

Estimates of genetic variability, heritability, genetic advance and genetic divergence in bottle gourd [*Lagenaria siceraria* (Mol.) Stadle.]

ABSTRACT

The present investigation was conducted at Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002 (UP) during *Kharif* season in 2022. ~~The objective of the study was.....???~~ During the study the analysis of variance for ~~Thirty- two~~ 32 genotypes of Bottle gourd were used in ~~the~~ randomized complete block design. ~~Eleven characters were studied. Results indicated and revealed significant differences for all the 11 characters studied amongst the genotypes. This indicated the presence of wide spectrum of variability among the genotypes. The results showed generally low to moderate values of genotypic coefficient of variation (GCV). The phenotypic coefficient of variation (PCV) was higher than the respective genotypic coefficient of variation (GCV) for all the traits. However, a narrow differences were small indicating that environmental influence on traits was low. between PCV and GCV were recorded for all of the traits. High heritability was generally observed in all the characters studied while and high genetic advance as per cent of mean wasere observed for about 50% of the characters studied all eleven characters which meant that additive genes controlled some of these traits. The highest heritability was recorded in vine length and lowest for number of primary branches. The analysis of genetic divergence through Mahalanobis D^2 statistics revealed that a considerable genetic diversity was found among the genotypes studied. The implications for further breeding were discussed. 32 genotypes of bottle gourd were grouped into 5 clusters. Out of the 5 clusters, Cluster IV had ten genotypes, Cluster III had eight genotypes, Cluster II had eight genotypes, Cluster I had three genotypes and Cluster V had three genotypes. Based on present investigation, it was concluded that in general, there was parallelism between genetic and geographic diversity. Maximum inter cluster distance was determined between clusters III and cluster V so crosses among genotypes of cluster III like KLG (8), AZAD HARIT (9), BG 7505 (10), BG 7127, BG 7512, BG 7306, BG 7502 and BG 7231 can be made as a parent for getting better hybrids.~~

Keywords: Genetic variability; heritability; genetic advance; bottle gourd; genetic divergence etc.

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Mol.) Stadle.] is a popular vegetable crop in India. It belongs to the Cucurbitacea family and has chromosome number $2n = 22$. It is grown in the majority of states, including Uttar Pradesh, Bihar, West Bengal, Assam, Punjab, and Gujarat. The fossil records show that it was cultivated in India before 2000 B.C. and was the first plant domesticated in America (Peter, 1998). According to Culter and Whittaker, the bottle gourd originated in Africa and is most likely endemic to tropical Africa. De Condole reported seeing it in the wild in South Africa and India. The bottle gourd belongs to the genus *Lagenaria* and was formerly thought to be monoecious, but it has recently been revealed to include dioecious and perennial species (Pitchaimuthu, 1991). It is a large pubescent plant, ascending or trailing, with five angled stems and bifid tendrils. It is commonly planted across the world's tropics and subtropics. In India, bottle gourd or white flowered gourd is known as Lauki or Ghiya. It is one of India's most significant cucurbit crops. It is cultivated both in the summer and in the rainy season (Yadav *et al.*, 2010). The common moniker bottle gourd derives from the bottle's fruit-like form and usage as a container for wines and spirits in the past. Bottle gourd is an annual soft vine that is monoecious and strongly cross pollinated. Cross pollination occurs at a rate of 60-80% (Choudhary, 1979). Bottle gourd fruits come in cylindrical, circular oval, and oblong shapes. Bottle gourd may be grown in any type of soil, although it grows best in thoroughly manured loam soil. It prefers a warm, humid climate, but it can also be grown in dry periods with lots of watering. In general, India grows two crops. Summer crops are cultivated from the middle of October to the middle of March, and the next harvest is grown from the beginning of March to the middle of July. The edible component of bottle gourds is composed mostly of 96.1 percent water, 0.1 percent fat, 2.5 percent carbs, 0.2 percent protein, and 2.0 percent fibre (Singh, 2014). For consumption outside of peak season, the fruits are also canned. It is advised for use during convalescence since it is easily digested. It has cooling capabilities. A leaf decoction can be used as a treatment for jaundice. The pulp works well to treat conditions including constipation, cough, night blindness, and acts as an antidote to several poisons (Chauhan, 1972). To lessen the effects of heat during the summer, people massage the sliced surface of small-sized fruit on their hands and feet. India, Sri Lanka, Indonesia, Malaysia, the Philippines, China, Hong Kong, Tropical Africa,

