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RESEARCH ARTICLE

Assessment of Genetic Variability and Correlation in Pointed Gourd (*Trichosanthes dioica* Roxb) Genotypes for Yield and Yield Attributing Traits

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Abstract

This study aimed to evaluate the nature and extent of genetic variability and relationships among key yield-attributing traits in pointed gourd (*Trichosanthes dioica* Roxb). A broad spectrum of variability was observed across selected genotypes for all traits assessed. The minimal disparity between genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) across traits suggests a lesser influence of environmental factors on these plant traits, indicating the potential effectiveness of selection based on phenotypic performance. High estimates of heritability, coupled with substantial genetic advances for fruit yield per plant (g), vine length, and number of fruits per vine, suggest the presence of additive genes, facilitating selection processes. Fruit yield per plant exhibited significant positive correlations with average fruit weight, fruit circumference, fruit length, fruit width, vine length, number of internodes per vine, and female flower length at both genotypic and phenotypic levels. Moreover, there was a notable positive direct effect by average fruit weight, vine length, number of internodes per vine, intermodal length, female flower length, fruit width, and number of primary branches, along with their significant positive correlation with yield. Considering their high heritability and genetic advance, these traits emerge as crucial components contributing to fruit yield, suggesting a need for greater emphasis on them during yield improvement programs in pointed gourd.

Keywords: Correlation, Heritability, Genetic advance, Path analysis, Pointed gourd.

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Introduction

Pointed gourd (*Trichosanthes dioica* Roxb.) stands out as a perennial, dioecious vegetable cherished for its nutritional and medicinal merits within the Cucurbitaceae family. Its cultivation spans approximately 20,000 hectares in India alone, yielding around 310,000 metric tons with a productivity rate of 14.89 t/ha (NHB 2018-19). Flourishing in tropical and subtropical climates, major producing states encompass Bihar, West Bengal, Odisha, Chhattisgarh, Assam, and Uttar Pradesh. This versatile vegetable finds its way into various culinary delights, from vegetable curries to pickles, owing to its enduring market presence and high demand fueled by its unique medicinal properties. Documented benefits include aiding digestion, acting as a diuretic and laxative, invigorating the heart and brain, and ameliorating circulatory disorders by regulating cholesterol levels while enriching vitamin, protein, and mineral content (Malek, 2009; Swamy, 2022).

Despite its significance, the widespread adoption of pointed gourd faces a bottleneck in low productivity, primarily attributed to the dearth of high-yielding varieties. As India serves as one of the primary centers of origin for *T. dioica* Roxb. (Chandra *et al.*, 1995), the fruit exhibits a wide spectrum of variability in shape, size, color, quality, and bearing characteristics (Hazra and Ghose, 1999).

Consumer and grower preferences lean towards green, fleshy fruits with soft seeds and high yields. To address this gap between potential and actual yields, there's an exigency for genetic restructuring in pointed gourd, focusing on consumer-preferred attributes such as appealing creamy flesh, green fruit, and fewer soft seeds.

The diverse genetic reservoir of parental lines harbors promising allelic variations for novel combinations. Understanding the genetic variability across various traits is pivotal for identifying suitable genes to enhance crop genetic behavior (Nwangburuka *et al*., 2011). Genetic diversity plays a vital role in meeting the multifaceted goals of plant breeding, encompassing increased yield, uniformity, desired quality, and resistance to biotic and abiotic stresses. Hence, a systematic comprehension of genetic diversity in targeted traits is a potent tool for breeding programs tailored to specific conditions. Previous studies have focused on accessions collected from surveys (Chandra *et al*., 1995; Debata *et al*., 2017) or identified important genotypes (Jena *et al*., 2017; Verma, *et al*., 2017; Pramila *et al*., 2023). This study marks the first attempt to explore the population resulting from crosses among different ecotypes from subtropical India, including parents used in its population development. The significance of this endeavor lies in recognition of the diverse genetic reservoir inherent in parental lines, which harbors promising allelic variations for novel combinations

However, the intricacies of horticultural specifications in pointed gourd present breeders with limited avenues for improvement, given that yield is a complex trait influenced by multiple components. Direct selection solely based on yield performance proves ineffectual. Thus, comprehending variability within available germplasm and unraveling the associations between yield and various component characters are imperative for targeted enhancements (Chotaliya and Kulkarni, 2017).

