The Pharma Innovation Journal 2023; 12(11): 1848-1853

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(11): 1848-1853

www.thepharmajournal.com
Received: 07-09-2023
Accepted: 14-10-2023

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Variability and correlation studies in F_4 generation of ridge gourd (*Luffa acutangula* L. Roxb.)

SP Deokar, BB Dhakare, BT Patil and DB Kshirsagar

Abstract
The study on variability and correlation in F_4 generation of ridge gourd (*Luffa acutangula* L. Roxb.) was carried out at AICRP on vegetable crops, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2022-2023. The aim of this study is to develop a superior and good quality inbred line. The present study was performed in randomized block design (RBD) with three replications. The five parents along with their five progenies selected for this study derived from the cross (Arka Sumeet x Konkan Harita) was used for this study. The results showed that a moderate GCV and PCV along with high heritability and high genetic advance as a percentage of the mean for the following characteristics: vine length, number of branches per vine, node at which the first male flower appeared, sex ratio, number of pickings, diameter of fruit, fruit yield per vine, fruit yield per plot and fruit yield per hectare. On the other hand, high heritability but with moderate to low genetic advance as a percentage of the mean for the following traits in the F_4 generation: days to first female flower appearance, days to first male flower appearance, node at which the first female flower appeared, days taken to reach 50 % flowering, days to the first harvest, days to the final harvest, fruit length, fruit weight and number of fruits per vine. In terms of correlation a significant and positive correlation was observed between fruit yield per vine and several growth-related traits. These factors included length of the vine, number of branches per vine, number of pickings, days to last picking, dimensions of the fruit (length and diameter), fruit weight and number of fruits per vine. Conversely, there was a substantial and negative correlation between fruit yield per vine and various reproductive traits. These traits encompassed days to first appearance of female and male flowers, node number at which the first female and male flowers emerged, duration until 50 % flowering, sex ratio and days taken for the first picking.

Keywords: Correlation, GCV, genetic advance, PCV, RBD and variability

1. Introduction
Luffa acutangula L. Roxb. generally known as ridge gourd, angled gourd, ribbed gourd, dish cloth gourd, ribbed loofah, silky gourd or chinese okra belongs to genus *Luffa* of Cucurbitaceae family is widely grown throughout India (Chandan *et al*. 2018) [3]. Ridge gourd is a cross-pollinated crop having diploid chromosome number 2n = 2x = 26. Ridge gourd is supposed to be originated from India and Malaya of Asiatic region. It is predominantly cultivated in China, India, Iran, Turkey and some parts of South-East Asia. It is widely cultivated in India during *kharif* and summer season. The progenitor of ridge gourd is "*Luffa graveolens*" (Yadav and Singh, 2022) [20]. 'Luffein' is the gelatinous compound found in ridge gourd. 18 °C – 28 °C is the most favourable temperature for cultivation of ridge gourd. Flower colour is pale yellow and anthesis time is in evening hours (Hazra, 2019) [9]. Being a monoecious and cross-pollinated crop, ridge gourd expresses abundant heterozygosity in the population and does not suffer much due to inbreeding depression resulting in natural variability in the population. In any successful breeding programme; genetic information on variability, combining ability, genetic advance, heritability, gene action, extent of heterosis and association between different characters is of paramount importance. This information helps in identifying best genotypes, best combinations and also breeding methods to be followed either for exploiting hybrid vigour or different selection procedures through pedigree breeding and also to construct a plant architecture through different selection indices.

2. Materials and Methods
The present study was conducted at AICRP on vegetables Department of Horticulture, MPKV, Rahuri. Maharashtra, India during *kharif* 2022. The five progenies derived from cross (Arka Sumeet x Konkan Harita) with their parents were used as genetic material for this study.

Five progenies along with five parents were sown during *kharif* 2022 and evaluated for F_4 generation. The F_4 generation was evaluated in randomized block design (RBD) with three replications. The observations were recorded during research *viz*., vine length, number of branches per vine, days to first female flower appearance, days to first male flower appearance, node at which first female flower appeared, node at which first male flower appeared, days taken to 50 % flowering, sex ratio, days to first picking, days to last picking, length of fruit, diameter of fruit, weight of fruit, number of fruits per vine, fruit yield per vine, fruit yield per plot and fruit yield per hectare.

