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The study on correlation and coefficient path analysis of ridge gourd (*Luffa acutangula* L.)

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Abstract
The present investigation was carried out during the 2024-2025 growing season at the Vegetable Research Farm, Department of Horticulture, SHUATS, Prayagraj, with the objective of assessing the correlation and path coefficient analysis in ridge gourd (*Luffa acutangula* L.). A total of ten diverse genotypes were evaluated using a randomized block design (RBD) with three replications to ensure precision and minimize environmental variation. Correlation analysis revealed a highly significant positive genotypic association between fruit yield per plant and days to first harvest (rg = 0.8696**), as well as a moderately significant positive correlation with days to first male flower (rg = 0.5741*, rp = 0.4148*). Conversely, a significant negative correlation was observed between average fruit weight and fruit yield per plant (rg = -0.6455*, rp = -0.5315**), indicating an inverse relationship. Genotypic correlations were generally stronger than phenotypic ones, indicating a predominant genetic influence, with environmental factors partially masking these relationships at the phenotypic level. Path analysis revealed that days to first female flower, days to first and last harvest, fruit weight, fruit diameter, and fruit length had direct positive effects on yield, making them important traits for selection.

Keywords: Correlation, path co-efficient, and ridge gourd

Introduction
Ridge gourd (*Luffa acutangula* L.) is a diploid species (2n = 2x = 26) belonging to the family Cucurbitaceae, characterized by its climbing growth habit and economic significance as a vegetable crop in tropical and subtropical regions. It is said to be originated in subtropical Asian region i.e. India. Ridge gourd or angled luffa is considered a very important vegetable from the family of cucurbitaceae. It is mainly grown in india and holds both agronomical and nutritional importance as a warm-season vegetables crops. It is also grown extensively in southeast asia and china due to its tender fruits and their quick growth as well as adaptability to varying conditions. Besides its use as food, *L. acutangula* is also known in traditional medicine and provides natural fibre when matured. Crop improvement strategies should focus on identifying and selecting genotypes with better yield potential, higher fruit quality, and resistance to both biological and environmental stresses. To aid in effective selection, understanding the nature and degree of genetic variability among genotypes, especially in traits related to yield, is essential. It's also important to evaluate how the environment influences the expression of these traits. A large portion of phenotypic variation may come from environmental factors instead of genetic differences. Therefore, it is crucial to confirm that the favorable phenotypes can be passed on and consistently expressed in future generations. In this regard, biometrical tools like estimating genetic variability parameters, correlation analysis, and path coefficient analysis are important methods. These techniques help to quantify the relationships between genotypic and phenotypic traits, allowing breeders to recognize the true genetic value of phenotypes and create effective selection criteria for genetic improvement. Selection based only on yield can be unreliable. Yield is a measurable trait shaped by many interacting factors and is heavily affected by environmental conditions. Because it involves multiple genes, improving yield requires a better understanding of how the individual traits that contribute to yield work together and affect overall yield. To do this, estimating correlation coefficients is helpful. It allows for the identification of important associations between traits. This understanding helps breeders select for yield indirectly through its closely related components,

making the selection process more accurate and reliable. Correlation analysis is crucial in plant breeding because it shows how two or more traits are related. When there is a genetic correlation between traits, selecting for one trait can also affect the correlated trait, either positively or negatively. These correlations come from pleiotropy or linkage disequilibrium, and the environment can change how they appear. Falconer (1981) points out that both genetic make-up and environmental factors affect the observed correlations. This underscores the need to differentiate between genotypic and phenotypic associations when developing breeding strategies.

While correlation coefficients are valuable in assessing the degree of association between traits, they fall short in discerning the precise magnitude and direction of the direct and indirect contributions of individual traits to yield. To address this limitation, path coefficient analysis, a method originally proposed by Wright (1921) [10], has emerged as a robust statistical tool. This technique allows for the decomposition of correlation coefficients into direct effects (causal relationships) and indirect effects (mediated through other traits), thereby offering a more comprehensive understanding of character interrelationships. Although this methodology has been widely applied in several vegetable crops to elucidate yield-contributing traits, limited systematic efforts have been directed toward its application in the genetic improvement of ridge gourd (*Luffa acutangula*). Therefore, the present study was undertaken to evaluate the correlation and path coefficient analysis in ridge gourd, with the aim of identifying key traits influencing yield for future breeding strategies.

