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Estimates of Genetic Variability, Heritability and Genetic Advance for Yield and Yield Component Traits in Ridge Gourd (*Luffa acutangula* Roxb.)

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ABSTRACT

The present experiment was executed during spring–summer season (February–July) of 2022 at the instructional farm, Department of Vegetable and Spice Crops, UBKV, Pundibari, Coochbehar, West Bengal, India in a Randomized Block Design with thirty-four genotypes to estimate the genetic variability, heritability and genetic advance for yield and yield contributing traits in ridge gourd. Result pertaining to analysis of variance revealed significant differences among the thirty-four ridge gourd genotypes for all the evaluated traits. Results further revealed higher PCV in magnitude as compared to GCV for all the traits studied indicating the influence of environmental factors on the character expression. The estimates of high PCV and GCV were recorded in traits like vitamin A, chlorophyll A, chlorophyll B and total chlorophyll content in fruits indicating the presence of considerable magnitude of genetic variability among the genotypes. A very high broad sense heritability was expressed by the traits such as vitamin A, crude fibre, days to first male flower emergence, TSS, number of fruits vine^{-1}, fruit length, vine length, internode length, fruit yield vine^{-1}, fruit diameter, total chlorophyll content, chlorophyll A content, vitamin C content and average fruit weight. Traits like vitamin A content, vitamin C content, crude fibre, chlorophyll A content, total chlorophyll content, TSS, vine length, fruit length, number of fruits vine^{-1} and fruit yield vine^{-1} showed very high heritability coupled with high genetic advance as percentage of mean, indicating existence of additive gene action and a good scope for selection of valuable initial breeding material for future crop improvement in ridge gourd.

KEYWORDS: Ridge gourd, variability, heritability, genetic advance

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1. INTRODUCTION

Ridge gourd (*Luffa acutangula* Roxb.) is an important warm season cucurbitaceous vegetable crop grown in diverse regions of India and tropical areas of Asia and Africa (Choudhary et al., 2014; Haldhar et al., 2015) for its tender fruits. It belongs to family Cucurbitaceae and bears a chromosome number 2n=2x=26 (Sen et al., 2023; Mithila et al., 2024). Crop is popularly known by different names such as Kalitori, angled gourd, angled loofah and ribbed gourd and believed to have originated from Subtropical Asian region including India (Yadav et al., 2015; Swarup, 2016). Ridge gourd acts as an appetizer and considered as a healthy food that contains 0.5 g of fiber, 0.5% of protein, 0.35% of carbohydrate, 37 mg of carotene, 5.0 mg of vitamin C, 18 mg of calcium and 0.5 mg of Iron in 100 g of the edible portion (Hazra and Som, 2005). They form a low-calorie diet, which is good for diabetes (Harshitha et al., 2019; Narasannavar, 2017) and found to be helpful as a natural remedy for the treatment of jaundice (Panicker et al., 2019). In India, ridge gourd is considered as one of the most important, cultivated and consumed summer vegetable crop. However, in spite of its good nutritive values, high acceptability among growers and consumers and wide range of available genetic variability, not much attention has been paid to ridge gourd improvement programmes till date, as a result of which not a lot high yielding and resistance varieties are available. These challenges can be tackled appropriately by moving forward with respect to identifying and developing varieties with superior yield contributing traits having wider adaptability to different environment conditions and such can be achieved by panoramic understanding of genetic variability, heritability and genetic advance which offers valuable insights into the degree of genetic control over the traits and their potential for improvement through selective breeding (Suvedha et al., 2023; Singh et al., 2024).

Evaluation and identification of superior genotypes among the existing germplasm is considered very imperative to utilize and improve the plant genetic resources in various crop improvement programmes (Pidigam et al., 2019; Terfa and Gurnu, 2020). According to Saisupriya et al. (2022), improvement of any crop depends upon the degree of genetic variability present and the level of heritability associated with economically significant traits. The significant degree of natural variation or extensive variability in multiple characteristics across genotypes enhances greater opportunity of identifying new genotypes and suggests a strong potential for improvement in economic traits (Jonah et al., 2024). The variability parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance are of utmost importance in establishing a breeding strategy that aims to exploit the inherent variability of the original population. Estimates of heritability reflect the inheritance of traits from one generation to another (Saidaiah et al., 2021). High heritability coupled with considerable genetic advance indicates that the trait is predominantly governed by genetic factors and is likely to yield a positive response to selection (Ogunniyan and Olakajo, 2014; Chacko et al., 2023). In the context of predicting genetic gain under selection, the combination of heritability estimates along with genetic advance is more effective than heritability alone (Demeke et al., 2023). Genetic advance provides information on expected gain stemming from selection of superior individuals (Limbani et al., 2017; Lingaiah et al., 2019). Thus, with respect to all above facts and focussing on crop improvement in ridge gourd a field experiment was undertaken to estimate the genetic variability, heritability and genetic advance for yield and yield attributing traits in ridge gourd aiming future prosperity of the crop for the human wellbeing.

2. MATERIALS AND METHODS

The experiment was carried out at the Instructional farm of the Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India during spring–summer season (February–July) of 2022. The experimental site was located at 26°40'N latitude and 89°38'E longitude with an elevation of 43 meter above mean seal level. The experiment was laid out in Randomized Block Design (RBD) with thirty-four ridge gourd genotypes in three replications. Out of the thirty-four ridge gourd genotypes twenty-seven genotypes were the collection from farmers who were growing these genotypes traditionally, since long in different regions of the country and remaining seven genotypes were open pollinated varieties including Pusa Nasdar a variety released from IARI, New Delhi (Table 1). The seeds were sown during last week of February in a well prepared pit at a spacing of 2×1 m^2. Recommended package of practices was adopted to raise the crop. The observations were recorded from five randomly selected plants for various growth, yield and quality parameters viz., number of primary branches, vine length (m), internode length (cm), days to first male flower emergence, node at which first male flower emergence, days to female flower emergence, node at which first female flower emergence, fruit length (cm), fruit diameter (cm), average fruit weight (g), days to first fruit harvest, days to last fruit harvest, number of fruits plant^{1}, fruit yield plant^{-1} (kg), total soluble solids (°Brix), vitamin C (mg 100 g^{-1}), vitamin A (IU), chlorophyll a content in fruits (mg g^{-1}), chlorophyll b content in fruits (mg g^{-1}), total chlorophyll content in fruits (mg g^{-1}) and crude fibre (%). The qualitative parameters under the study was estimated by various procedures i.e. the total soluble soilds (°Brix) content in fruits were determined

