Journal of Experimental Agriculture International

Volume 46, Issue 8, Page 658-665, 2024; Article no.JEAI.120776
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Study of Metroglyph Analysis in Faba Bean (*Vicia faba* L.) Genotypes for Different Quantitative Characters

Warale Shashank [a++] and Neha Thomas [a#*]

[a] Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.), India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i82748

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120776

Original Research Article

Received: 28/05/2024
Accepted: 01/08/2024
Published: 06/08/2024

ABSTRACT

The study conducted at the Research Farm of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences during the rabi/winter season of 2022-23 aimed to estimate the genetic diversity and morphological variations among 20 Faba bean (*Vicia faba* L.) genotypes using Anderson's metroglyph analysis for different quantitative traits. Analysis of variance revealed significant differences for all the characters studied indicating the presence of considerable amount of variability among the genotypes. The genotypes viz, IVT HB19-14 I, IVT HB 19-11, ABSPS-2-1, AVT I HB16-15, IVT HB18-15, VIKRANT (CHECK), ABSPS-1-5, ABSPS-1-2 recorded significantly superior seed yield and yield contributing traits respectively. Six distinct morphological complexes were identified as a result of the analysis, which

[++] *M.Sc. Agri.;*
[#] *Assistant Professor;*
**Corresponding author: E-mail: neha.thomas@shiats.edu.in;*

Cite as: *Shashank, Warale, and Neha Thomas. 2024. "Study of Metroglyph Analysis in Faba Bean (Vicia Faba L.) Genotypes for Different Quantitative Characters". Journal of Experimental Agriculture International 46 (8):658-65. https://doi.org/10.9734/jeai/2024/v46i82748.*

showed significant variation among the genotypes for the majority of traits. Complex I included eight genotypes with high seed yield and a high number of seeds per plant, while Complex II comprised five genotypes with low seed yield and a low number of seeds per plant. Complex III: High seed yield with a lower number of seeds per plant including three genotypes. Complex IV: Moderate seed yield with a higher number of seeds per plant, represented by two genotypes, Complex V: Very low seed yield and a very low number of seeds per plant, represented by one genotype and Complex VI: Low plant height with a very low number of spikelet's per panicle, represented by one genotype. The genotypes IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB19-11, ABSPS-1-1, ABSPS-1-2, ABSPS-1-4, and VIKRANT were identified as superior due to their high index scores and were suggested for use in breeding programs to enhance yield and other desirable traits. The study concluded that metroglyph analysis is an effective method for assessing genetic diversity and morphologicalvariations, providing valuable insights for breeders to improve Faba bean yield and adaptability through targeted cross-breeding of superior genotypes.

Keywords: Faba bean; genotype complexes; morphological variations; metroglyph analysis; quantitative traits and qualitative traits.

1. INTRODUCTION

The faba bean is a legume plant belonging to the fabacea family., Scientifically known as *Vicia faba L*. [1] Broad bean, horse bean, winter bean, windsor bean, and pigeon bean are some different names given to the faba bean (*Vicia faba* L.; 2n = 2x = 12, 14; Family: Fabaceae), which is also well known in India as bakla and kala matar [2]. It is a resistant plant that can survive very cold temperatures. The faba bean is the only bean that is grown as a winter crop.

The faba bean originates in the Middle East. Some parts of Australia and South America, including Mexica, Brazil, are home to its cultivation. It is the third-most commonly grown feed grain legume in the world, after peas and soybeans (*Glycine max* L.) (*Pisum sativum* L.) [3]. After common beans (*Phaseolus vulgaris* L.), peas (*Pisum sativum* L.), chickpeas (*Cicer arietinum* L.), cowpeas (*Vigna unguiculata* L. Walp.), and lentils (*Lens culinaris* Medik), faba beans ranked in sixth place in the world production rankings with 4.5 Mt from 2.5 Mha. [4,5].

Botanically faba bean has three type and they are based on the seed size. *Vicia faba* major is the first botanical species. Its seed form is flattened and its size is larger. The second variety contains medium-sized seeds and is called *Vicia faba* equine. The third variety, *Vicia faba* minor, features spherical seeds that are smaller in size. Each type of plant has several variations that known by several common names. Botanical type *Vicia faba* major includes broad beans and Windsor beans, while type *Vicia faba* minor includes pigeon beans and tic(k) beans. In fact, the term "faba bean" refers to the entire species of *Vicia faba* L. [1].