Materials and Methods

The present investigation entitled "The study on correlation and coefficient path analysis on ridge gourd (*Luffa acutangula* L.) was undertaken at Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP) during 2024-2025. The experiment was carried out to study the genetic parameters i.e. correlation and path coefficient analysis of all the traits of different ridge gourd genotypes. Details are mentioned in this chapter regarding the materials and techniques used throughout the course of the investigation.

Table 1: List of the of Ridge gourd genotypes used in the Experiment

S. No.	Genotypes	Symbols	Source
1.	AVT II/2021/RIGVAR-1	G1	IIVR, Varanasi
2.	AVT II/2021/RIGVAR-2	G2	IIVR, Varanasi
3.	AVT II/2021/RIGVAR-3	G3	IIVR, Varanasi
4.	AVT II/2021/RIGVAR-4	G4	IIVR, Varanasi
5.	AVT II/2021/RIGVAR-5	G5	IIVR, Varanasi
6.	AVT II/2021/RIGVAR-6	G6	IIVR, Varanasi
7.	Rani	G7	Tanda Seed Company, Ambedkar Nagar
8.	jaipuri long	G8	Green Crop Hybrid Seed, Ayodhya
9.	Rekha	G9	R.K. Seeds, Solan
10.	Kashi Khushi	G10	Tycoon Company, Varanasi

Results and Discussion

Genotypic correlation coefficient analyses-

Correlation between fruit yield per plant and other component characters-

Correlation coefficient analysis indicated that fruit yield per plant had a significant positive correlation with days to first harvest (r = 0.8696**) and days to appearance of the first male flower (r = 0.5741*). Additionally, non-significant but positive correlations were observed with days to last harvest (r = 0.1367), number of fruits per plant (r = 0.3197), and fruit yield per hectare (r = 0.6030). On the other hand, a significant negative correlation was noted with average fruit weight (r = -0.6455*), while non-significant negative associations were recorded with days to appearance of the first female flower (r = -0.0664), average fruit diameter (r = -0.0136), and fruit length (r = -0.3592). Similar trends have also been documented by Suvedha *et al*. (2024) [6], who reported comparable associations among yield and its contributing traits in ridge gourd.

Days to appearance of first male flower

Days to first male flower exhibited a significant positive correlation with days to appearance of the first female flower (r = 0.6489*), days to first harvest (r = 0.9409**), and average fruit diameter (r = 0.5986*), indicating a close association with phenological and morphological traits. Additionally, non-significant but positive correlations were observed with days to last harvest (r = 0.0697), average fruit weight (r = 0.208), and fruit length (r = 0.4908 cm). In contrast, non-significant negative correlations were recorded with number of fruits per plant (r = -0.2523) and fruit yield per hectare (r = -0.3466), suggesting limited or indirect influence of this trait on yield performance. Similar results have been recorded by Gautam *et al*. (2017) [12].

Days to appearance of first female flower

Days to first female flower exhibited a significant positive correlation with days to first harvest (r = 0.5812*) and average fruit diameter (r = 0.5003*), indicating a meaningful association with reproductive phenology and fruit morphology. Additionally, non-significant but positive correlations were observed with days to last harvest (r = 0.3959), average fruit weight (r = 0.3154), and fruit length (r = 0.495), suggesting a moderate relationship with these traits. Conversely, non-significant negative associations were found with number of fruits per plant (r = -0.4533) and fruit yield per hectare (r = -0.4861), implying a potential trade-off between early female flowering and overall yield performance. Similar results have been recorded by Ramesh *et al*. (2018) [7], The Pharma Innovation Journal (2021).

Days to taken first harvest

Days to first harvest showed a significant positive correlation with fruit length (r = 0.5559*) and average fruit diameter (r = 0.7395*), indicating that delayed harvesting is associated with increased fruit size. Additionally, non-significant positive correlations were observed with days to last harvest (r = 0.0205) and average fruit weight (r = 0.1502). In contrast, non-significant negative associations were recorded with number of fruits per plant (r = -0.0231) and fruit yield per hectare (r = -0.2307), suggesting that earlier harvesting may favor yield improvement despite its minimal impact on individual fruit size. Similar results have been recorded by Suvedha *et al*. (2024) [6].