3. Results and Discussion

The extent of variability present in the selected genotype of ridge gourd in F_4 generation of cross Arka Sumeet x Konkan Harita was measured for variability, heritability and genetic advance as percentage of mean are presented in table 1.

3.1 Genotypic and phenotypic coefficient of correlation

Significant variability was evident across a wide range of traits in the F_4 generations of cross Arka Sumeet x Konkan Harita. Notably, for all quantitative traits, the genotypic coefficient of variation was consistently lower than the phenotypic coefficient of variation. This observation indicates the influence of the environment on the expression of these traits.

The results revealed that low levels of genetic and phenotypic variation were noted for various traits, such as days to first appearance of female (4.73; 4.85) and male flowers (4.33; 4.50), node at which the first female flower appeared (7.34; 7.72), time taken for 50 % flowering (3.37; 3.60), days to the first harvest (3.90; 4.16), days to the final harvest (5.04; 5.16), fruit length (4.15; 4.490, fruit weight (4.40; 4.43) and number of fruits per vine (8.78; 8.93). This indicates selection resulted in attaining homozygosity and further selection will not alter these traits. These characters will not be considered for selection. This agrees with the findings of Sravani *et al*. (2021) [16], Vijayakumar *et al*. (2020) [19], Durga *et al*. (2021) [6] and Farheen *et al*. (2022) [7] in ridge gourd, Kanal *et al*. (2019) [11], Ingole *et al*. (2021) [10], Krishnamoorthy and Avinashgupta (2021) [14] and Ban *et al*. (2022) [2] in pumpkin.

Moderate level of genotypic and phenotypic variation was noted for various traits such as vine length (14.88; 15.42), number of branches per vine (12.21; 12.74), node at which first male flower appeared (17.89; 19.34), sex ratio (10.62; 11.27), number of pickings (10.65; 11.69), fruit yield per vine (13.86; 14.03), fruit yield per plot (13.90; 14.07) and fruit yield per hectare (13.90; 14.07). This indicates the presence of medium amount of variability and improvement of these traits is possible up to some extent in further generation and to attain homozygosity. Similar results were reported by Kannan and Rajamanickam (2019) [12] and Thulasiram *et al*. 2022 [17] in ridge gourd, Krishnamoorthy and Avinashgupta (2021) [14] and Ingole *et al*. (2021) [10] in pumpkin, Vaidya *et al*. (2020) [18] and Dubey *et al*. (2022) [5] in bottle gourd.

High levels of genetic and phenotypic variation were observed for fruit diameter (22.76; 23.73). Similar findings were reported by Gautham and Balamohan (2018) [8] concerning ridge gourd, Kanal *et al*. (2019) [11], Krishnamoorthy and Avinashgupta (2021) [14] and Ingole *et al*. (2021) [10] in relation to pumpkin, Pradhan *et al*. (2021) [15] for bitter gourd and Vaidya *et al*. (2020) [18] in relation to bottle gourd. Across the progenies of this cross, there was generally a moderate to low range of variation observed for most traits, indicating that F_4 generation of ridge gourd exhibit moderate to low levels of variation.

3.2 Heritability and genetic advance as percent of mean

In the case of Cross (Arka Sumeet × Konkan Harita), observed substantial heritability along with significant genetic advancements as a percentage of the mean for the following characteristics: vine length (93.02; 29.56), number of branches per vine (91.85; 24.11), node at which the first male flower appeared (85.58; 34.10), sex ratio (88.83; 20.63), number of pickings (83.07; 20.01), diameter of fruit (91.98; 44.98), fruit yield per vine (97.65; 28.23), fruit yield per plot (97.58; 28.29) and fruit yield per hectare (97.58; 28.30). High heritability along with high genetic advance indicated the presence of flexible additive gene effects and will be a useful criterion for selection. Further these traits were less influenced by environment and selecting plants based on such characters could be worthwhile. These findings are in similarity with Koppad *et al*. (2015) [13] in ridge gourd, Abhijeet *et al*. (2018) [1] in sponge gourd and Ingole *et al*. (2021) [10] in pumpkin, Pradhan *et al*. (2021) [15] in bitter gourd.