Table 1: List of evaluated ridge gourd genotypes along with their sources

Genotype No.	CODE	Genotypes	Source of collection
1	PRGC-1	Pundibari ridge gourd collection-1	Bashdaha Natibari, Cooch Behar, West Bengal
2	PRGC-2	Pundibari ridge gourd collection-2	Pundibari, Cooch Behar, West Bengal
3	PRGC-3	Pundibari ridge gourd collection-3	Panchal, Bankura, West Bengal
4	PRGC-4	Pundibari ridge gourd collection-4	Padamchey, East Sikkim. Sikkim
5	PRGC-5	Pundibari ridge gourd collection-5	Tirikhola, South Sikkim, Sikkim
6	PRGC-6	Pundibari ridge gourd collection-6	Gangtok , East Sikkim, Sikkim
7	PRGC-7	Pundibari ridge gourd collection-7	Kayong, East Sikkim, Sikkim
8	PRGC-8	Pundibari ridge gourd collection-8	Gidabling, Kalimpong, West Bengal
9	PRGC-9	Pundibari ridge gourd collection-9	Mangpoo, Darjeeling, West Bengal
10	PRGC-10	Pundibari ridge gourd collection-10	Munsong, Kalimpong, West Bengal
11	PRGC-11	Pundibari ridge gourd collection-11	Golabari, Alipurduar, West Bengal
12	PRGC-12	Pundibari ridge gourd collection-12	Lolay, Kalimpong, West Bengal
13	PRGC-13	Pundibari ridge gourd collection-13	Lingee, Kalimpong, West Bengal
14	PRGC-14	Pundibari ridge gourd collection-14	Nimbong, Kalimpong, West Bengal
15	PRGC-15	Pundibari ridge gourd collection-15	Kagay, Kalimpong, West Bengal
16	PRGC-16	Pundibari ridge gourd collection-16	Pala, Kalimpong, West Bengal
17	PRGC-17	Pundibari ridge gourd collection-17	Pedong, Kalimpong, West Bengal
18	PRGC-18	Pundibari ridge gourd collection-18	Karanprayag, Chamoli, Uttarakhand
19	PRGC-19	Pundibari ridge gourd collection-19	Karimnagar, Telangana
20	PRGC-20	Pundibari ridge gourd collection-20	Amarpur, Gomati, Tripura
21	PRGC-21	Pundibari ridge gourd collection-21	Mohanpur, Nadia, West Bengal
22	PRGC-22	Pundibari ridge gourd collection-22	Dispur, Assam
23	PRGC-23	Pundibari ridge gourd collection-23	Baganbari, Dhalai, Tripura
24	PRGC-24	Pundibari ridge gourd collection-24	Tura, West Garo Hills, Meghalaya
25	PRGC-25	Pundibari ridge gourd collection-25	Narayanpur, Dhalai, Tripura
26	PRGC-26	Pundibari ridge gourd collection-26	Pasighat, East Siang, Arunachal Pradesh
27	PRGC-27	Pundibari ridge gourd collection-27	Namthang, South Sikkim, Sikkim
28	Amoha	Amoha (OP variety)	Acsen hyveg seeds
29	12 Patta Jhinga	12 Patta Jhinga (OP variety)	Badkulla seeds
30	Debsundari	Debsundari (OP variety)	Debgiri seeds
31	Jaipur Long	Jaipur long (OP variety)	Solar seeds
32	Maharastra 16 Patta	Maharastra 16 Patta (OP variety)	Badkulla seeds
33	Rekha	Rekha (OP variety)	R.K. seeds
34	Pusa Nasdar	Pusa Nasdar (OP variety)	Agrilabh beej (Agrosiaa)

OP- Open pollinated

using an "ERMA hand refractometer" with a Brix range of 0° to 32°, vitamin C content in freshly harvested fruits (mg 100 g^{-1}) was measured as per the methodology outlined by Ranganna (2001), Vitamin A content in fruits was estimated in accordance with calorimetric method using spectrophotometer suggested by Davies (1976), fruit chlorophyll content was determined using the procedure given by Witham et al. (1971) and the crude fibre content in fruits was estimated as per the procedure suggested by Anonymous (1980). The statistical analyses were undertaken using Statistical Tools for Agricultural Research (STAR) version 2.0.1 and TNAUSTAT Statistical Package developed by Manivannan (2014). The average values of the data gathered for the different attributes were analyzed with the help of the analysis of variance method outlined by Panse and Sukhatme (1967). Estimation of Genotypic Coefficients of Variability (GCV %) and Phenotypic Coefficients of Variability (PCV %) was conducted in accordance with the formula established by Burton and De-Vane in 1953. Heritability in a broad sense (h^2) was calculated using the formula suggested by Hanson et al. (1956) and classified as per Robinson (1966) and the genetic advance expressed as a percentage of the mean for each trait was calculated and classified utilizing the formula established by Johnson et al. (1955).

3. RESULTS AND DISCUSSION

The results pertaining to analysis of variance revealed significant differences among the 34 ridge gourd genotypes for all the evaluated traits indicating the presence of considerable magnitude of genetic variability among the genotypes (Table 2) favouring selection for future crop improvement in ridge gourd. The findings are in consonance with the findings of Varalakshmi et al. (2016) and Yadav and Singh (2022) in ridge gourd.