Comment [M1]: Kindly revise the introduction. It appears the whole introduction is about the botany of the plant. How are you going to discuss your results? Show some empirical report of other scientists in relation to your work. What are the implications of your studies in terms of breeding? The use of all the parameters stated in your title i.e. genetic variability, heritability, genetic advance and genetic divergence. Let us know what they mean to us as breeders in your introduction. Mention also some of the side effects reported of cucurbitacins in the bottle gourd to justify the need to broaden your genetic base for further breeding as reported by Ankur Verma and Sanjay Jaiswal.
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PMCID: PMC4677076
PMID: 26693268

Columbia, and Brazil are the top producers of bottle gourd. In India, its share is roughly 186 thousand hectares with a production of 3052 thousand metric tonnes (**NHB - 2018-19 3rd advance estimate**). It covers 14.40 thousand acres in Uttar Pradesh and produces 427.81 MT/ha (**NHB - 2018**). Agra district leads Uttar Pradesh in both area (0.95 thousand acres) and output (27.78 thousand metric tonnes) (**NHB - 2016-17**). But because of the strain from the growing population, productivity needs to be improved. One factor contributing to the bottle gourd's low yield is the vine's tendency to produce fewer female flowers than male flowers. Furthermore, the bulk of the less productive farmers plant the native varieties of bottle gourd. The crop becomes infected with diseases including Fusarium wilt, anthracnose, powdery mildew, and mosaic as well as pests such as the red pumpkin beetle, aphids, mites, fruit fly, nematodes, etc. This results in a marked decrease in output. The critical and initial phases in every crop development strategy are the collection, preservation, and assessment of germplasm. A good breeding scheme must be created with a better understanding of the kind and degree of genetic diversity contained in the breeding material.

MATERIAL AND METHODS

The investigation comprised of a field experiment which was carried out at the Vegetable Science Research Farm, Chandra shekhar azad university of agriculture and technology, Kanpur during *kharif* season 2022. The university is located about 70 km away from lucknow (State Capital of Uttar Pradesh), which is situated at an altitude of 127 meters. The latitude being 26.40°N and longitude 80.10°E at elevation of 125.90m above mean sea level. The experimental site's land topography was mostly homogeneous, with good surface drainage. The experimental location has a modest internal drainage system. During Kharif 2022, thirty two different bottle gourd genotypes were assessed for a variety of yield and yield contributing factors, ~~at the Experimental Field of the Department of Vegetable Science "Chandra Shekhar Azad University of Agriculture and Technology Kalyanpur Kanpur, Uttar Pradesh"~~. Table 1 lists the names of the genotypes as well as their sources. A single factor experiment with three replications of each accession per plot was set up using a randomised complete block design (RCBD). The three blocks (experimental units) that made up the entire experimental area were each organised into thirty two rows to correspond to the thirty two treatments. ~~Each block received seeds from each genotype at random, with a Spacing used was of~~ 1 m between rows and 0.60 m between seeds. A recommended set of procedures was

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used to cultivate a robust crop. The observations were recorded for the following characters viz. number of primary branches, length of internode of main stem, days to first male flower, days to first female flower, days to first fruit harvest, length of the fruit, number of fruits per plant, vine length, seed length, seed width and fruit yield per plant. The mean values of genotypes in each replication were used for statistical analysis. The data were analyzed for a randomized block design to test the significance of differences between the genotypes for various characters as described by Panse and Sukhatme (1967). The genotypic and phenotypic coefficients of variation were calculated as per the formula suggested by Burton (1952). GCV and PCV values were categorized as low (0-10%), moderate (11-20%) and high (> 20%) as indicated by Sivasubramaniam and Menon (1973). Heritability (broad sense) was calculated as per Lush (1949), Burton and Devance (1953), and Weber and Moorty (1952). The heritability percentage was categorized as low (0-30%), moderate (30 -60 %) and high (>60%) as given by Johnson *et al.* and genetic advance as per Johnson *et al.* were also worked out. Genetic advance as per cent of mean was categorized as low (0-10%), moderate (11 – 20%) and high (>20%) as suggested by Johnson *et al.* The genetic divergence in twenty genotypes was estimated using Mahalanobis D^2 statistic (1936) following Rao (1952).