On the other hand, high heritability but with moderate to low genetic advance as a percentage of the mean for the following traits in the F_4 generation: days to first female flower appearance (95.05; 9.51), days to first male flower appearance (92.57; 8.60), node at which the first female flower appeared (90.46; 14.39), days taken to reach 50 % flowering (87.72; 6.51), days to the first harvest (87.83; 7.54), days to the final harvest (95.21; 10.13), fruit length (85.15; 7.89), fruit weight (98.48; 9.00) and number of fruits per vine (96.63; 17.79). These results were revealed that, presence of certain degree of non-additive gene effect and selection may not be effective. Similar results were reported by Kannan and Rajamanickam (2019) [12] in ridge gourd and Ingole *et al*. (2021) [10] in pumpkin and Pradhan *et al*. (2021) [15] in bitter gourd.

3.3 Correlation coefficient

Inter correlations among yield attributing components

The present study revealed that at both the genotypic and phenotypic level, the vine length during harvest exhibited a statistically significant positive connection with various parameters. These encompassed number of primary branches per vine, number of pickings, days taken to first picking, days to last picking, dimensions of the fruit (length and diameter), weight of the fruit, number of fruits per vine as well as the overall fruit yield per vine and per plot. Furthermore, across both the genotypic and phenotypic level, vine length displayed a notable and significantly negative relationship with several factors. These included days to appearance of first female flowers, days to appearance of first male flowers, specific node at which the initial female flower appeared, node at which the initial male flower appeared, time taken for 50% flowering to occur, sex ratio as well as the duration until first picking.

Both in the genotypic and phenotypic level, number of branches per vine exhibited a noteworthy and statistically significant positive relationship with a range of factors. These included number of pickings, days to last picking, dimensions of the fruit (length and diameter), weight of the fruit, number of fruits per vine as well as the overall fruit yield per vine and

per plot. Simultaneously, at both the genotypic and phenotypic levels, number of branches per vine displayed a significant and notable negative correlation with several parameters. These encompassed days to first female flower appearance, days to first male flower appearance, specific node where the first female flower appeared, node where the first male flower emerged, sex ratio and days to first picking.

At both the genotypic and phenotypic tiers, days to first female flower appearance exhibited a notable and statistically significant positive relationship with factors such as days to first male flower appearance, specific node at which first female flower appeared, node at which the first male flower appeared, period required for 50% flowering, sex ratio as well as the time needed for the first picking. Furthermore, across both the genotypic and phenotypic perspectives, these days to first female flower appearance displayed a significant and substantial negative correlation with various parameters. These included number of pickings, days to last picking, dimensions of the fruit (both length and diameter), weight of the fruit, number of fruits per vine as well as the overall fruit yield per vine and per plot.

Both in the genotypic and phenotypic dimensions, the days to first male flower appearance displayed a substantial and statistically significant positive relationship with factors like specific node where the first female flower appeared, node where the first male flower emerged, period required for 50 % flowering to occur, sex ratio and days needed for the first picking. Moreover, across both the genotypic and phenotypic perspectives, this the days to first male flower appearance exhibited a meaningful and significant negative correlation with various parameters. These included number of pickings, days to last picking, dimensions of the fruit (Both length and diameter), weight of the fruit, number of fruits per vine as well as the overall fruit yield per vine and per plot.

Table 1: Mean, range, GCV, PCV, ECV, heritability, genetic advance and genetic advance as percent of mean of F_4 population in ridge gourd C-1 (Arka Sumeet x Konkan Harita)