Days taken to last harvest

Days to last harvest exhibited a non-significant positive correlation with both number of fruits per plant (r = 0.0266) and fruit yield per hectare (r = 0.2712), suggesting a limited yet favorable influence on overall productivity. However, a significant negative association was observed with average fruit diameter (r = -0.5434*), indicating that prolonged harvesting may adversely affect fruit girth. Additionally, non-significant negative correlations were noted with average fruit weight (r = -0.2865) and fruit length (r = -0.2497 cm), implying a potential decline in fruit size with extended harvest duration.

Number of Fruits/plant (till last harvest)

Number of fruits per plant exhibited a significant positive correlation with fruit yield per hectare (r = 0.5997*), highlighting its direct contribution to overall yield. In contrast, non-significant negative associations were observed with average fruit diameter (r = -0.2732), average fruit weight (r = -0.2729), and fruit length (r = -0.4597), suggesting a potential trade-off between fruit number and individual fruit size and dimensions. Similar results have been recorded by Chauhan *et al*. (2023) [13].

Average fruit weight (g)

Average fruit weight exhibited a highly significant positive correlation with both average fruit diameter (r = 0.8257**) and fruit length (r = 0.9024**), indicating a strong interdependence between fruit mass and its dimensional traits. Conversely, a highly significant negative association was observed with fruit yield per hectare (r = -0.9087**), suggesting that an increase in individual fruit weight may be associated with a reduction in total yield, likely due to a decrease in fruit number.

Average fruit diameter(cm)

Average fruit diameter showed a highly significant positive correlation with fruit length (r = 0.9024**), indicating strong synchrony between fruit girth and length in ridge gourd. In contrast, a highly significant negative association was observed with fruit yield per hectare (r= -0.798**). Similar results have been recorded by Parkash *et al*. (2000) [14] in ash gourd and Bhave *et al*. (2003) [15] in bitter gourd.

Average fruit length(cm)

Average fruit length(cm) showed as negative significant association was observed with Fruit yield (t/ha) (-0.948**). Similar results have been recorded by Gangadhara *et al*. (2019) [16] in cucumber.

Table 2: Estimates of genotypic correlation coefficient for 10 growth and yield component with fruit yield per plant

	Days to first male flower	Days to first female flower	Days to first harvest	Days to last harvest	No. of fruits/plant	Fruit wt	Fruit diameter	Fruit length	Yield/ plant	Yield/ ha
Days to first male flower	1 **									
Days to first female flower	0.6489 *	1 **								
Days to first harvest	0.9409 **	0.5812 NS	1 **							
Days to last harvest	0.0697 NS	0.3959 NS	0.0205 NS	1 **						
No. of fruits/plant	-0.2523 NS	-0.4533 NS	-0.0231 NS	0.0266 NS	1 **					
Fruit wt	0.208 NS	0.3154 NS	0.1052 NS	-0.2865 NS	-0.2729 NS	1 **				
Fruit diameter	0.5986 NS	0.5003 NS	0.7395 *	-0.5434 NS	-0.2732 NS	0.8257 **	1 **			
Fruit length	0.4908 NS	0.495 NS	0.5559 NS	-0.2497 NS	-0.4597 NS	0.9024 **	0.9552 **	1 **		
Yield/plant	0.5741 NS	-0.0664 NS	0.8696 **	0.1367 NS	0.3197 NS	-0.6455 *	-0.0136 NS	-0.3592 NS	1 **	
Yield/ha	-0.3466 NS	-0.4861 NS	-0.2307 NS	0.2712 NS	0.5997 NS	-0.9087 **	-0.798 **	-0.948 **	0.603 NS	1 **

* and ** significant at 5% and 1% level of significance, respectively
NS = non-significant

Phenotypic correlation coefficient analyses

Correlation between fruit yield per plant and other component characters.