In this context, statistical tools emerge as indispensable aids in estimating variability. Heritability is a predictive tool for gauging the reliability of phenotypic values, guiding breeders in selecting characters with high heritability. It determines to what extent the environment impacts yield by determining genotypic and phenotypic yield and yield components of diverse crop genotypes (Ullah *et al*., 2012). Genetic progress is the quantity of heritable genes gained in a character under a certain selection pressure. High genetic progress, as well as high heritability estimates, provides the best conditions for selection. Genetic advance provides insights into the expected progress resulting from selection within populations. Characters with high heritability can quickly progress by using simple selection. Heritability, on the other hand, has been explored and shown to be of no practical value without the involvement of genetic advancements. The coefficient of variation depicts the degree of variability present in many different traits, but it does not include the heritable component. A correlation study can also provide trustworthy and helpful information about the selection type, scope, and direction. Correlation analysis delineates associations, while path analysis disentangles causative factors and their relative importance. Leveraging these tools empowers breeders to grasp the associations between independent and dependent variables; thus guiding crop improvement endeavors through selecting component traits (Singh *et al*., 2017). Against this background, this study endeavors to elucidate the nature and extent of genetic variability across a diverse set of genotypes sourced from various regions across India, coupled with heterotic selections and aims to identify traits exhibiting significant genetic variability and high heritability, providing valuable insights for genotype selection and breeding programs.

Materials and Methods

The research spanned two consecutive years, from 2019 to 2021, and took place at the experimental farm of ICAR-Central Institute for Subtropical Horticulture Rehmankhera, Kakori, Lucknow specifically within block I. Positioned between 26º 45′ to 27º 10′ N latitude and 80º 30′ to 80º 5′ E longitude, with an elevation of 123 m above sea level, the experimental site provided an ideal environment for studying pointed gourd genotypes. A diverse set of genotypes sourced from West Bengal, Bihar, and Uttar Pradesh and heterotic selections bred at ICAR-CISH were meticulously studied over two consecutive years and sourced from different regions across India. To ensure uniformity and reliability in the experimental setup, each genotype's rooted plants (cuttings) were transplanted in October 2018. Planting was done with a spacing of 2 x 1 m in rows, maintaining a female-to-male ratio of 9:1, a configuration commonly used to optimize pollination and fruit set in pointed gourd cultivation. The experiment was laid out in a randomized block design with three replications.

The soil of the experimental plot was identified as loamy, indicating a balanced mixture of sand, silt, and clay, which is typically favorable for plant growth. With a pH of 6.8 and an electrical conductivity of 0.36 Sm^{-1}, the soil provided adequate nutrients and conductivity for robust plant development. Cultural practices were meticulously implemented throughout the experiment to ensure consistent growth and phenotypic expression of the pointed gourd traits under study. Plants were trained using a curtain system, a common practice in vine crops like pointed gourd, to maximize sunlight exposure and facilitate air circulation, which is crucial for optimal growth and yield.

Data collection was conducted systematically, with observations recorded from five randomly selected plants in each plot and replication. A comprehensive set of traits was measured, including vine length, number of internodes per vine, internodal length, number of primary branches per plant, female flower length, fruit length, fruit width, fruit circumference, average fruit weight, and fruit yield per plant. These traits were chosen based on their relevance to plant growth, development, and yield potential.

Statistical analysis of the data was carried out using analysis of variance following the guidelines outlined by Panse and Sukhatme (1967). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated using the formulas provided by Burton and De Vane (1953). Additionally, heritability (broad sense) and genetic advance as a percentage of means were computed following the protocols outlined by Allard (1960) and Johnson *et al*. (1955), respectively.

Results and Discussion

With the exception of the length of the female flowers and the circumference of the fruit, the analysis of variance that was carried out for the experiment design revealed a considerable amount of variation among the thirty genotypes of pointed gourd across all of the parameters examined. This variability can be traced to the many sources of genetic material and environmental effects, the primary factors that shape the phenotype. The considerable prevalence of variability shows that there are ample options for selection to increase yield in pointed gourd species (Table 1).