Table 2: Mean performance of thirty-four genotypes for yield and yield component traits in ridge gourd

Genotypes	PB	VL	IL	DMFE	NMFE
1. PRGC-1	5.13^{ghij}	6.21^{a}	17.66^{ab}	41.20^{klmno}	6.67^{bc}
2. PRGC-2	6.40^{abc}	4.45^{cdef}	16.60^{cdefg}	39.27^{qr}	5.07^{jk}
3. PRGC-3	5.13^{ghij}	3.18^{p}	14.59^{lm}	46.60^{b}	5.53^{ghijk}
4. PRGC-4	5.93^{abcdef}	2.74^{q}	13.14^{no}	40.47^{nop}	6.13^{cdefg}
5. PRGC-5	6.00^{abcde}	4.58^{cde}	15.90^{defghi}	41.80^{jk}	7.67^{a}
6. PRGC-6	4.93^{ijk}	3.38^{nop}	15.18^{ijkl}	42.33^{hijk}	6.60^{bcd}
7. PRGC-7	5.07^{hij}	4.12^{efghijk}	16.94^{abcd}	41.67^{klm}	5.93^{cdefghi}
8. PRGC-8	5.93^{abcdef}	3.65^{klmnop}	13.50^{no}	49.40^{a}	6.00^{cdefgh}
9. PRGC-9	6.07^{abcde}	3.36^{nop}	12.47^{o}	42.00^{jk}	5.40^{ghijk}
10. PRGC-10	5.20^{fghij}	3.84^{hijklmn}	15.36^{hijkl}	45.07^{cd}	5.40^{ghijk}
11. PRGC-11	6.07^{abcde}	4.66^{cd}	16.54^{cdefg}	38.40^{r}	6.67^{bc}
12. PRGC-12	5.53^{defghi}	3.58^{lmnop}	16.72^{bcdef}	42.87^{ghij}	5.07^{jk}
13. PRGC-13	6.20	3.52^{lmnop}	12.66o	41.60^{klmn}	5.67^{ghij}
14. PRGC-14	5.33^{efghij}	4.23^{defgh}	15.65^{fghijkl}	45.33^{c}	6.53^{bcde}
15. PRGC-15	5.67^{cdefghi}	4.13^{efghijk}	16.00^{defghi}	42.93^{ghij}	5.60^{ghij}
16. PRGC-16	5.33^{efghij}	3.96^{fghijkl}	15.82^{efghij}	43.27^{fghi}	5.33^{hijk}
17. PRGC-17	4.73^{jk}	3.88^{ghijklm}	15.21^{ijkl}	44.60^{cde}	5.53^{ghijk}
18. PRGC-18	5.87^{abcdefg}	4.40^{cdef}	15.95^{defghi}	40.53^{mnop}	5.73^{fghij}
19. PRGC-19	6.33^{abc}	3.73^{ijklmno}	13.44^{no}	46.73^{b}	5.60^{ghij}
20. PRGC-20	5.73^{bcdefgh}	3.41^{mnop}	16.33^{defgh}	42.27^{hijk}	6.13^{cdefg}
21. PRGC-21	5.20^{fghij}	4.36^{cdefg}	16.79^{bcde}	44.80^{cd}	7.73^{a}
22. PRGC-22	6.27^{abcd}	4.20^{defghij}	15.74^{efghijk}	39.93^{pq}	5.73^{fghij}
23. PRGC-23	4.60^{jk}	3.71^{jklmno}	15.59^{ghijkl}	40.07^{opq}	6.47^{bcdef}
24. PRGC-24	4.33^{k}	3.96^{fghijkl}	16.55^{cdefg}	40.73^{lmnop}	6.07^{cdefgh}
25. PRGC-25	5.73^{bcdefgh}	3.24^{op}	13.16^{no}	44.13^{def}	6.07^{cdefgh}
26. PRGC-26	5.93^{abcdef}	3.61^{lmnop}	15.25^{hijkl}	43.67^{efg}	6.53^{bcde}
27. PRGC-27	6.47^{ab}	3.36^{nop}	15.40^{hijkl}	42.13^{ijk}	7.07^{ab}
28. Amoha	5.80^{abcdefgh}	4.22^{defghi}	13.93^{mn}	41.60^{klmn}	6.07^{cdefgh}

Genotypes	PB	VL	IL	DMFE	NMFE
29. 12 Patta Jhinga	5.87^{abcdefg}	3.73^{ijklmno}	14.78^{jklm}	39.87^{pq}	5.20^{ijk}
30. Debsundari	6.53^{a}	4.14^{efghijk}	16.57^{cdefg}	41.13^{klmno}	5.33^{hijk}
31. Jaipur Long	5.80^{abcdefgh}	4.81^{c}	17.86^{a}	43.40^{fgh}	5.74^{fghij}
32. Maharastra 16 Patta	4.93^{ijk}	4.12^{efghijk}	15.88^{defghi}	42.00^{klmn}	5.80^{efghi}
33. Rekha	6.13^{abcd}	4.43^{cdef}	14.70^{klm}	41.93^{jk}	4.80^{k}
34. Pusa Nasdar	5.20^{fghij}	5.41b	17.47^{abc}	39.27^{qr}	5.87^{defghi}
Mean	5.63	4.01	15.45	42.43	5.96
CV (%)	6.89	6.41	3.62	1.45	6.57
SEm±	0.22	0.15	0.32	0.36	0.23
CD (p=0.05)	0.63	0.42	0.91	1.01	0.64
ANOVA (Probability values)					
Replication	0.09	0.79	0.02	0.09	0.02
Genotypes	0.00	0.00	0.00	0.00	0.00

Table 2 continue...