Correlation coefficient analysis indicated that fruit yield per plant exhibited a significant positive association with days to appearance of the first male flower (r = 0.4148*) and fruit yield per hectare (r = 0.483**), suggesting their direct influence on productivity. Additionally, non-significant but positive correlations were observed with days to first harvest (r = 0.3449) and number of fruits per plant (r = 0.2233). In contrast, a significant negative correlation was found with average fruit weight (r = -0.5315**), indicating a trade-off between individual fruit mass and total yield per plant. Other traits such as days to appearance of the first female flower (r = -0.0405), days to last harvest (r = -0.0195), average fruit diameter (r = -0.1854), and fruit length (r = -0.2884) showed non-significant negative associations, implying minimal or indirect influence on yield performance. Similar results have been recorded by Choudhary *et al*. (2008) [8].

Days to appearance of first male flower

Days to first male flower exhibited significant positive correlations with several key traits, including days to appearance of the first female flower (r = 0.5618**), days to first harvest (r = 0.581**), average fruit diameter (r = 0.5574**), and fruit length (r = 0.4553*), indicating a strong association with both reproductive timing and fruit morphology. A non-significant but positive correlation was also observed with average fruit weight (r = 0.2046). Conversely, non-significant negative associations were recorded for days to last harvest (r = -0.0086), number of fruits per plant (r = -0.2364), and fruit yield per hectare (r = -0.3325), suggesting that delayed male flowering may not directly favor yield-related parameters. Similar results have been recorded by The Pharma Innovation Journal (2021).

Days to appearance of first female flower

Days to first female flower showed a significant positive correlation with average fruit diameter (r = 0.393*) and fruit length (r = 0.441*), suggesting that delayed female flowering may be associated with increased fruit size. Additionally, non-significant positive correlations were observed with days to first harvest (r = 0.3561), days to last harvest (r = 0.2969), and average fruit weight (r = 0.2691), indicating a mild association with harvest timing and fruit mass. In contrast, a significant negative correlation was recorded with fruit yield per hectare (r = -0.4001*), while number of fruits per plant exhibited a non-significant negative correlation (r = -0.3514). Similar results have been recorded by Madhuri *et al*. (2022) [17].

Days to taken first harvest

Days to first harvest exhibited a significant positive correlation with average fruit diameter (r = 0.4489*), indicating a tendency for later harvesting to be associated with increased fruit girth. Additionally, non-significant positive correlations were observed with number of fruits per plant (r = 0.0171), average fruit weight (r = 0.0613), and fruit length (r = 0.274), suggesting a weak association with these yield components. In contrast, non-significant negative correlations were recorded with days to last harvest (r = -0.1952) and fruit yield per hectare (r = -0.1175). Similar results have been recorded by Ramesh *et al*. (2018) [7].

Days taken to last harvest

Days to last harvest exhibited a non-significant positive correlation with both number of fruits per plant (r = 0.0319) and fruit yield per hectare (r = 0.1498), suggesting a slight tendency for extended harvesting duration to be associated with increased yield and fruit count. Conversely, non-significant negative correlations were observed with average fruit diameter (r = -0.1547 cm), average fruit weight (r = -0.1458 g), and fruit length (r = -0.1165 cm). Similar results have been recorded by Ramesh *et al*. (2018) [7].

Number of Fruits/plant (till last harvest)

Number of fruits per plant demonstrated a highly significant positive correlation with fruit yield per hectare (r = 0.6049**), confirming its crucial role in enhancing overall productivity. However, it showed a significant negative association with fruit length (r = -0.4242*), suggesting a trade-off between fruit quantity and size. Additionally, non-significant negative correlations were noted with average fruit diameter (r = -0.2181) and average fruit weight (r = -0.260). Similar results have been recorded by Mitu *et al*. (2020) [18].

Average fruit weight(g)

Average fruit weight(g) showed positive significant association with Average fruit diameter(cm) (0.7558**) and Fruit length (cm) (0.8785**). While as negative significant association was observed with Fruit yield (t ha^{-1}) (-0.901**).