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	H^2 (B.S.) (%)	GA	GAM (%)
1	Vine length (m)	5.15	4.43-6.04	14.88	15.42	4.07	93.02	1.52	29.56
2	Number of branches per vine	7.90	6.76-9.06	12.21	12.74	3.63	91.85	1.90	24.11
3	Days to 1st female flower appearance	45.45	42.07-48.27	4.73	4.85	1.08	95.05	4.32	9.51
4	Days to 1st male flower appearance	38.70	37.03-41.28	4.33	4.50	1.22	92.57	3.32	8.60
5	Node of 1st female flower	15.55	14.06-17.41	7.34	7.72	2.38	90.46	2.24	14.39
6	Node of 1st male flower	3.79	3.16-4.84	17.89	19.34	7.34	85.58	1.29	34.10
7	Days to 50 % flowering	52.76	50.33-55.66	3.37	3.60	1.26	87.72	3.44	6.51
8	Sex ratio	14.71	12.29-16.57	10.62	11.27	3.76	88.83	3.04	20.63
9	Days to first picking	56.14	53.33-59.66	3.90	4.16	1.45	87.83	4.23	7.54
10	Number of pickings	14.80	12.33-16.66	10.65	11.69	4.81	83.07	2.96	20.01
11	Days to last picking	108.00	99.33-113	5.04	5.16	1.13	95.21	10.94	10.13
12	Length of fruit (cm)	28.82	27.17-30.19	4.15	4.49	1.73	85.15	2.27	7.89
13	Diameter of fruit (cm)	2.82	2.10-3.50	22.76	23.73	6.72	91.98	1.27	44.98
14	Weight of fruit (g)	126.59	118.50-133.14	4.40	4.43	0.54	98.48	11.40	9.00
15	Number of fruits per vine	18.10	15.63-20.23	8.78	8.93	1.63	96.63	3.22	17.79
16	Fruit yield /vine (kg)	2.09	1.65-2.42	13.86	14.03	2.14	97.65	0.59	28.23
17	Fruit yield /plot (kg)	20.88	16.42-24.17	13.90	14.07	2.18	97.58	5.91	28.29
18	Fruit yield (t/ha)	13.92	10.95-16.11	13.90	14.07	2.19	97.58	3.94	28.30

GCV: Genotypic coefficient of variation, **PCV:** Phenotypic coefficient of variation, **ECV:** Environmental coefficient of variation, **H^2 (b.s.):** Heritability in broad sense and **GAM:** Genetic advance as percent of mean

Table 2: Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F_4 generation of ridge gourd C - 1 (Arka Sumeet x Konkan Harita)

		VL	NOBPV	DTFFFA	Dtfmfa	NOFF	NOMF	DT50%F	SR	DTFP	NOP	DTLP	LOF	DOF	WOF	NOFPV	FYPV	FYPP
1.VL	G	1.00	0.973**	-0.889**	-0.844*	-0.923**	-0.722	-0.867*	-0.882**	-0.861*	0.870*	0.731	0.855*	0.922**	0.753	0.869*	0.860*	0.859*
	P	1.00	0.922**	-0.878**	-0.828**	-0.904**	-0.702**	-0.811**	-0.828**	-0.835**	0.824**	0.714**	0.833**	0.889**	0.746**	0.846**	0.842**	0.842**
2.NOBPV	G		1.00	-0.819*	-0.778*	-0.950**	-0.583	-0.817*	-0.818*	-0.809*	0.787*	0.625	0.761*	0.877**	0.651	0.840*	0.806*	0.804*
	P		1.00	-0.804**	-0.765**	-0.910**	-0.584**	-0.799**	-0.804**	-0.778**	0.779**	0.630**	0.730**	0.858**	0.636**	0.824**	0.791**	0.790**
3. DTFFFA	G			1.00	0.908**	0.900**	0.849*	0.969**	0.850*	0.969**	-0.945**	-0.855*	-0.924**	-0.832*	-0.917**	-0.852*	-0.898**	-0.898**
	P			1.00	0.905**	0.890**	0.826**	0.924**	0.824**	0.932**	-0.910**	-0.854**	-0.893**	-0.830**	-0.906**	-0.849**	-0.894**	-0.894**
4. DTFMFA	G				1.00	0.922**	0.955**	0.994**	0.715	0.965**	-0.968**	-0.967**	-0.972**	-0.934**	-0.978**	-0.975**	-0.993**	-0.994**
	P				1.00	0.907**	0.926**	0.946**	0.708**	0.950**	-0.956**	-0.955**	-0.956**	-0.912**	-0.955**	-0.960**	-0.984**	-0.984**
5.NOFF	G					1.00	0.797*	0.938**	0.855*	0.935**	-0.946**	-0.840*	-0.900**	-0.899**	-0.830**	-0.962**	-0.945**	-0.944**
	P					1.00	0.788**	0.918**	0.835**	0.914**	-0.916**	-0.837**	-0.882**	-0.878**	-0.808**	-0.948**	-0.929**	-0.929**
6. NOMF	G						1.00	0.900**	0.680	0.933**	-0.963**	-0.972**	-0.968**	-0.792*	-0.975**	-0.914**	-0.955**	-0.956**
	P						1.00	0.857**	0.709**	0.883**	-	-	-	-	-	-	-	-