Genotypes	DFFE	NFFE	FL	FD	AFW	DFFH
1. PRGC-1	48.67^{bcde}	12.40^{ab}	30.48^{cde}	4.73^{a}	171.24^{abc}	56.93^{ijkl}
2. PRGC-2	45.47^{ijk}	10.40^{cdefghijk}	25.58^{ghijk}	3.95^{cde}	151.76^{efghijkl}	57.60^{ghijk}
3. PRGC-3	51.40^{a}	11.33^{bcdef}	26.32^{fghij}	3.91^{cdefg}	153.66^{efghijk}	59.80^{cdef}
4. PRGC-4	46.60^{fghij}	11.67^{bc}	28.86^{def}	3.33^{lmn}	155.29^{defghij}	56.53^{klm}
5. PRGC-5	46.07^{hij}	11.33^{bcdef}	30.23^{cde}	4.62^{a}	168.85^{abcd}	57.07^{hijkl}
6. PRGC-6	47.13^{defghi}	13.13^{a}	29.88^{cde}	3.45^{jklm}	162.38^{abcdef}	57.13^{hijkl}
7. PRGC-7	46.27^{ghij}	10.40^{cdefghijk}	35.19^{b}	3.31^{mn}	168.30^{abcd}	55.27^{lmn}
8. PRGC-8	45.93^{ij}	11.60^{bcd}	22.42^{kl}	3.74^{efghij}	140.28^{klm}	57.93^{fghijk}
9. PRGC-9	48.00^{cdefgh}	10.07^{defghijkl}	24.63^{hijkl}	3.47^{ijklm}	148.34^{fghijklm}	54.13^{n}
10. PRGC-10	50.07^{ab}	8.73^{l}	26.12^{fghij}	3.74^{efghij}	148.80^{efghijkl}	60.13^{bcde}
11. PRGC-11	45.20^{jk}	11.53^{bcd}	24.57^{hijkl}	3.59^{hijklm}	146.17^{ghijklm}	56.80^{jklm}
12. PRGC-12	49.73^{abc}	9.47^{hijkl}	29.21^{cdef}	3.34^{lmn}	156.40^{defghij}	60.93^{abc}
13. PRGC-13	46.87^{efghij}	10.07^{defghijkl}	24.16^{ijkl}	3.41^{klm}	146.15^{ghijklm}	59.13^{cdefg}
14. PRGC-14	51.13^{a}	13.60^{a}	23.81^{ijkl}	3.65^{efghijk}	146.14^{ghijklm}	59.80^{cdef}
15. PRGC-15	47.87^{cdefgh}	9.73^{ghijkl}	32.06^{c}	3.42^{klm}	160.76^{bcdefg}	56.73^{jklm}
16. PRGC-16	48.13^{cdefg}	11.13^{bcdefg}	26.39^{fghij}	3.83^{defgh}	156.21^{defghij}	57.60^{ghijk}
17. PRGC-17	49.67^{abc}	10.20^{cdefghijkl}	22.66^{kl}	3.80^{efgh}	142.68^{ijklm}	58.40^{efghijk}
18. PRGC-18	47.13^{defghi}	11.00^{bcdefgh}	22.17^{l}	3.76^{efghi}	142.14^{jklm}	58.27^{efghijk}
19. PRGC-19	51.00^{a}	9.67^{ghijkl}	25.43^{ghijk}	3.89^{cdefgh}	151.42^{efghijkl}	61.87^{ab}
20. PRGC-20	48.87^{bcd}	11.07^{bcdefg}	23.65^{ijkl}	3.83^{defgh}	144.41^{hijklm}	61.80^{ab}
21. PRGC-21	50.13^{ab}	10.60^{cdefghij}	22.72^{kl}	3.78^{efgh}	140.22^{klm}	60.13^{bcde}
22. PRGC-22	48.07^{cdefg}	9.40^{ijkl}	21.68^{l}	3.81^{efgh}	138.96^{lm}	58.87^{efghi}
23. PRGC-23	47.93^{cdefgh}	9.80^{fghijkl}	26.76^{fghi}	3.60^{ghijklm}	154.86^{defghijk}	59.67^{cdef}
24. PRGC-24	46.33^{ghij}	9.20^{jkl}	16.03^{m}	3.87^{cdefgh}	87.42^{n}	57.67^{ghijk}
25. PRGC-25	48.40^{bcdef}	10.60^{cdefghij}	42.27^{a}	3.07^{n}	176.12^{a}	58.93^{defgh}
26. PRGC-26	51.20^{a}	9.87^{fghijkl}	31.42^{cd}	3.93^{cdef}	174.35^{ab}	62.07^{a}

Table 2: Continue...

Genotypes	DFFE	NFFE	FL	FD	AFW	DFFH
27. PRGC-27	47.93^{cdefgh}	10.80^{cdefghi}	25.41^{ghijk}	3.87^{cdefgh}	148.74^{efghijkl}	57.00^{hijkl}
28. Amoha	46.73^{efghij}	11.33^{bcdef}	27.82^{efg}	3.92^{cdef}	158.72^{cdefgh}	57.40^{ghijk}
29. 12 Patta Jhinga	44.13^{k}	8.87^{kl}	23.26^{jkl}	3.68^{efghijk}	142.16^{jklm}	55.07^{mn}
30. Debsundari	46.40^{ghij}	9.93^{efghijkl}	21.45^{l}	3.62^{fghijkl}	134.20^{m}	57.40^{ghijk}
31. Jaipur Long	48.47^{bcdef}	13.13^{a}	27.44^{efgh}	4.36^{b}	157.10^{cdefghi}	58.53^{efghij}
32. Maharastra 16 Patta	48.40^{bcdef}	9.27^{ijkl}	26.54^{fghi}	4.17^{bc}	156.38^{defghi}	60.80^{abcd}
33. Rekha	49.13^{bc}	11.13^{bcdefg}	27.96^{efg}	4.12^{bcd}	160.26^{cdefg}	58.27^{efghijk}
34. Pusa Nasdar	46.40^{ghij}	11.47^{bcde}	28.25^{efg}	4.28^{b}	163.34^{abcde}	58.07^{fghijk}
Mean	47.97	10.70	26.55	3.79	151.59	58.35
CV (%)	2.06	7.36	6.20	4.19	4.89	1.70
SEm±	0.57	0.45	0.95	0.09	4.28	0.57
CD (p=0.05)	1.61	1.28	2.68	0.26	12.10	1.62
ANOVA (Probability values)						
Replication	0.63	0.21	0.57	0.28	0.79	0.01
Genotypes	0.00	0.00	0.00	0.00	0.00	0.00

The values in superscript indicate the DMRT ranks of the ridge gourd genotypes for a particular trait and the genotypes having the same rank do not differ significantly from each other for that trait; PB-primary branches, VL-vine length (m), IL-internode length (cm), DMFE-days to first male flower emergence, NMFE-node in which first male flower emergence, DFFE- days to first female flower emergence NFFE- node in which first female flower emergence, FL-fruit length (cm), FD-fruit diameter (cm) , AFW-average fruit weight (g), DFFH-days to first fruit harvest

Table 2: Continue...