Average fruit diameter(cm)

Average fruit diameter exhibited a strong significant positive correlation with fruit length (r = 0.8165**), indicating that larger fruits in girth tend to be longer as well. In contrast, a significant negative association was observed with fruit yield per hectare (r = -0.7126**). Similar results have been recorded by Mitu *et al*. (2020) [18].

Average fruit length(cm)

Average fruit length (cm) showed as negative significant association was observed with Fruit yield (t ha^{-1}) (-0.9143**).

Table 3: Estimates of phenotypic correlation coefficient for 10 growth and yield component with fruit yield per plant

	Days to First Male Flower	Days to First Female Flower	Days to First Harvest	Days to Last Harvest	No. of Fruits/ Plant	Fruit Wt.	Fruit Diameter	Fruit Length	Yield/ Plant	Yield/ Ha
Days To First Male Flower	1 **									
Days To First Female Flower	0.5618 **	1 **								
Days To First Harvest	0.581 **	0.3561 NS	1 **							
Days To Last Harvest	-0.0086 NS	0.2969 NS	-0.1952 NS	1 **						
No. Of Fruits/Plant	-0.2364 NS	-0.3514 NS	0.0171 NS	0.0319 NS	1 **					
Fruit Wt	0.2046 NS	0.2691 NS	0.0613 NS	-0.1458 NS	-0.26 NS	1**				
Fruit Diameter	0.5574 **	0.393 *	0.4489 *	-0.1547 NS	-0.2181 NS	0.7558**	1**			
Fruit Length	0.4553 *	0.441 *	0.274 NS	-0.1165 NS	-0.4242 *	0.8785**	0.8165**	1 **		
Yield/Plant	0.4148 *	-0.0405 NS	0.3449 NS	-0.0195 NS	0.2233 NS	-0.5315**	-0.1854NS	-0.2884 NS	1 **	
Yield/Ha	-0.3325 NS	-0.4001 *	-0.1175 NS	0.1498 NS	0.6049 **	-0.901**	-0.7126**	-0.9143 **	0.483 **	1**

* and ** significant at 5% and 1% level of significance respectively
NS = non significant

Table 4: Genotypic path coefficient analysis

	Days to first male flower	Days to first female flower	Days to first harvest	Days to last harvest	No. of fruits/plant	Fruit wt	Fruit diameter	Fruit length	Yield/plant
Days to first male flower	-15.31346	0.06312	1.14598	0.59417	3.1673	6.41714	10.4896	-17.53826	10.62785
Days to first female flower	-9.93706	0.09727	0.70786	3.37245	5.69098	9.73201	8.76733	-17.68764	-1.22929
Days to first harvest	-14.40828	0.05653	1.21797	0.17482	0.28949	3.2473	12.95875	-19.86353	16.09625
Days to last harvest	-1.06796	0.0385	0.02499	8.51973	-0.33355	-8.83996	-9.52227	8.9219	2.52984
No. of fruits/plant	3.86359	-0.04409	-0.02809	0.22637	-12.55372	-8.42063	-4.78759	16.42656	5.91728
Fruit wt	-3.18474	0.03068	0.12818	-2.44082	3.42591	30.85609	14.47038	-32.24598	-11.94839
Fruit diameter	-9.16633	0.04866	0.90067	-4.62945	3.42968	25.47911	17.52414	-34.13349	-0.251
Fruit length	-7.51569	0.04814	0.67702	-2.12712	5.77069	27.84361	16.73888	-35.73476	-6.64882
Yield/plant	-8.79222	-0.00646	1.05911	1.16439	-4.01305	-19.9173	-0.23763	12.83557	-18.51058

Genotypic path coefficient analysis for fruit yield per plant

The genotypic path coefficient analysis was performed to evaluate the direct effects of various traits on fruit yield per plant (kg) in ridge gourd (*Luffa acutangula* L.). Examination of Table 3 revealed that fruit yield per plant exhibited positive direct effects from several traits, including days to appearance of the first female flower (0.0972), days to first harvest (1.217), days to last harvest (8.5197), fruit weight (30.856), fruit diameter (17.5241), and fruit length (16.7388), indicating their favorable contribution to yield. In contrast, negative direct effects were observed for days to appearance of the first male flower (-15.3134), number of fruits per plant (-12.5537), and yield per plant itself (-18.5105), suggesting that these traits may exert a suppressive influence on fruit yield under genotypic control. Similar results have been recorded by Rajput *et al*. (1996) [19].