In India, faba beans are still regarded as minor, neglected, underutilized, less utilized, and still not fully exploited crops due to their low production and acreage. Faba beans are grown in rainfed areas of South India, such as Jammu & Kashmir, Himanchal Pradesh, and Uttrakhand. In the country, faba beans contribute less in production [2].

It is one of the earliest cultivated, growing extensively for human consumption, animal feed, and fodder in temperate and subtropical regions of the world [6]. The faba bean is regarded as a promising legume in India that could serve as an alternative source of protein for both people and animals [7]. The nutritional composition of a whole faba bean is 20–35% protein, 1% fat, 55–65% carbs, 10% fiber, and other vitamins and minerals like calcium, magnesium, potassium, iron, and zinc. [8].

The main objective of Anderson's (1957) initial metroglyph analysis was to determine the relationships between crop plant races and biotypes. Various crops' genetic diversity has been accessed through metroglyph analysis [9]. Metroglyph analysis is used for analyzing the preliminary grouping of germplasms and to study the pattern of morphological variation in crop species [10].

2. MATERIALS AND METHODS

The present investigation on “Estimation of Metroglyph Analysis in Faba Bean (*Vicia faba* L.)

Genotypes for Different Quantitative Traits" was carried out during rabi 2022-23 at Genetics And Plant Breeding Research Farm Of Sam Higginbottom University of Agriculture, Technology And Sciences, Naini Prayagraj, Uttar Pradesh.

Days to 50 % flowering, Number of Flower per Plant, Day to 50% pod setting, Number of Branches per Plant, Number of pod per Plant, Plant Height (cm), Number of day to Maturity, Pod Length, Pod Width, Number of Seed per Pod, Seed index (g), Biological Yield per plant (g), Harvest index (%), Number of seed per Plant, Seed Yield per Plant (g), Seed Yield per Plot, Seed Yield per Hectare data were recorded on plot basis.

Data were recorded to the analysis of variance followed by Anderson's Meteroglyph technique to study the patterns of morphological variations in different genotypes.

Twenty Faba bean genotypes were represented by one glyph. The Y and X axes were assigned to the two most variable characters, Number of Seed per Plant and Seed Yield per Plant, respectively. A scatter diagram was created by representing the remaining qualities, aside from these, as rays on a glyph, where each glyph denoted a genotype.

Table 1. List of genotypes

Sr. no.	Name of Genotypes	Source
1	IVT HB18-10	NBPGR, NEW DELHI
2	IVT HB18-15	NBPGR, NEW DELHI
3	IVT HB19-10	NBPGR, NEW DELHI
4	IVT HB19-12	NBPGR, NEW DELHI
5	IVT HB19-13	NBPGR, NEW DELHI
6	IVT HB19-14 I	NBPGR, NEW DELHI
7	IVT HB19-11	NBPGR, NEW DELHI
8	IVT HB19-4	NBPGR, NEW DELHI
9	AVT 1 HB16-15	NBPGR, NEW DELHI
10	AVT II HB14-31	NBPGR, NEW DELHI
11	AVT II HB15-38	NBPGR, NEW DELHI
12	ABSPS-1-1	NBPGR, NEW DELHI
13	ABSPS-1-2	NBPGR, NEW DELHI
14	ABSPS-1-4	NBPGR, NEW DELHI
15	ABSPS-1-5	NBPGR, NEW DELHI
16	ABSPS-2-1	NBPGR, NEW DELHI
17	ABSPS-2-2	NBPGR, NEW DELHI
18	HFB-1 (CHECK)	NBPGR, NEW DELHI
19	HFB-2 (CHECK)	NBPGR, NEW DELHI
20	VIKRANT (CHECK)	NBPGR, NEW DELHI

3. RESULTS

For seventeen traits, the analysis of variance indicated a significant variation between the twenty genotypes. scatter diagram shows morphological variation allowed six complexes to be identified (Table 2 and Fig. 1). For seventeen characters, the index scores and signs used for Meteroglyph analysis are shown in Table 3.