Comment [M3]: For repeatability briefly show how these parameters were taken and what instruments used

Table 1 – Genotypes of bottle gourd

Sr.No.	Germplasm	Source
1	BG-7002	Dept. of Vegetable Science, CSAUA&T Kanpur
2	BG-7117	Dept. of Vegetable Science, CSAUA&T Kanpur
3	BG-7201	Dept. of Vegetable Science, CSAUA&T Kanpur
4	BG-6503	Dept. of Vegetable Science, CSAUA&T Kanpur
5	BG-6401	Dept. of Vegetable Science, CSAUA&T Kanpur
6	BG-7003	Dept. of Vegetable Science, CSAUA&T Kanpur
7	BG-7303	Dept. of Vegetable Science, CSAUA&T Kanpur
8	KALAYANPUR LONG GREEN	Dept. of Vegetable Science, CSAUA&T Kanpur

Comment [M4]: Again for repeatability kindly indicate the formulae according to the suggested workers.

Comment [M5]: Delete Table see explanation under source

Comment [M6]: Same source. Brief description of the varieties would help otherwise delete table and indicate in text 32 genotypes since the entries appear in the divergence studies.

9	AZAD HARIT	Dept. of Vegetable Science, CSAUA&T Kanpur
10	BG-7505	Dept. of Vegetable Science, CSAUA&T Kanpur
11	BG-7107	Dept. of Vegetable Science, CSAUA&T Kanpur
12	BG-7112	Dept. of Vegetable Science, CSAUA&T Kanpur
13	BG-7127	Dept. of Vegetable Science, CSAUA&T Kanpur
14	BG-7512	Dept. of Vegetable Science, CSAUA&T Kanpur
15	BG-7306	Dept. of Vegetable Science, CSAUA&T Kanpur
16	BG-7504	Dept. of Vegetable Science, CSAUA&T Kanpur
17	BG-6802	Dept. of Vegetable Science, CSAUA&T Kanpur
18	BG-7304	Dept. of Vegetable Science, CSAUA&T Kanpur
19	BG-7404	Dept. of Vegetable Science, CSAUA&T Kanpur
20	KALAYANPUR LONG GREEN	Dept. of Vegetable Science, CSAUA&T Kanpur
21	AZAD HARIT	Dept. of Vegetable Science, CSAUA&T Kanpur
22	BG-7503	Dept. of Vegetable Science, CSAUA&T Kanpur
23	BG-7509	Dept. of Vegetable Science, CSAUA&T Kanpur
24	BG-7502	Dept. of Vegetable Science, CSAUA&T Kanpur
25	BG-7231	Dept. of Vegetable Science, CSAUA&T Kanpur
26	BG-7302	Dept. of Vegetable Science, CSAUA&T Kanpur
27	BG-7505	Dept. of Vegetable Science, CSAUA&T Kanpur

28	BG-8502	Dept. of Vegetable Science, CSAUA&T Kanpur
29	AZAD HARIT	Dept. of Vegetable Science, CSAUA&T Kanpur
30	BG-7202	Dept. of Vegetable Science, CSAUA&T Kanpur
31	BG-7233	Dept. of Vegetable Science, CSAUA&T Kanpur
32	BG-7232	Dept. of Vegetable Science, CSAUA&T Kanpur

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Table 2. Mean sum squares of 32 genotypes of bottle gourd for 11 characters

Source of variation	df	Number Of primary branches	Length of internode of main stem (c.m.)	Days to male flower (days)	Days to female flower (days)	Days to first fruit harvest (days)	Length of the fruit (c.m.)	Number Of fruits per plant	Vine length (c.m.)	Seed length (c.m.)	Seed width (c.m.)	Fruit yield per plant (kg)
Replication	2	0.078	1.19	1.22	1.49	2.26	6.64	0.21	196.54	0.0230	0.0005	1.03
Treatment	31	0.614**	9.57**	31.82**	30.02**	35.02**	74.19**	8.26**	7676.32**	0.0515**	0.0043**	15.52**
Error	62	0.111	0.44	2.70	2.55	2.37	5.10	0.31	116.61	0.0073	0.0006	0.27
Total	95	0.275	3.44	12.17	11.49	13.02	27.68	2.90	2585.14	0.0221	0.0018	5.26