The average vine length was 790.78 cm, with a range that extended from 382.67 to 1527.33 cm. Similarly, the number of internodes present in each vine ranged from 35.00 to 105.33, with a mean value of 77.93. Intermodal lengths varied from 6.75 to 15.17 cm, with 10.18 cm being the average. Other characteristics, such as the number of primary branches, the length of the female flower, the length of the fruit, the breadth of the fruit, the circumference of the fruit, the average weight of the fruit, and the amount of fruit produced by each plant, were found to exhibit a broad range of variance (Table 2). These differences highlight the genetic diversity among genotypes, showing the possibility for yield improvement through breeding programs that incorporate a variety of parental lines.

The GCV and the PCV provide insights into the variability of traits within pointed gourd genotypes. As shown in Table 2, a comparison of GCV and PCV values reveals the relative contributions of genetic and environmental factors to trait variation. The characteristics, including vine length, the count of internodes per vine, and internodal length (cm), demonstrate a range of GCV values from 27.42 to 18.49%. This variability underscores the substantial genetic diversity among genotypes, pointing to a predominant influence of genetic factors on these traits.

In contrast, traits like fruit width (cm) and circumference (cm) display relatively lower GCV values than their PCV values. This indicates a stronger influence of environmental factors on the variation observed in these traits. Moreover, traits with high GCV values, such as average fruit weight (g) and fruit yield per plant (g), suggest significant genetic variability among genotypes for these economically important traits. This variability presents opportunities for selection and breeding programs to improve yield and fruit quality in pointed gourd. Overall, comparing GCV and PCV values provides valuable insights into the relative contributions of genetic and environmental factors to trait variation, guiding breeders in identifying traits with higher genetic potential for improvement in pointed gourd genotypes.

Local germplasm is a rich resource that may be used to breed robust cultivars (According to Yadav *et al*., 2013; Singh *et al*., 2014). This is especially true when adapting to specific climatic zones, which can help mitigate environmental concerns connected with climate change. The GCV and the PCV are two estimates that can be utilized to evaluate the degree of variability among specific physical characteristics. There appears to be a limited amount of environmental influence on the expression of horticultural traits, as indicated by the proximity between the phenotypic and genotypic coefficients of variation. When compared to genotypic coefficients, phenotypic coefficients that are larger imply that environmental factors have an impact on the expression of traits. The study conducted by Jena *et al*. (2017) showed that some characteristics, including fruit production per plant, average fruit weight, number of primary branches, and vine length, demonstrated large coefficients of variation. These characteristics are considered economically significant and offer a significant potential for improvement through selection.

Table 1: Mean square of different traits in pointed gourd genotypes

Source of variation	*Degree of freedom*	*Vine length*	*Number of internodes/ vine*	*Inter nodal length*	*No. of Primary branches/ vine*	*Female flower length*	*Fruit length*	*Fruit diameter*	*Fruit circumference*	*Average Fruit weight*	*Fruit yield /plant*
Replications	2	15199.19	5.59	1.81	9.79	0.171	0.350	0.240	0.307	2.54	38119945.701
Genotypes	29	149548.61**	624.15**	12.48**	81.95**	0.865	7.309*	0.562	5.070*	617.56 **	513260851.225**
Error	58	8454.63	1.04	1.46	4.95	0.181	0.103	0.012	0.108	0.59	16838203.541

** Significant at 1% level
*Significant at 5% level

Table 2: Range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advances (GA) in pointed gourd

Traits	Range		Mean	Genotypic variance (%)	Phenotypic variance (%)	Phenotypic coefficient variation (%)	Genotypic coefficient variation (%)	Heritability in broad sense (%)	Genetic advance (%)
	Min	Max							
Vine length (cm)	382.67	1527.33	790.78	47031.32	55486.00	29.788	27.425	84.76	411.30
Number of internodes per vine	35.00	105.33	77.93	207.70	208.74	18.540	18.494	99.50	29.61
Inter nodal length (cm)	6.75	15.17	10.18	3.67	5.13	22.269	18.839	71.57	3.34
No. of primary branches/plant	6.33	21.67	13.19	25.66	30.62	41.954	38.411	83.82	9.56
Female flower length (cm)	5.17	7.33	6.07	0.23	0.41	10.540	7.872	55.78	0.74
Fruit length (cm)	5.97	12.28	9.30	2.40	2.50	17.021	16.667	95.89	3.13
Fruit width (cm)	2.39	4.40	3.55	0.18	0.20	12.462	12.068	93.78	0.85
Fruit circumference (cm)	9.17	15.40	12.16	1.65	1.76	10.918	10.577	93.86	2.57
Average fruit weight (g)	22.38	81.46	45.40	205.66	206.24	31.634	31.589	99.72	29.50
Fruit yield /plant (g)	504.00	4923.07	1787.36	165474215.89	182312419.44	38.178	36.372	90.76	1275.81