Complex I: Higher seed yield with higher number of seeds per plant: This complex was represented by eight genotypes which are IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB 19-11, ABSPS-1-1, ABSPS-1-2, ABSPS-1-4 and VIKRANT (CHECK). These genotypes were having average index score of the complex (25.5).

Complex II: Lower seed yield with lower number of seeds per plant: Complex II comprised five genotypes which are IVT HB18-10, IVT HB19-10, IVT HB19-4, ABSPS-1-5 and HFB-1(CHECK). These genotypes were having average index score of the complex (22.50).

Complex III: Higher seed yield with lower number of seeds per plant: This complex was represented by three genotypes including AVT II HB15-38, ABSPS-2-1 and ABSPS-2-2. The genotypes were having average index score of the complex (22.67).

Complex IV: Moderate seed yield with higher number of seeds per plant: This complex was represented by two genotypes including IVT HB19-12, AVT I HB16-15, AVT II HB14-31 and HFB-2 (CHECK). The genotype was having average index score of the complex (21.75).

Complex V: Very low seed yield with very low number of seeds per plant: This complex was represented by one genotypes including AVT II HB14-31. The genotype was having index score of the complex (19).

Complex VI: Low plant height with very low number of spikelets per panicle: This complex was represented by one genotypes including AVT I HB16-15. The genotype was having index score of the complex (22).

The germplasm distributions of Faba beans are displayed in Table 3. Twenty germplasms of Faba bean were grouped into 6 complexes among group comprising of eight advance lines, group containing five advance lines, group containing three advance lines, group comprising of two advance line, group containing one advance lines and group containing one advance lines. Total index score values recorded for 20 germplasms ranged from 19 to 30 (Table 3).

Table 2. Meteroglyph study of a complex constellation

Complex	Name of complex	No. of lines	Name of lines	Range and average score
I	Higher seed yield with higher number of seeds per plant	8	IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB 19-11, ABSPS-1-1, ABSPS-1-2, ABSPS-1-4, VIKRANT (CHECK)	$22.00-30.00(25.5)$
II	Lower seed yield with lower number of seeds per plant	5	IVT HB18-10, IVT HB19-10, IVT HB19-4, ABSPS-1-5, HFB-1(CHECK)	20.00-24.00 (22.50)
III	Higher seed yield with lower number of seeds per plant	3	AVT II HB15-38, ABSPS-2-1, ABSPS-2-2	$21.00-24.00(22.67)$
IV	Moderate seed yield with higher number of seeds per plant	2	IVT HB19-12, AVT IHB16-15, AVT II HB14-31, HFB-2 (CHECK)	$19.00-23.00(21.75)$
V	Very low seed yield with very low number of seeds per plant	1	AVT II HB14-31	19
VI	Low plant height with very low number of spikelet's per panicle	1	AVT IHB16-15	22