*, ** significant at 5% and 1% level, respectively

Comment [M7]: check they are all **

Table 3. Genetic variability of 32 genotypes of bottle gourd for 11 characters

Genotypes	Mean	Min	Max	var (g)	var (p)	Heritability (%)	GA	GA% mean	GCV (%)	PCV (%)	% cont
Number Of primary branches	3.44	2.57	4.00	0.17	0.28	60.10	0.65	19.04	11.92	15.37	11.58
Length of internode main stem	11.40	9.00	16.22	3.04	3.49	87.28	3.36	29.45	15.30	16.38	8.72

(cm)											
Days to first male flower	44.35	38.33	50.78	9.71	12.41	78.23	5.68	12.80	7.03	7.94	9.87
Days to first female flower	46.77	42.56	54.00	9.15	11.71	78.20	5.51	11.78	6.47	7.32	11.68
Days to first fruit harvest	71.99	60.33	76.67	10.88	13.25	82.13	6.16	8.56	4.58	5.06	9.83
Length of the fruit (c.m.)	29.87	19.67	39.22	23.03	28.13	81.87	8.95	29.95	16.07	17.76	8.91
Number Of fruits per plant	6.30	3.11	8.89	2.65	2.96	89.48	3.17	50.36	25.84	27.32	7.78
Vine length (c.m.)	656.49	534.22	806.56	2519.91	2636.51	95.58	101.10	15.40	7.65	7.82	6.05
Seed length (c.m.)	1.57	1.27	1.80	0.01	0.02	66.81	0.20	13.01	7.73	9.46	9.39
Seed width(c.m.)	0.24	0.19	0.31	0.00	0.00	65.32	0.06	23.77	14.28	17.67	9.40
Fruit yield per plant (kg)	6.83	2.94	11.49	5.08	5.36	94.91	4.52	66.25	33.01	33.88	6.81

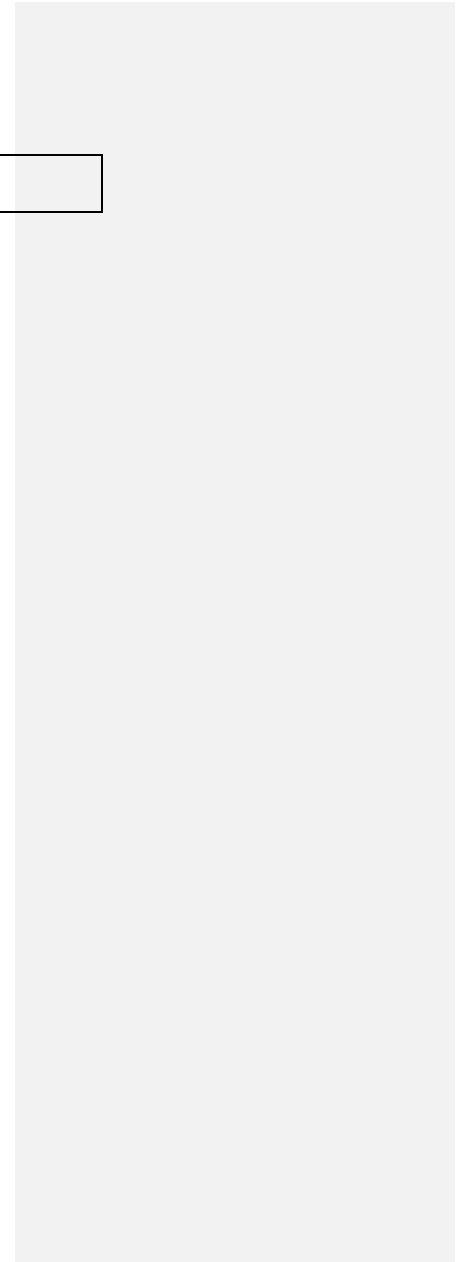
Comment [M8]: remove the dots it should just be cm