											0.940**	0.969**	0.947**	0.778**	0.926**	0.874**	0.912**	0.913**
7. DT50%F	G							1.00	0.727	0.994**	-0.975**	-0.924**	-0.973**	-0.922**	-0.979**	-0.940**	-0.978**	-0.978**
	P							1.00	0.53	0.982**	-0.947**	-0.901**	-0.914**	-0.875**	-0.925**	-0.912**	-0.941**	-0.942**
8. SR	G								1.00	0.754	-0.813*	-0.695	-0.761*	-0.654	-0.653	-0.776*	-0.760*	-0.759*
	P								1.00	0.722**	-0.806**	-0.682**	-0.758**	-0.642**	-0.635**	-0.755**	-0.740**	-0.739**
9.DTFP	G									1.00	-0.991**	-0.952**	-0.982**	-0.917**	-0.988**	-0.952**	-0.989**	-0.989**
	P									1.00	-0.955**	-0.918**	-0.941**	-0.880**	-0.944**	-0.917**	-0.951**	-0.951**
10. NOP	G										1.00	0.986**	0.982**	0.891**	0.978**	0.989**	0.963**	0.970**
	P										1.00	0.943**	0.961**	0.865**	0.912**	0.939**	0.955**	0.956**
11. DTLP	G											1.00	0.974**	0.807*	0.968**	0.928**	0.961**	0.962**
	P											1.00	0.940**	0.796**	0.956**	0.925**	0.957**	0.958**
12. LOF	G												1.00	0.926**	0.978**	0.976**	0.973**	0.964**
	P												1.00	0.877**	0.934**	0.926**	0.954**	0.955**
13. DOF	G													1.00	0.853*	0.925**	0.929**	0.929**
	P													1.00	0.830**	0.910**	0.914**	0.914**
14. WOF	G														1.00	0.889**	0.947**	0.948**
	P														1.00	0.879**	0.942**	0.942**
15. NOFPV	G															1.00	0.999**	0.998**
	P															1.00	0.978**	0.988**
16. FYPV	G																1.00	0.981**
	P																1.00	0.973**

* Significance at 5% and ** Significance at 1% levels VL: Vine length, NOBPV: Number of branches per vine, DTFFFA: Days to first female flower appearance, DTFMFA: Days to first male flower appearance, NOFF: Node at which first female flower appeared, NOMF: Node at which first male flower appeared, DT50% F: Days taken to 50% flowering, SR: Sex ratio, DTFP: Days to first picking, NOP: number of picking, DTLP: Days to last picking, LOF: Length of fruit, DOF: Diameter of fruit, WOF: weight of fruit, NOFPV; Number of fruits per vine, FYPV: Fruit yield per vine, FYPP: fruit yield per plot.

The specific node at which first female flower appeared displayed a statistically significant positive relationship with factors including node where the first male flower appeared, time required for 50% flowering, sex ratio as well as the duration until first picking. Furthermore, spanning both the genotypic and phenotypic dimensions, this particular node exhibited a significant and notable inverse correlation with various parameters. These encompassed number of pickings, days to last picking, dimensions of the fruit (length and diameter), Weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

The specific node at which first male flower appeared exhibited a notable and statistically significant positive relationship with factors such as time required for 50 % flowering, sex ratio and days to first picking. Furthermore, across both the genotypic and phenotypic dimensions, this particular node demonstrated a significant and negative correlation with various parameters. These encompassed number of pickings, days to last picking, dimensions of the fruit (length and diameter), Weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

The days taken to 50 % flowering exhibited a notable and statistically significant positive relationship with factors such as sex ratio and days to first picking. Additionally, across both the genotypic and phenotypic contexts, this duration demonstrated a significant and meaningful negative correlation with various parameters. These encompassed number of pickings, days to last picking, dimensions of the fruit (both length and diameter), Weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

The observed sex ratio exhibited a notable and statistically significant positive relationship with the days to first picking, observed across both genotypic and phenotypic levels. Simultaneously, there was a significant and meaningful negative correlation between sex ratio and various parameters, including number of pickings, days to last picking, dimensions of the fruit (both length and diameter), Weight of the fruit, number of fruits per vine as well as the overall fruit yield per vine and per plot.