Table 3. Mean performance of 20 genotype for 17 characters of Faba bean

Sl. No.	Genotypes	DF50	NFPP	NP50	NBP	NPP	PH	DM	PLP	PPP	NSPP	SI	BY	HI	NSPP	SYPP	SYPPL	SYPH
1	IVT HB18-10	69	17.067	95.333	4.6	12.26	89.06	119.3	4.633	0.673	2.797	27.38	30.86	31.33	35.733	9.137	912	6.95
2	IVT HB19-12	69	18.537	96.333	4.06	12	81.39	124	4.793	0.753	3.403	31.50	30.86	33.19	41.333	9.733	945.25	7.203
3	IVT HB19-10	69	19.8	96.667	3.467	11.46	89.31	130.3	4.9	0.733	3.00	31.87	32.40	37.86	35.003	11.663	866.16	6.603
4	IVT HB18-15	69	18.07	96	3.8	13.86	91.77	123.3	4.967	0.8	3.203	33.09	33.73	46.0	44.2	14.867	1030.5	7.853
5	IVT HB19-13	69	18.47	96.667	3.8	14.26	93.33	123	4.993	0.76	3.2	33.17	33.80	39.48	44.733	12.403	962.75	7.337
6	IVT HB19-14 I	69	19.6	95.667	3.933	14.93	92.14	123	4.833	0.84	3.197	33.04	31.06	56.44	47.333	15.667	1039.0	7.917
7	IVT HB 19-11	71	18.333	96.333	4.267	13	86.27	123	5.167	0.773	3.667	32.3	34.93	45.67	47.133	15.667	939.74	7.16
8	IVT HB19-4	71	18.867	95	4.00	12.46	85.96	111.3	4.67	0.68	2.933	33.44	30.93	38.94	36.533	11.603	835.25	6.367
9	AVT I HB16-15	69	18.867	95.333	4.733	14	78.43	119	4.43	0.733	3.2	31.04	36.26	43.37	44.537	14.933	893.49	6.807
10	AVT II HB14-31	69	18.533	95.667	4.533	13.33	77.02	120.3	4.86	0.787	2.867	28.02	35.4	31.72	38	10.2	790.75	6.027
11	AVT II HB15-38	69	22.27	96.333	5.133	17.13	74.4	119	4.48	0.7	2.87	31.22	32.13	41.67	48.667	12.733	884.24	6.74
12	ABSPS-1-1	81.33	18.87	95.333	4.267	13.73	85.86	119	4.567	0.787	3.663	28.08	21.66	59.87	50.4	12.867	996.63	7.597
13	ABSPS-1-2	85.66	18.87	98.667	5.2	14.33	84.2	116.3	4.733	1.293	3.733	29.50	23.2	58.5	52.467	13.467	1000.8	7.627
14	ABSPS-1-4	79	17.933	88	6.003	12.4	85.66	124.3	4.733	0.76	3.4	28.97	22.66	53.79	42	11.87	989.37	7.54
15	ABSPS-1-5	75.33	18.733	87.667	5.333	14.00	90.39	118	4.5	0.853	2.8	30.06	22.4	61.37	39.6	13.667	887.50	6.767
16	ABSPS-2-1	67.6	19.067	92.333	4.8	15.26	94.67	116.6	4.47	0.82	3.467	30.64	23.86	65.86	50.8	15.533	864.38	6.583
17	ABSPS-2-2	68.33	17.8	92.667	5.467	12.99	87.2	115.3	4.793	0.827	4	29.33	24.53	51.58	51.803	12.533	842.12	6.417
18	HFB-1(CHECK)	69	19.533	95.333	4.40	14.73	77.76	120.3	5.067	0.82	2.803	32.98	30.33	35.40	40.933	10.267	837.50	6.38
19	HFB-2 (CHECK)	69	19.533	94.333	5	13.4	80.8	112.6	5.23	0.933	2.933	33.02	29.13	42.8	39.733	12	969	7.383
20	VIKRANT (CHECK)	71	19.4	95.333	4.8	12.86	83.76	113	5.167	0.773	3.6	31.61	43.67	32.99	46.133	13.8	1009.2	7.69
Mean		71.47	18.91	94.75	4.58	13.62	85.47	119.5	4.8	0.81	3.24	31.02	30.19	45.4	43.85	12.73	924.79	7.05

Table 4. Index scores and signals for 17 characters analyzed using Meteroglyph

Sl.No.	Character	Range of Mean	Score 1	Sign	Score 2	Sign	Score 3	Sign
			Value <		Value from - to		Value >	
1	Days to 50% flowering	73.67-79.67	73.67	○	73.67-79.67		79.67	
2	No. of flowers per plant	18.8-20.54	18.80	○	18.8-20.54		20.54	
3	Days to 50% pod setting	91.33-95	91.33	○	91.33-95		95.00	
4	Number of branches per plant	4.31-5.16	4.31	○	4.31-5.16		5.16	
5	No. of pod per plant	13.36-15.24	13.36	○	13.36-15.24		15.24	
6	Plant height	81.16-87.91	81.16	○	81.16-87.91		87.91	
7	Days to maturity	117.67-124	117.67	○	117.67-124	○	124.00	○
8	Pod length per plant	4.7-4.96	4.70	○	4.7-4.96	○	4.96	○
9	Pod width per plant	0.88-1.09	0.88	○	0.88-1.09		1.09	
10	No. of seeds per pod	3.2-3.6	3.20	○	3.2-3.6		3.60	
11	Seed index	29.41-31.43	29.41	○	29.41-31.43		31.43	
12	Biological yield	29-36.34	29.00	○	29-36.34		36.34	
13	Harvest index	42.84-54.35	42.84	○	42.84-54.35		54.35	
14	No. of seeds per plant	35-52.47	40.82	○	40.82-46.65		46.65	
15	Seed yield per plant	9.14-15.67	11.31	○	11.31-13.49		13.49	
16	Seed yield per plot	790.75-1039	873.50	○	873.5-956.25		956.25	
17	Seed yield per hectare	6.03-7.92	6.66	○	6.66-7.29		7.29	