Table 4. Distribution of bottle gourd genotypes in different clusters

Clusters	No of genotypes	Genotypes
I	3	BG-6401, KLG (20), BG-7232
II	8	BG-7002, BG-7303, BG-6802, BG-7304, BG-7302, BG-7505, AZAD HARIT (29), BG-7202
III	8	KLG (8), AZAD HARIT (9), BG-7505 (10), BG-7127, BG-7512, BG-7306, BG-7502, BG-7231
IV	10	BG-7117, BG-7201, BG-6503, BG-7003, BG-7107, BG-7112, BG-7504, AZAD HARIT (21), BG-7503, BG-7509

v	3	BG-7404, BG-8502, BG-7233
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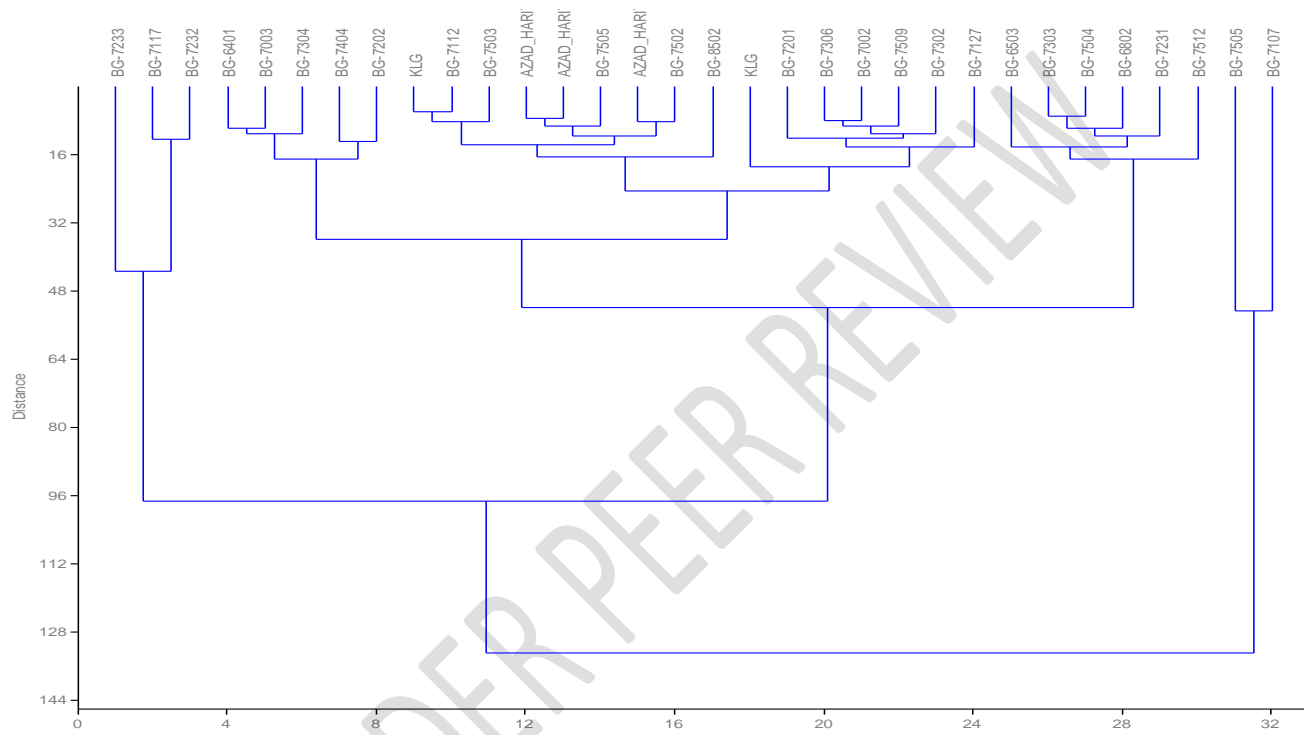


Fig1. Clustering by Tocher method (Dendrogram)