Genotypes	DLFH	NFPV	FYPV	TSS	VIT- C	VIT- A	CH-A	CH-B	T-CH	CF	Y/ha.
1. PRGC-1	94.60^{cdefgh}	12.80^{a}	2.19^{a}	3.18^{fg}	4.58^{cdefgh}	48.92^{op}	2.17^{abc}	0.69^{bcd}	2.95^{a}	2.57^{def}	16.75^{a}
2. PRGC-2	97.20^{bcd}	10.33^{cd}	1.57^{cdef}	3.77^{b}	4.37^{efghi}	45.14^{pqrs}	2.12^{abc}	0.66^{bcde}	2.73^{abcd}	2.36^{ijk}	12.28^{cde}
3. PRGC-3	86.47^{klmn}	7.53^{mn}	1.16^{no}	3.28^{cdefg}	3.99^{fghi}	92.56^{a}	1.38^{gh}	0.47^{ghij}	1.68^{ijk}	1.72^{op}	9.05^{mno}
4. PRGC-4	93.20^{cdefghij}	6.80^{n}	1.06^{op}	3.45^{cd}	5.06^{bcde}	59.45^{ijkl}	1.96^{abcde}	0.56^{defghi}	2.50^{bcdef}	2.38^{ij}	8.35^{no}
5. PRGC-5	89.27^{hijkl}	10.93^{bc}	1.85^{b}	3.28^{cdefg}	4.18^{fghi}	52.46^{no}	2.08^{abcde}	0.62^{cdef}	2.71^{abcd}	2.40^{hij}	14.55^{b}
6. PRGC-6	97.33^{bcd}	8.00^{klm}	1.30^{ijklmn}	3.43^{cde}	4.30^{fghi}	84.37^{c}	1.74^{def}	0.58^{defgh}	2.26^{efg}	2.66^{cd}	9.96^{ijklm}
7. PRGC-7	89.80^{fghijkl}	9.33^{efgh}	1.57^{cde}	3.28^{cdefg}	4.34^{efghi}	38.66^{u}	0.93^{j}	0.33^{k}	1.22^{l}	2.25^{klm}	12.33^{cde}
8. PRGC-8	94.47^{cdefgh}	10.47^{bcd}	1.47^{defghij}	4.00^{ab}	3.86^{hi}	60.43^{ijk}	1.29^{hij}	0.38^{jk}	1.65^{ijk}	2.31^{jkl}	11.42^{cdefghi}
9. PRGC-9	85.40^{lmn}	7.93^{lm}	1.18^{mno}	3.15^{g}	4.59^{cdefgh}	40.18^{tu}	1.88^{bcde}	0.63^{cdef}	2.58^{abcdef}	2.36^{ijk}	9.11^{mno}
10. PRGC-10	86.20^{klmn}	9.20^{ghi}	1.37^{ghijkl}	2.65^{i}	4.36^{efghi}	58.24^{jkl}	1.41^{fgh}	0.36^{jk}	1.76^{hij}	2.82^{b}	10.63^{fghijklm}
11. PRGC-11	91.53^{efghijk}	10.60^{bc}	1.55^{cdefg}	3.37^{cdefg}	5.14^{bcd}	56.72^{klm}	1.17^{hij}	0.45^{hijk}	1.62^{ijkl}	2.51^{efgh}	12.21^{cdef}

Table 2: Continue...

Genotypes	DLFH	NFPV	FYPV	TSS	VIT- C	VIT- A	CH-A	CH-B	T-CH	CF	Y/ha.
12. PRGC-12	95.20^{cdefg}	8.47^{hijkl}	$1.32^{hijklmn}$	3.24^{defg}	4.15^{fghi}	77.69^{e}	2.15^{abc}	0.66^{bcde}	2.75^{abcd}	2.42^{hij}	9.95^{ijklm}
13. PRGC-13	83.60^{mn}	8.33^{ijklm}	1.22^{lmno}	2.92^{h}	4.18^{fghi}	60.48^{ijk}	1.36^{gh}	0.57^{defgh}	1.91^{ghi}	1.77^{o}	9.57^{klmn}
14. PRGC-14	$92.27^{defghij}$	10.13^{cdef}	$1.48^{cdefghi}$	3.51^{c}	4.25^{fghi}	88.29^{b}	2.03^{abcde}	0.56^{defghi}	2.59^{abcdef}	2.54^{efg}	11.48^{cdefgh}
15. PRGC-15	88.47^{ijklm}	9.40^{efg}	1.51^{cdefgh}	3.93^{ab}	4.46^{defghi}	82.12^{cd}	1.24^{hij}	0.60^{cdefg}	1.78^{hij}	3.12^{a}	11.79^{cdefgh}
16. PRGC-16	75.20^{o}	10.20^{cde}	1.59^{cd}	3.81^{b}	3.88^{ghi}	61.41^{hij}	1.97^{abcde}	0.46^{hij}	2.47^{bcdef}	1.94^{n}	12.29^{cde}
17. PRGC-17	95.33^{cdef}	9.13^{ghi}	1.30^{ijklmn}	3.99^{ab}	4.20^{fghi}	63.28^{ghi}	1.20^{hij}	0.43^{ijk}	1.74^{ij}	2.25^{klm}	10.20^{hijklm}
18. PRGC-18	81.73^{n}	10.60^{bc}	1.51^{cdefgh}	3.51^{c}	4.13^{fghi}	56.12^{lmn}	1.71^{efg}	0.52^{fghi}	2.17^{fgh}	2.38^{ij}	11.79^{cdefgh}
19. PRGC-19	$90.40^{fghijkl}$	9.13^{ghi}	$1.38^{fghijkl}$	3.19^{efg}	4.63^{cdefg}	45.37^{pqr}	1.84^{bcde}	0.56^{defghi}	2.52^{abcdef}	2.44^{ghi}	$10.65^{fghijklm}$
20. PRGC-20	86.60^{klmn}	8.13^{jklm}	1.18^{mno}	3.39^{cdef}	4.71^{cdef}	42.68^{rst}	2.29^{a}	0.72^{abc}	2.86^{ab}	2.86^{b}	9.17^{lmn}
21. PRGC-21	96.13^{cde}	9.67^{defg}	1.36^{hijklm}	4.11^{a}	5.09^{bcd}	44.89^{pqrs}	1.41^{fgh}	0.51^{fghi}	1.92^{ghi}	1.99^{n}	10.46^{ghijkl}
22. PRGC-22	$91.20^{efghijk}$	10.07^{cdef}	$1.40^{efghijkl}$	3.41^{cdef}	5.48^{b}	66.34^{g}	2.14^{abc}	0.82a	2.82^{abc}	2.59^{de}	$10.98^{defghijk}$
23. PRGC-23	$92.33^{defghij}$	8.80^{ghijk}	1.36^{hijklm}	2.87^{h}	4.06^{fghi}	34.19^{v}	1.05^{hij}	0.38^{jk}	1.47^{jkl}	2.71^{c}	$10.48^{ghijklm}$
24. PRGC-24	89.13^{hijkl}	11.27^{b}	0.98^{p}	3.27^{defg}	5.49^{b}	39.46^{tu}	1.94^{abcde}	0.63^{cdef}	2.63^{abcde}	1.65^{p}	7.67^{o}
25. PRGC-25	98.73^{bc}	7.67^{lm}	1.35^{hijklm}	3.25^{defg}	3.81^{i}	58.26^{jkl}	1.90^{bcde}	0.62^{cdef}	2.41^{cdef}	2.58^{de}	$10.74^{efghijkl}$
26. PRGC-26	89.60^{ghijkl}	8.93^{ghij}	1.55^{cdef}	3.19^{fg}	4.24^{fghi}	64.73^{gh}	1.90^{bcde}	0.64^{cdef}	2.58^{abcdef}	2.71^{c}	12.05^{cdefg}
27. PRGC-27	95.27^{cdef}	8.87^{ghij}	$1.32^{hijklmn}$	2.91^{h}	7.15^{a}	41.26^{stu}	0.98^{ij}	0.35^{jk}	1.31^{kl}	2.24^{lm}	10.12^{ijklm}
28. Amoha	$93.60^{cdefghi}$	10.13^{cdef}	1.61^{cd}	2.91^{h}	5.69^{b}	32.18^{v}	1.31^{hi}	0.55^{efghi}	1.90^{ghi}	2.46^{fghi}	12.52^{cd}
29. 12 Patta Jhinga	$91.27^{efghijk}$	9.00^{ghi}	1.28^{jklmn}	3.40^{cdef}	4.36^{efghi}	80.22^{de}	2.20^{ab}	0.66^{bcde}	2.86^{ab}	1.81^{o}	9.99^{ijklm}
30. Debsundari	101.40^{b}	9.47^{efg}	1.27^{klmn}	3.81^{b}	6.85^{a}	44.36^{qrs}	1.38^{gh}	0.52^{fghi}	1.91^{ghi}	2.14^{m}	9.75^{jklmn}
31. Jaipur Long	94.33^{cdefgh}	12.07^{a}	1.90^{b}	2.92^{h}	4.33^{efghi}	53.62^{mn}	1.91^{bcde}	0.78^{ab}	2.76^{abcd}	2.45^{ghi}	14.17^{b}
32. Maharastra 16 Patta	$93.27^{cdefghij}$	9.33^{fgh}	$1.46^{defghijk}$	3.83^{b}	5.18^{bc}	46.29^{pqr}	2.10^{abcd}	0.77^{ab}	2.84^{abc}	2.22^{lm}	$11.23^{cdefghij}$
33. Rekha	106.73^{a}	10.33^{cd}	1.66c	2.91^{h}	4.12^{fghi}	70.82^{f}	2.16^{abc}	0.62^{cdef}	2.70^{abcd}	2.18^{m}	12.81^{c}
34. Pusa Nasdar	87.67^{jklm}	8.80^{ghijk}	$1.44^{defghijk}$	3.41^{cdef}	5.62b	48.34^{pq}	1.81^{cde}	0.64^{cdef}	2.36^{def}	2.86^{b}	$11.24^{cdefghij}$
Mean	91.62	9.47	1.43	3.37	4.67	57.05	1.71	0.57	2.26	2.37	11.11