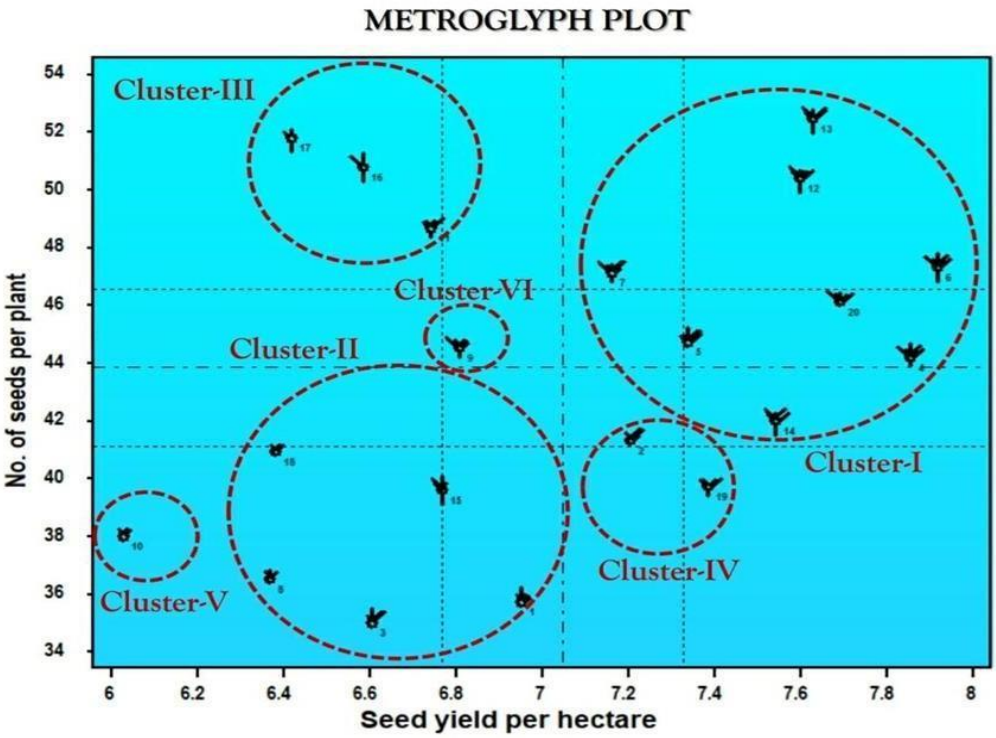

Fig. 1. Scattered diagram of Metroglyph in 20 Faba bean genotypes

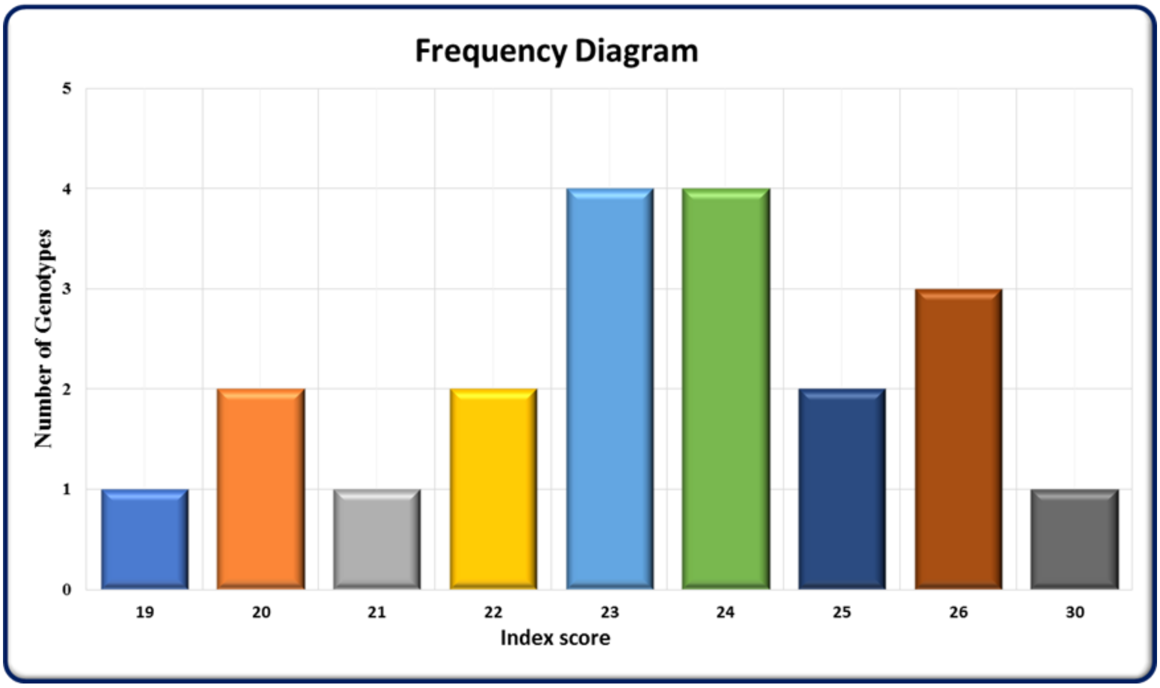

Fig. 2. Frequency diagram with Index score and number of genotypes

Germplasms ranging between the index score of 22 and 30 comprised the lower (inferior) class, whereas germplasms with an index score between 22 and 30 comprised the upper superior class. Which include IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB 19-11, ABSPS-1-1, ABSPS-1-2 and ABSPS-1-4 Genotype. Metroglyph analysis of genotypes in various crop plants was proposed by several workers.i.e. Chhabra *et al.* [11] in Faba bean, Thakur *et al*. [12] in Chickpea, Arya *et al*. [13] in Cowpea used this method to assess the morphological variations.

4. DISCUSSION

Anderson's metroglyph analysis is a simple technique and is used for preliminary grouping of germplasms. The range of variability for characters, their values for index score and signs with rays are presented in Table 4. It was observed that maximum variability was in Seed yield per plot followed by No. of seeds per plant, Harvest index, Biological yield, Days to maturity, Plant height, Days to 50% flowering, No. of pod per plant, No. of flowers per plant, Seed index, Seed yield per hectare, Pod length per plant, Number of branches per plant, No. of seeds per pod. The results were in the agreement with the findings of R. Chandirakala *et al*., (2015) for Plant Height, Thakur *et al*. [12] for plant height (cm), 100 seed weight (g), number seeds pod, seed yield per plant (g), biological yield (g) and harvest index (%), days to 50% flowering and days to maturity. Singh *et al.* [2] for a high yield, Ahmad *et al.* (2019) for plant height, pods per plant, pod length, seeds per pod and yield per plant.

The genotypes which had the index score from 22 to 30 constituted the upper superior class and the genotypes which were between the index score of 22 constituted the lower (inferior) class. Which include IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB 19-11, ABSPS-1-1, ABSPS-1-2 and ABSPS-1-4 Genotype. Several scientists had suggested metroglyph analysis of genotypes in different crop plants i.e. Chhabra *et al.* [11] in Faba bean, Thakur *et al*. [12] in Chickpea, Arya *et al*. [13] in Cowpea evaluated the morphological changes using this method [14-19].

5. CONCLUSION

On the basis of metroglyph analysis, The germplasm lines IVT HB18-15, IVT HB19-13, IVT HB19-14 I, IVT HB 19-11, ABSPS-1-1, ABSPS-1-2, ABSPS-1-4, VIKRANT (CHECK) recorded high index score and fell into different clusters can be crossed to maximum variability of good combinations. Therefore, these characters should be given priority during selection for yield improvement in Faba bean.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENTS

We thank to Dr. Neha Thomas, Department Genetics and plant Breeding, SHUATSI wish to convey my deep thanks and gratitude for his valuable guidance, honorable support, enormous support, constant supervision, and honesty.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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