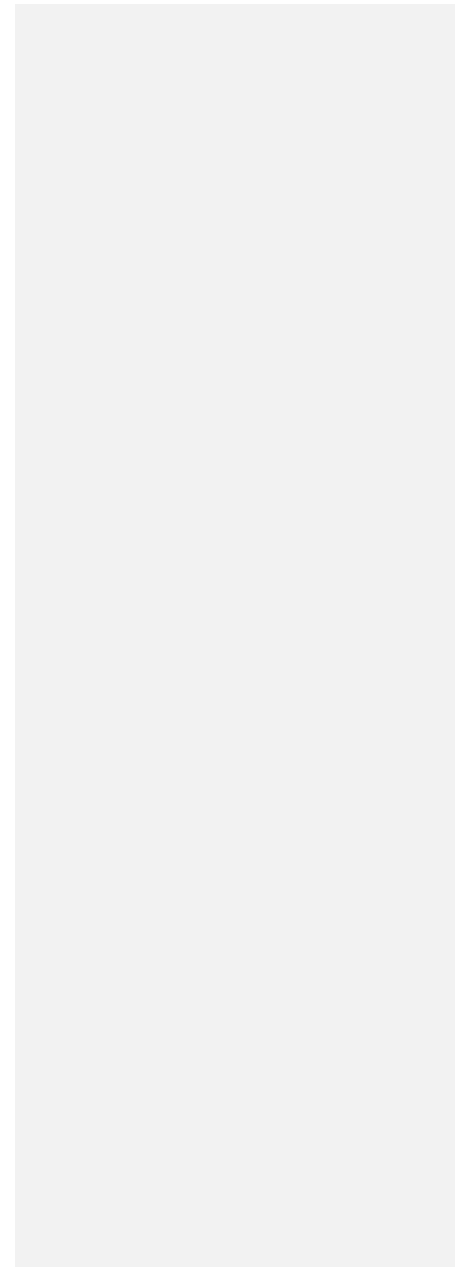


Table 5. Inter and intra distances

Clusters	I	II	III	IV	V
I	2.430				
II	3.058	2.200			
III	3.734	3.402	2.797		
IV	3.901	2.989	2.840	2.395	
V	4.083	3.176	5.084	5.064	1.958

Table 6. Contribution of various characters towards total genetic divergence

S.N.	Character	Contribution %
1.	Number Of primary branches	11.58
2.	Length of internode of main stem(c.m.)	8.72
3.	Days to first male flower (days)	9.87
4.	Days to first female flower (days)	11.68
5.	Days to first fruit harvest (days)	9.83
6.	Length of the fruit (c.m.)	8.91
7.	Number Of fruits per plant	7.78
8.	Vine length (c.m.)	6.05
9.	Seed length (c.m.)	9.39
10.	Seed width(c.m.)	9.40
11.	Fruit yield per plant (kg)	6.81

RESULTS AND DISCUSSION

1. Analysis of Variance

The analysis of variance for different characters is presented in Table 1. The result showed highly significant differences among thirty two genotypes for different characters under study. These characters were No. of primary branches, Length of internode of main stem, Days to male flower, Days to female flower, Days to first fruit harvest, Length of the fruit, No. of fruits per plant, Vine length, Seed length, Seed width, Fruit yield per plant.

2. Heritability Analysis

Heritability in broad sense was found high for vine length (95.58%), fruit yield per plant (94.91%), number of fruits per plant (89.48%), length of internode of main stem (87.28%), days to first fruit harvest (82.13%), length of fruit (81.87%), days to first male flower (78.23%) and days to first female flower (78.20%) .

3. Genetic Advance Analysis

During the rainy season, most attributes showed strong genetic advance as a percentage of mean (genetic gain), ranging from 66.25% for fruit yield per plant to 8.56% days to first fruit harvest. Number of fruits per plant (50.36%), length of the fruit (29.95%), length of internode of main stem (29.45%), seed width (23.77%), number of primary branches (19.04%), and vine length (15.40%) were other parameters with strong genetic gain as a percentage of mean.

