yield via 100 seed weight followed by number of branches per plant while, negative indirect effects via plant height. The character number of seeds per pod showed positive direct effects on seed yield per plant via 100 seed weight while, negative indirect effects via plant height. Similar results for one or more characters were reported by Bakhiet *et al.*, 2015; Tofiq *et al.*, 2016; Arya *et al.*, 2019 and Dewangan *et al.*, 2019.

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