Traits such as vine length (cm), number of internodes per vine, and average fruit weight (g) demonstrate high heritability values, exceeding 80%. This suggests that a substantial proportion of the observed variation in these traits is attributable to genetic factors rather than environmental influences (Table 2). Conversely, traits like female flower length (cm) and inter nodal length (cm) exhibit relatively lower heritability estimates, indicating a stronger influence of environmental factors on their expression. Furthermore, traits with high heritability estimates, such as fruit yield per plant (g) and fruit length (cm), present promising opportunities for targeted selection and breeding efforts to improve yield and fruit quality in pointed gourd genotypes.

Overall, the heritability estimates provide breeders with valuable insights into the genetic control of traits, guiding the selection of superior genotypes with desirable characteristics for further breeding programs.

Heritability estimates help predict a section of traits since they indicate the dependability of phenotypic values for selection purposes. The combination of high heritability and developments in genetics supports the existence of additive gene effects, particularly in characteristics such as the number of fruits produced by each vine, the length of the vine, and the number of fruits produced by each plant. This suggests that there is the possibility of achieving genetic advantages through selection.

The correlation between traits and yield in pointed gourd genotypes is crucial for understanding their potential impact on overall productivity. Table 3 shows significant correlations with fruit yield per plant (g) for several traits. Vine length (cm) displays a positive correlation with fruit yield per plant at both genotypic (G: 0.4564) and phenotypic (P: 0.469) levels. This suggests that longer vines may increase fruit yield in pointed gourd.

Fruit length (cm) also exhibits a notable positive correlation with fruit yield per plant, with genotypic (G: 0.600) and phenotypic (P: 0.559) coefficients indicating a strong association. Longer fruits may thus contribute to higher yields in pointed gourd genotypes. Additionally, fruit circumference (cm) demonstrates a significant positive correlation with fruit yield per plant, showing genotypic (G: 0.883) and phenotypic (P: 0.777) coefficients. This implies that fruits with larger circumferences may contribute positively to overall yield. These correlations highlight the importance of considering vine length, fruit length, and fruit circumference to enhance yield in pointed gourd genotypes. Breeders and researchers can leverage this information to prioritize traits that positively influence yield during selection and breeding programs.

There is a possibility that pleiotropic gene action or linkage is responsible for the associations that exist between various trait components. Insights into the overall and genetic relationships between desired features

Table 3: Genotypic (G) and phenotypic (P) coefficient correlation estimation among the traits of pointed gourd genotypes

Traits		Vine length (cm)	Number of internode per vine	Inter nodal length (cm)	No. of primary branches/vine	Female flower length(cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit circumferenc (cm)	Average fruit weight (g)	Fruit yield/ plant (g)
Vine length (cm)	G	1	0.651**	0.683**	0.160**	-0.149	0.038	-0.089	-0.081**	-0.182	0.456**
	P	1	0.603**	0.733**	0.128**	-0.069	0.032	-0.070	-0.078**	-0.164	0.511**
Number of internodes per vine	G		1	-0.086	0.168	-0.047**	0.032**	-0.352**	0.133**	-0.072	0.347**
	P		1	-0.068	0.152	-0.043**	0.033**	-0.342**	0.132**	-0.072	0.334**
Inter nodal length (cm)	G			1	0.062	-0.112	0.129	0.172**	-0.221**	-0.159	0.280**
	P			1	0.039	-0.015	0.103	0.155**	-0.192**	-0.129	0.373**
Number of primary branches/vine	G				1	-0.386**	-0.494	-0.363**	-0.516**	-0.638**	-0.476**
	P				1	-0.285**	-0.427	-0.334**	-0.464**	-0.588**	-0.423**
Female flower length (cm)	G					1	0.225**	-0.191	0.405	0.312**	0.256**
	P					1	0.168**	-0.100	0.245	0.233**	0.207**
Fruit length (cm)	G						1	0.291**	0.584**	0.653**	0.598**
	P						1	0.289**	0.580**	0.639**	0.559**
Fruit width (cm)	G							1	0.526**	0.574**	0.409**
	P							1	0.549**	0.592**	0.430**
Fruit circumference (cm)	G								1	0.834**	0.683**
	P								1	0.808**	0.628**
Average fruit weight (g)	G									1	0.777**
	P									1	0.7441**