Table 2: Continue...

Genotypes	DLFH	NFPV	FYPV	TSS	VIT- C	VIT- A	CH-A	CH-B	T-CH	CF	Y/ha.
CV (%)	3.12	4.82	6.71	3.63	8.06	3.89	11.29	12.07	9.99	2.68	7.43
SEm±	1.65	0.26	0.06	0.07	0.22	1.28	0.11	0.04	0.13	0.04	0.48
CD (p=0.05)	4.66	0.74	0.16	0.20	0.61	3.61	0.31	0.11	0.37	0.10	1.35
ANOVA (Probability values)											
Replication	0.45	0.99	0.84	0.05	0.73	0.16	0.82	0.14	0.06	0.99	0.14
Genotypes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The values in superscript indicate the DMRT ranks of the ridge gourd genotypes for a particular trait and the genotypes having the same rank do not differ significantly from each other for that trait; DLHF: Days to last fruit harvest; NFPV: Number of fruits vine^{-1}; FYPV: Fruit yield vine^{-1} (kg), TSS: Total soluble solids (°Brix), VIT-C-vitamin C content in fruits (mg 100 g^{-1}), VIT-A-vitamin A content in fruits (IU), CH-A-chlorophyll A content in fruits (mg g^{-1}), CH-B-cholrophyll B content in fruits (mg g^{-1}), T-CH-total chlorophyll content in fruits (mg g^{-1}), CF-crude fibre content in fruits (%), Y-yield ha^{-1} (t)