Both at the genotypic and phenotypic tiers, the days to first picking displayed a significant and inverse relationship with a range of factors. These encompassed number of pickings, days to last picking, dimensions of the fruit (both length and diameter), Weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

The number of pickings exhibited a notable and statistically significant positive correlation, observed across both the genotypic and phenotypic dimensions. This correlation extended to various parameters, including duration until the days to last picking, dimensions of the fruit (length and diameter), weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

Both at the genotypic and phenotypic level, there was a meaningful and statistically significant positive relationship observed between days to last picking and various factors. These encompassed dimensions of the fruit (length and diameter), weight of the fruit, Number of fruits per vine as well as overall fruit yield per vine and per plot.

Both within the genotypic and phenotypic dimensions, fruit length exhibited a notable and statistically significant positive correlation with various attributes, including fruit diameter, fruit weight, Number of fruits per vine as well as overall fruit yield per vine and per plot.

Both in the genotypic and phenotypic contexts, there was a significant positive correlation observed between fruit diameter and attributes such as fruit weight, number of fruits per vine as well as overall fruit yield per vine and per plot.

A positive significant correlation observed between fruit weight and factors including number of fruits per vine as well as overall fruit yield per vine and per plot.

At both the genotypic and phenotypic levels, the number of fruits per vine exhibited a meaningful and statistically significant positive correlation with both fruit yield per vine and fruit yield per plot.

There was a notable and significant positive correlation between fruit yield per vine and fruit yield per plot, observed at both the genotypic and phenotypic levels.

It was necessary to determine the magnitude and direction of relationship between yield and its components for the improvement of yield in ridge gourd. In general, genotypic correlation coefficients were higher magnitude than phenotypic correlation coefficients. Yield per vine exhibited positive and significant correlations at both genotypic and phenotypic levels with vine length (0.860; 0.842), number of branches per vine (0.806; 0.791), number of pickings (0.963; 0.955), days to the last picking (0.961; 0.957), fruit length (0.973; 0.954), fruit diameter (0.929; 0.914), fruit weight (0.947; 0.942) and number of fruits per vine (0.999; 0.978). Indicating that any increase in these characters would bring about an enhancement in the yield.

Conversely, a negative and significant correlation was observed between yield per vine and traits such as days to first female flower appearance (-0.898; -0.894), days to first male flower appearance (-0.993; -0.984), node at which the first female flower appeared (-0.945; -0.929), node at which the first male flower appeared (-0.955; - 0.912), days taken to reach 50 % flowering (-0.978; - 0.941), sex ratio (-0.760; -0.740) and days to first picking (-0.989; -0.951). This means that selection of these traits would result in early and superior fruit yield per vine. It's important to highlight that several of these traits displayed either positive or negative relationships with one another. Analogous findings were reported by Kannan and Rajamanickam (2019) [12] in the context of ridge gourd, sponge gourd and Vaidya *et al*. (2020) [18] concerning bottle gourd.

4. Conclusion

Moderate GCV, PCV, high heritability with high genetic advance as percent of mean were observed for characters *viz*., vine length, number of branches per vine, node at which first male flower appeared, sec ratio, number of pickings, diameter of fruit, fruit yield per vine, fruit yield per plot and fruit yield per hectare. These findings indicate presence of additive gene action and the traits were less influenced by environment and selecting the genotypes based on such characters could be effective. Fruit yield per vine recorded positive and significant correlation with vine length, number of branches per vine, number of pickings, days to the last picking, fruit length, fruit diameter, fruit weight, number of fruits per vine and fruit yield per vine. Conversely, a negative and significant correlation was observed between yield per vine and traits such as days to first female flower appearance, days to first male flower appearance, node at which the first female flower appeared, node at which the first male flower appeared, days taken to reach 50 % flowering, sex ratio and days to first picking.

5. References

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