*Significant at 5% level
** significant at 1% level

Table 4: Estimates of direct (bold) and in direct of significant traits on yield pointed gourd

Characters	*Vine length*	*Number of internodes per vine*	*Inter nodal length*	*No. of primary branches/vine*	*Female flower length*	*Fruit length*	*Fruit diameter*	*Fruit circumference*	*Average fruit weight*	*Fruit yield/ plant (g)*
Vine length (cm)	0.3087	0.201	0.211	0.0495	-0.0458	0.012	0.028	0.056	0.4564	0.469
Number of internodes per vine	0.1814	0.279	-0.024	0.0468	-0.013	0.009	-0.098	-0.020	0.347	0.347
Inter nodal length (cm)	0.1539	0.182	0.226	0.0139	-0.0252	0.029	0.039	-0.036	0.28	0.280
No. of primary branches	0.0001	0.000	0.000	0.0003	-0.0001	0.000	0.000	0.000	-0.476	0.476
Female flower length (cm)	-0.0169	-0.005	-0.013	-0.0440	0.114	0.026	-0.022	0.036	0.2556	0.256
Fruit length (cm)	-0.0016	-0.001	-0.006	0.0215	-0.0098	-0.044	-0.013	-0.029	0.598	0.600
Fruit width (cm)	-0.0050	-0.020	0.010	-0.0203	-0.0107	0.016	0.056	0.033	0.43	0.430
Fruit circumference (cm)	0.0105	-0.017	0.029	0.0670	-0.0527	-0.076	-0.071	-0.108	0.777	0.883
Average fruit weight (g)	-0.1746	-0.069	-0.152	-0.6108	0.2989	0.626	0.567	0.958	0.4564	0.777

Residual effect -0.128

can be gained through phenotypic and genotypic correlations, respectively. According to Debate *et al*. (2017), fruit production per plant displayed substantial positive relationships with various characteristics, including fruit weight, fruit circumference, fruit length, and vine length. These correlations indicate the significance of these characteristics as factors that contribute to productivity. According to Khan *et al*. (2009), Verma *et al*. (2017), and Jena *et al*. (2017), selection strategies ought to give priority to characteristics that have high positive associations with fruit yield. Some examples of such characteristics include fruit weight per plant and vine length.

The analysis of path coefficients makes it possible to divide correlation coefficients into two categories: direct and indirect impacts of independent factors on the variable that is being studied (the dependent variable). The fruit yield that each plant produced was regarded as the dependent variable in this investigation, whereas the other characteristics were deemed to be independent factors (Table 4). The intricate interrelationships between characteristics were further underlined by indirect impacts that occurred through a variety of channels. Positive contributions to fruit yield per plant were also made by characteristics such as fruit length, fruit circumference, and female flower length. These contributions were made indirectly through a variety of cellular pathways.

Overall, the fruit's average weight, the vine's length, the number of internodes on each vine, and the length of the fruit were essential components for increasing yield in a pointed gourd. The variation in genotypic path coefficients suggests that incorporating new traits into pointed gourd breeding programs in subtropical climates could lead to enhanced fruit yield.

Conclusion

The analysis indicates significant variability among pointed gourd genotypes, offering ample selection opportunities for yield enhancement. Traits like vine length and average fruit weight exhibit considerable genetic variability, while high heritability estimates suggest predominant genetic influence. Positive correlations between traits like vine length, fruit length, and fruit circumference with yield per plant underscore their importance. Path coefficient analysis highlights the significance of traits like average fruit weight and vine length in yield enhancement of pointed gourd. Leveraging genetic diversity and understanding trait associations could improve pointed gourd yield, particularly in subtropical climates.

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