3.1. Genetic variability

The success of any crop improvement efforts relies on the amount of genetic variability that exists and the extent to which the traits of interest can be inherited. Presence of genetic variation is vital for improving genetic traits in plant breeding as because it plays a key role in the successful utilization of germplasm in breeding programs. Thus, an appropriate grasp of genetic variability is necessary to achieve the desired outcomes in certain significant traits. The estimates of existing variability of thirty-four ridge gourd genotypes with respect to twenty-one evaluated characters have been depicted in Table 3. The result of experiment revealed that the number of primary branches ranged from 4.33–6.53, vine length and internode length ranged between 2.74 m–6.21 m and 12.47 cm–17.86 cm respectively, days taken to first male flower emergence was recorded between 38.40 days –49.40 days, node at which first male flower emerged was noticed between 4.80–7.73. When it comes to the days taken to first female flower emergence it was recorded between 44.13 days–51.40 days with the node at which it emerged ranging from 8.73–13.60. Significant variation in the flowering behavior was also reported by Harshitha et al. (2019) during the variability studies in ridge gourd. The fruit characters along with the yield attributes also showed significant differences under the study. The fruit length and fruit diameter ranged between 16.03 cm–42.27 cm and 3.07 cm–4.73 cm respectively, average fruit weight was observed between 87.42 g–176.12 g, number of fruits vine^{-1} was recorded between 6.80–12.80 and yield vine^{-1} ranged between 0.98 kg–2.19 kg indicating presence of variability among the genotypes. The considerable variability exhibited by these parameters can be helpful to establish a basis for the successful selection of superior lines in ridge gourd. Presence of such variability in fruit characters and yield attributing traits was also earlier reported by Choudhary and Kumar (2011), Rabbani et al. (2012), Varalakshmi et al. (2015) and Yadav and Singh (2022) in ridge gourd. Genotypes under study also showed significant variation with respect to the harvesting parameters such as days to first fruit harvest (54.13 days–62.07 days) and days to last fruit harvest (75.20–106.73 days). Significant variation in such harvesting parameters was also reported by Harshitha et al. (2019) in ridge gourd. Variation in fruit quality parameters such as Total Soluble Solids ranged from 2.65–4.11 (°Brix), Vitamin C content was recorded between 3.81–7.15 (mg 100 g^{-1}), Vitamin A content had a range from 32.10–92.56 (IU), Chlorophyll A, B and total chlorophyll contents in fruit ranged between 0.93–2.29 (mg g^{-1}), 0.33–0.82 (mg g^{-1}) and 1.22–2.95 (mg g^{-1}) respectively and the values for crude fibre content in fruits among the genotypes was recorded between 1.65%–3.12%. Similar findings on variation in fruit quality parameters were also earlier reported by Kandoliya et al. (2016) for vitamin C and chlorophyll content in fruits of ridge gourd. Harshitha et al. (2019) and Patil et al. (2022) for vitamin C content in ridge gourd, and Kousthubha et al. (2023) for total soluble solids (TSS) and fibre content in sponge gourd.

3.2. Genotypic and phenotypic coefficient of variation (GCV and PCV)

Estimation of genotypic and phenotypic variance is of immense significance in order to determine the variability present within the genotypes. The estimates with respect to genotypic and phenotypic coefficients of variation among the evaluated yield and yield components are depicted in Table 3. The result revealed that phenotypic coefficient of variation (PCV) was higher in magnitude as compared to genotypic coefficient of variation (GCV) for all the traits studied indicating the influence of environmental factors on the character expression (Ghosh et al., 2010). When selection is made for these traits based solely on phenotype, it is essential to be conscientious as environmental variation can be inherently unpredictable (Dabalo et al., 2020). Low GCV values than PCV also signifies that direct selection may not be effective for these traits indicating a potential

Table 3: Estimates of mean, range, coefficient of variation, heritability and genetic advance as percentage of mean for yield and yield component traits in ridge gourd

Sl. No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (Broad sense %)	Genetic advance (% of mean)
			Minimum	Maximum				
1.	Number of primary branches	5.63	4.33	6.53	9.27	11.55	64.43	15.33
2.	Vine length (m)	4.01	2.74	6.21	16.12	17.35	86.37	30.86
3 .	Internode length (cm)	15.45	12.47	17.86	8.96	9.66	85.98	17.11
4.	Days to first male flower emergence	42.43	38.40	49.40	5.57	5.76	93.63	11.11
5.	Node at which first male flower emergence	5.96	4.80	7.73	10.86	12.69	73.22	19.14
6.	Days to first female flower emergence	47.97	44.13	51.40	3.67	4.20	76.08	6.59
7.	Node at which first female flower emergence	10.70	8.73	13.60	10.44	12.78	66.80	17.58
8.	Fruit length (cm)	26.55	16.03	42.27	17.05	18.14	88.33	33.00
9.	Fruit diameter (cm)	3.79	3.07	4.73	9.22	10.13	82.88	17.29
10.	Average fruit weight (g)	151.59	87.42	176.12	9.83	10.98	80.14	18.13
11.	Days to first fruit harvest	58.35	54.13	62.07	3.14	3.57	77.32	5.68
12.	Days to last fruit harvest	91.62	75.20	106.73	6.13	6.88	79.45	11.26
13.	Number of fruits vine^{-1}	9.47	6.80	12.80	13.34	14.18	88.46	25.84
14.	Fruit yield vine^{-1} (kg)	1.43	0.98	2.19	16.25	17.58	85.42	30.93
15.	Total soluble solids (°Brix)	3.37	2.65	4.11	10.75	11.34	89.75	20.97
16.	Vitamin C (mg 100 g^{-1})	4.67	3.81	7.15	16.21	18.10	80.16	29.89
17.	Vitamin A (IU)	57.05	32.10	92.56	27.89	28.16	98.09	56.90
18.	Chlorophyll A content in fruits (mg g^{-1})	1.71	0.93	2.29	22.95	25.58	80.52	42.42
19.	Chlorophyll B content in fruits (mg g^{-1})	0.56	0.33	0.82	21.01	24.23	75.19	37.52
20.	Total chlorophyll content in fruits (mg g^{-1})	2.26	1.22	2.95	21.79	23.97	82.63	40.80
21.	Crude fibre (%)	2.37	1.65	3.12	14.35	14.60	96.63	29.07

GCV: Genotypic Coefficients of Variation; PCV: Phenotypic coefficients of Variation

reliance on heterosis breeding for further improvement (Varalakshmi et al., 2015). Higher magnitude of PCV than GCV has also been reported by Choudhary and Kumar (2011), Varalakshmi et al. (2015), Koppad et al. (2016) and Yadav and Singh (2022) in ridge gourd. Among the evaluated traits highest estimate of PCV was recorded in vitamin A content in fruits (28.16%) followed by chlorophyll A content in fruits (25.58%), chlorophyll B content in fruits (24.23%) and total chlorophyll content in fruits (23.97%). Similar finding on highest PCV in vitamin A content in fruits among other evaluated traits was reported by Ramjan (2021) in pumpkin. However, the moderate estimate of PCV was recorded in fruit length (18.14%) followed by vitamin C content in fruits (18.10%), fruit yield vine^{-1} (17.58), vine length (17.35%), crude fibre (14.60%), number of fruits vine^{-1} (14.18%), node at which first female flower emergence (12.78%), node at which first male flower emergence (12.69%), number of primary branches (11.55%), TSS (11.34%), average fruit weight (10.98%) and fruit diameter (10.13%). Koppad et al. (2016) also reported moderate PCV estimates in vine length, number of fruits vine^{-1}, average fruit weight, fruit length and fruit diameter in ridge gourd. On the other hand, the lowest estimate of PCV were recorded in internode length (9.66%), days to last fruit harvest (6.88%), days to first male flower emergence (5.76%), days to first female flower emergence (4.20%) and days to first fruit harvest (3.57%). Ramjan (2021) also reported lowest estimate of PCV for days to first male and female flower emergence and days to first fruit harvest in pumpkin.