Days to appearance of first male flower

Days to appearance of the first male flower exhibited a strong negative direct effect on fruit yield per plant (-15.3134). It contributed positively but modestly through indirect effects via days to first harvest (1.2138) and days to last harvest (0.6920). However, it exerted notable negative indirect effects through days to first female flower (-0.0004), number of fruits per plant (-12.7193), fruit weight (-127.244), fruit diameter (-2.492), and fruit length (-225.232), suggesting its overall detrimental impact on yield is largely mediated through key yield components. Similar results have been recorded by Ramesh *et al*. (2018) [7].

Days to appearance of first female flower

Days to appearance of the first female flower showed a positive direct effect on fruit yield per plant (0.0972). It also contributed positively through indirect effects via days to first harvest (0.7501) and days to last harvest (3.9267). However, it had notable negative indirect effects through days to first male flower (-1.1685), number of fruits per plant (-22.8377), fruit weight (-193.949), fruit diameter (-2.0839), and fruit length (-227.1876). Similar results have been recorded by Ramesh *et al*. (2018) [7], Mitu *et al*. (2020) [18].

Days to first harvest

The direct effect of days to first harvest on fruit yield per plant (g) was positive (1.2179). The positive indirect effect of this trait was positive *via* days to first harvest (0.7501), and fruit length (25.2113). However, its indirect effect was negative *via*, days to appearance of first male flower (-21.308), no. of fruits per plant (-1.162), fruit weight (-64.6577), and fruit diameter (-0.2277).

Days to last harvest

Days to last harvest exhibited a positive direct effect on fruit yield per plant (8.5197). It also showed favorable indirect effects through days to first harvest (0.1849), fruit diameter (1.4651), and fruit length (106.0134). However, its influence was partially offset by negative indirect effects via days to first male flower (-10.9982), number of fruits per plant (-0.9088), and fruit weight (-62.9153).

No. of fruits per plant

Number of fruits per plant showed a negative direct effect on fruit yield per plant (-12.5537). However, it contributed positively through indirect effects via days to first harvest (0.3066), fruit weight (176.0592), fruit diameter (2.262), and fruit length (163.0528). In contrast, negative indirect effects were observed through days to first male flower (-58.6474) and days to last harvest (-0.3883).

Fruit weight(g)

Fruit weight exhibited a positive direct effect on fruit yield per plant (30.856), along with favorable indirect effects via days to first harvest (3.4390), days to last harvest (3.6776), number of fruits per plant (35.4765), and fruit length (146.591). However, negative indirect effects were noted through days to first male flower (-118.779) and fruit diameter (-0.1891).

Fruit diameter(cm)

Fruit diameter (cm) exerted a positive direct effect on fruit yield per plant (0.8751), along with positive indirect contributions via days to first harvest (1.0152), number of fruits per plant (38.2122), and fruit length (94.0831). Conversely, negative indirect effects were observed through days to first male flower (-194.165), days to last harvest (-7.1749), and fruit weight (-15.8586).

Fruit length(cm)

Fruit length (cm) exhibited a positive direct effect on fruit yield per plant (13.4766), with favorable indirect effects via days to first male flower (324.886), days to first harvest (2.0796), and days to last harvest (9.6156). However, negative indirect contributions were noted through number of fruits per plant (-50.9061), fruit weight (-227.386), and fruit diameter (-1.7143).

Conclusion

The correlation analysis at both the genotypic and phenotypic levels showed that fruit yield per plant was significantly and positively linked to days until the first harvest, days until the first male flower appeared, and fruit yield per hectare. Genotypic path coefficient analysis also indicated that days to the first female flower, days to the first and last harvest, fruit weight, fruit diameter, and fruit length had a direct positive effect on fruit yield per plant. In contrast, days to the first male flower, the number of fruits per plant, and fruit length had a direct negative impact on yield. These results emphasize the need to select for early flowering, balanced fruit size, and optimized harvest duration as key factors for improving yield in ridge gourd breeding programs.

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