4. Genetic Divergence

4.1. Clustering pattern

The studies of genetic divergence among the thirty two genotypes of bottle gourd were carried out by using Mahalanobis D^2 statistics. Thirty two genotypes were grouped into five different non-overlapping clusters. Cluster IV had highest number of genotypes (10) followed by cluster II (8) and cluster III (8). In cluster I and cluster V had 3 genotypes.

4.2 Inter and intra cluster distance

The average intra and inter cluster D^2 presented in Table 5. revealed maximum inter cluster D^2 value (5.084), between cluster III and V followed by cluster IV and V (5.084), whereas the minimum average inter cluster D^2 value (2.840) was recorded between cluster III and IV . The maximum intra cluster distance were found 2.797 for cluster III followed by cluster I (2.430), 2.395 for cluster IV, 2.200 for cluster II, whereas minimum intra cluster value was recorded between cluster V (1.958).

4.3. Contribution Percentage of Each Character towards Total Divergence

The contribution percentages of traits under studied towards total divergence are tabulated in table 6. The highest contribution in the manifestation of genetic divergence was exhibited by days to first female flower contributes maximum (11.68) towards total divergence and this was followed number of primary branches (11.58), days to first male flower (9.87), days to first fruit harvest (9.83), seed width (9.40), seed length (9.39), length of the fruit (8.91), length of internode of main stem (8.72), number of fruits per plant (7.78), fruit yield per plant (6.81), vine length (6.05).

Comment [M9]: Please this section must be rewritten following some of these authors
Dev Nidhi Tiwari et al. 2019. Genetic Variability and Correlation Coefficients of Major Traits in Early Maturing Rice under Rainfed Lowland Environments of Nepal. *Hindawi Advances in Agriculture* Volume 2019, Article ID 5975901, 9 pages
<https://doi.org/10.1155/2019/5975901>

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Endashaw Girma Seyoum, Alemnesh Sisay. Genetic Variability, Heritability and Genetic Advance Study in Bread Wheat Genotypes (*Triticum aestivum* L.). *Advances in Bioscience and Bioengineering*. Vol. 9, No. 3, 2021, pp. 81-86. doi: 10.11648/j.abb.20210903.13
As indicated earlier, because you could not do a proper review in the introduction you have nothing to discuss.

Comment [M10]: I think your table 1 was a table of your genotypes which is suggested to be deleted if you agree the the Mean square table becomes 1 then edit the rest.

CONCLUSION

The prior discussion shows that there is significant potential for merging the top allelic resources found in these bottle gourd genotypes using a systematic breeding and selection technique in order to recover high producing recombinants with good quality features. Analysis of variance exhibited significant variation among the genotypes for all the characters viz., Leaf shape, Vine length, length of Internode of main stem, Number of primary branches, Days to first male flower, Days to first female flower, Days to first fruit harvest, length of the fruit, Number of fruit per plant, seed length (cm), seed width (cm) and fruit yield per plant (kg) indicating wide spectrum of variation among the genotypes. . The high PCV and GCV was recorded for the traits like fruit yield per plant, number of fruits per plant, whereas length of the fruit, seed width, length of internode of main stem, number of primary branches showed moderate PCV and GCV while seed length, vine length, days to first male flower, days to first female flower, days to first fruit harvest showed lowest GCV and PCV. Heritability in broad sense was found high for vine length, fruit yield per plant, number of fruits per plant, length of internode of main stem, days to first fruit harvest, length of fruit, days to first male flower and days to first female flower. High genetic advance showed in number of fruits per plant, length of the fruit, length of internode of main stem, seed width, number of primary branches and vine length. • The intra cluster distance among various clusters exhibited maximum intra cluster distance for cluster III followed by cluster I and the lowest intra cluster distance was recorded for cluster V. So crosses among genotypes of cluster V like BG-7404, BG-8502, BG-7233 and genotype of cluster III i.e. KLG (8), AZAD HARIT (9), BG-7505 (10), BG-7127, BG-7512, BG-7306, BG-7502, BG-7231 can be made. Inter cluster distance was determined highest for cluster III and cluster V therefore, genotypes in cluster III can be crossed among themselves to get better result in the breeding programme.

Comment [M11]: Please this is just a repetition of your results which is not accepted as conclusion. Let it come out the implications and applications of your results in the field of breeding. New things learnt and any innovations.

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