GCV serves as a measure of the degree of genetic diversity found within a population. Highest estimate of GCV among the evaluated traits were recorded in vitamin A content in fruits (27.89%) followed by chlorophyll A content in fruits (22.95%), total chlorophyll content in fruits (21.79%) and chlorophyll B content in fruits (21.01%). Highest GCV in vitamin A content in fruits among the evaluated traits is in accordance with the finding of Ramjan (2021). Moderate estimates of GCV were observed in fruit length (17.05%), fruit yield vine^{-1} (16.25%), vitamin C content in fruits (16.21%), vine length (16.12%), crude fibre (14.35%), number of fruits vine^{-1} (13.34%), node at which first male flower emergence (10.86%), TSS (10.75%) and node at which first female flower emergence (10.44%). Moderate estimate of GCV in traits like fruit length, number of fruits vine^{-1} and vine length has also been reported by Koppad et al. (2016) in ridge gourd. On the other hand, the lowest estimates of GCV were recorded in average fruit weight (9.83%) followed by number of primary branches (9.27%), fruit diameter (9.22%), internode length (8.96%), days to last fruit harvest (6.13%), days to first male flower emergence (5.57%), days to first female flower emergence (3.67%) and days to first fruit harvest (3.14%). Koppad et al. (2016) and Harshitha et al. (2019) also reported lowest estimates of GCV in traits like fruit diameter, days to first fruit harvest and days to last fruit harvest in ridge gourd. The results further illustrated narrow differences between PCV and GCV for most of the traits indicating limited influence of environmental factors on the expression of these traits, thereby improving the prospects for achieving significant selection gains in future crop improvement (Thirumalmurugan et al., 2020; Rajanna et al., 2024). Although, GCV offers a valuable insight into the genetic variability that exists, its effectiveness in the selection of particular traits is more effective when paired with heritability. This is because GCV alone does not provide a comprehensive assessment of the extent of variation (Singh and Kumar, 2005).

3.3. Heritability

GCV by itself is insufficient for evaluating the extent of heritable variation. Thus, estimates of heritability will reflect the potential success of selection for exploiting existing genetic variability. Heritability offers insight into the degree of genetic influence on the manifestation of a specific trait, as well as the dependability of phenotype in forecasting its breeding value (Chopra, 2000). Under the present experiment, heritability in a broad sense was estimated for twenty-one yield and yield component traits (depicted in Table 3) which ranged from 98.09%–64.43% and all the evaluated traits showed very high (>80%) and high (61–80%) heritability. A very high broad sense heritability was expressed by the traits such as vitamin A content in fruits (98.09%) followed by crude fibre content (96.63%), days to first male flower emergence (93.63%), TSS (89.75%), number of fruits vine^{-1} (88.46%), fruit length (88.33%), vine length (86.37%), internode length (85.98), fruit yield vine^{-1} (85.42%), fruit diameter (82.88%), total chlorophyll content in fruits (82.63%), chlorophyll A content in fruits (80.52%), vitamin C content in fruits (80.16%) and average fruit weight (80.14%). A high degree of heritability confirms the existence of additive gene action and suggests that the observed variation is less affected by environmental factors (Songsri et al., 2008 and Eid, 2009) and during selection these traits in genotypes must be selected as because expression of these highly heritable traits will be higher in succeeding generations. Samadia (2011) also reported very high broad sense heritability in traits like fruit length, fruit diameter, fruit weight, number of fruits plant^{-1}, fruit yield plant^{-1} and vine length in ridge gourd. Similarly, Harshitha et al. (2019) also reported very high broad sense heritability in number of fruits vine^{-1}, vine length, fruit yield vine^{-1}, chlorophyll and vitamin C content in ridge gourd. High broad sense heritability was noticed in days to last fruit harvest (79.45%) followed by days to first fruit harvest (77.32%), days to first female flower emergence (76.08%), chlorophyll B content in fruits (75.19%), node at which first male flower emergence (73.22%), node at which first female flower emergence (66.80%) and number of primary branches plant^{-1} (64.43%). High broad sense heritability for the traits like days to last fruit harvest, days to first fruit harvest, days to female flower emergence and node at which first male flower emergence was also reported by Harshitha et al. (2019) in ridge gourd.

3.4. Genetic advance

According to Johnson et al. (1955) inclusion of genetic advance along with heritability will be more effective than heritability alone in estimating the effect of selecting the superior individual genotype as it gives us an idea about the presence of additive gene effects. In the present experiment high heritability coupled with high genetic advance (Table 3) was observed in vitamin A (56.90%) followed by chlorophyll A content in fruits (42.42%), total chlorophyll content in fruits (40.80%), chlorophyll B content in fruits (37.52%), fruit length (33.00%), fruit yield vine^{-1} (30.93%), vine length (30.86%), vitamin C content in fruits (29.89%), crude fibre (29.07%), number of fruits vine^{-1} (25.84%)

and TSS (20.97%). However, moderate genetic advance was noticed in node at which first male flower emergence (19.14%) followed by average fruit weight (18.13%), node at which first female flower emergence (17.58%), fruit diameter (17.29%), internode length (17.11%), number of primary branches (15.33%), days to last fruit harvest (11.26%) and days to first male flower emergence (11.11%). Traits such as days to first female flower emergence (6.59%) and days to first fruit harvest (5.68%) recorded low genetic advance under the experiment. The finding is in accordance with Chaudhary and Kumar (2011) in ridge gourd.

4. CONCLUSION

Significant differences were observed among the genotypes for all the evaluated traits indicating the existence of wide range of variability. High PCV and GCV were reported in traits like vitamin A, chlorophyll A, B and total chlorophyll. Traits like vitamin A, vitamin C, crude fibre, chlorophyll A, total chlorophyll, TSS, fruit and vine length, number of fruits vine^{-1} and fruit yield vine^{-1} showed very high heritability coupled with high genetic advance as percent of mean indicating a good scope for selection for future crop improvement in ridge gourd.

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