



RESEARCH ARTICLE

Quantitative genetic analysis of yield contributing traits in pointed gourd genotypes

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Abstract

A field experiment was conducted at the Vegetable Research Farm of the Horticulture Garden, Bihar Agricultural College, Sabour, Bhagalpur, to assess the genetic variability, heritability and genetic advance in pointed gourd genotypes. The experiment was laid out in a randomised block design (RBD) with three replications, comprising 25 genotypes. Analysis of variance (ANOVA) revealed significant differences among the genotypes for all the studied traits, indicating sufficient variability in yield and quality parameters. In all cases, the phenotypic coefficients of variation (PCV) values were higher than the corresponding genetic coefficients of variation (GCV) values. The highest GCV and PCV were observed for chlorophyll b (35.71 % and 36.06 % respectively), followed by marketable fruits per plant, yields of marketable fruits per plant and chlorophyll a. The high magnitude of GCV in chlorophyll b indicates substantial genetic variability among the genotypes, suggesting the potential for crop improvement through the selection of superior parents for direct selection. In the present study, heritability estimates ranged from 48 % to 98 %, suggesting that these traits are largely governed by additive gene action. These findings indicate that selection for early maturity, number of fruits and chlorophyll a and b content effectively improve yield and quality, providing key traits for breeding high-yielding and superior pointed gourd cultivars.

Keywords: genetic coefficients of variation; genetic variability; heritability; phenotypic coefficients of variation; pointed gourd

Introduction

Pointed gourd (*Trichosanthes dioica* Roxb.) is a tropical perennial cucurbit that grows under a dioecious reproductive system and produces fruits from February to October, followed by winter latency. This species is thought to have originated in the Indo-Malayan region and has a diploid chromosome number of $2n = 22$. It is locally known by different names such as Parwal, Patal, Palwal, Parmal, Parora and Patola (1). The crop is grown in the Gangetic valleys of India, particularly West Bengal, Bihar, eastern Uttar Pradesh and Assam and there are some regions in the states of Odisha, Chhattisgarh, Madhya Pradesh and Maharashtra. Being an excellent source of essential nutrients and rich in genotypic diversity, it has been termed the King of Gourds (2, 3). In India, pointed gourd is generally cultivated on sandy riverbed soils, with an estimated acreage of about 20000 ha producing nearly 310000 tonnes annually, corresponding to an average productivity of 14.89 t ha^{-1} . Its low input demand, high economic returns and suitability for marginal and smallholder farming systems make it particularly remunerative in Bihar's agro-climatic zone III.

Morphologically, the plant has a deep tuberous taproot and a slender, perennial vine habit. Floral development is characterised by a period of anthesis, i.e., 16–19 days in pistillate flowers and 10–14 days in staminate flowers, with stigma receptivity for 14 hr and fruit setting of 40–70 % (4). Based on fruit characteristics, pointed gourds are classified into four distinct types: long, dark green fruits with white striations (10–13 cm); thick, pale-striped fruits (10–16 cm); (iii) round, white-striped fruits (5–8 cm); and tapering, green-striped fruits (5–8 cm) (5). The nutrient content (per 100 g edible portion) is approximately as follows: vitamin A, 255 IU; ascorbic acid, 29 mg; protein, 2.0 g; fat, 0.3 g; carbohydrate, 2.2 g and 3.1 g fibre, as well as reasonable amounts of magnesium (9 mg), potassium (83 mg) and phosphorus (40 mg) (6). Pointed gourds have therapeutic significance in traditional medicine. Leaves are reported to possess antipyretic, diuretic, cardiotonic, laxative and anti-ulcer properties. Leaf juice is used as a tonic, febrifuge and for the treatment of oedema, alopecia and hepatic enlargement. Propagation is primarily achieved through vegetative cuttings of 60–90 cm basal vines that are coiled and planted at a depth of 15 cm (7). Sexual propagation through seeds is limited by poor germination, sex-

based unpredictability before flowering and a highly skewed sex ratio of approximately 10 : 1 in favour of female plants (8).

From a phylogenetic perspective, *Trichosanthes* represents the largest genus within Cucurbitaceae, encompassing more than 90 species worldwide, of which 22 have been reported in India (9, 10). Assam is considered the centre of domestication, although wild and semi-wild relatives are distributed across peninsular India and the Himalayan region (11). The strict dioecy of the crop and morphological similarity of sexes create challenges for breeding, particularly as reliable early sex-diagnostic markers are yet to be developed.

Despite the considerable economic and nutritional importance, breeding efforts in pointed gourds remain minimal, with few systematic attempts to develop improved cultivars. Germplasm collections in Bihar demonstrate marked variability in fruit morphology and phenology; however, this genetic wealth remains underutilised. Evaluating the magnitude of variability and heritability, along with genetic advances for yield and quality components, is fundamental in designing successful breeding schemes. These actions will facilitate the identification of superior genotypes for hybridisation and cultivar release. Hence, the present investigation was initiated to study genetic variability, heritability and genetic advances in pointed gourd genotypes for their yield and quality characteristics and to identify promising genotypes for use in future breeding programmes.

Materials and Methods

Genetic variability, heritability and genetic advances in pointed gourds (*T. dioica*) genotypes were carried out during the period of 2015–16 and 2016–17 in the Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural University, Sabour, Bhagalpur. The experimental field is located at 25°15'40" N latitude and 86°59' 42" E longitude in Bhagalpur district with an altitude of 46 m above mean sea level. The place is situated in the fertile Indo Gangetic plains of North India. The experimental design was a randomised block design (RBD) with three replications. The plant material included 25 genotypes of pointed gourds drawn from the different agro-climatic zones of Bihar, Uttar Pradesh and West Bengal. These genotypes are available in the germplasm of the repository of the Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural University, Sabour, India (Table 1).

The experimental site was characterised by well-drained sandy loam soil. The pH of the soil was 7.2, which was slightly alkaline. The climate in the region has semi-arid, subtropical features with hot and dry summers and the moderate rainy season is followed by a cold winter. December and January are the coldest months with a mean minimum temperature of around 8.5 °C, while May and June are the hottest (35.3 °C) months along with the highest diurnal temperature range in summer (Table 1). Standard agronomic practices recommended for pointed gourds were adopted during the entire study period. Irrigation was performed immediately after planting to ensure optimal establishment. Each genotype was planted at an inter-row spacing of 2 m and an intra-

Table 1. Mean performance of genotypes for yield and quality traits in pointed gourd (Pooled analysis)

Sl. No.	Characters	Node No. at Which first female flower appears	Days to first fruit harvest	Fruit length (cm)	Fruit breadth (cm)	Primary branches /plant	Days to last fruit harvest	Marketable fruits per plant	Yield of marketable fruits per plant (kg)	Average fruit weights (g)	Chlorophyll 'a' (mg/100 g)	Chlorophyll 'b' (mg/100 g)
1	BRPG 12-1	13.19	172.00	8.75	3.29	7.83	439.16	112.50	4.29	46.35	13.53	5.44
2	BRPG 12-7	18.70	140.16	8.12	2.74	7.16	383.83	114.66	4.16	36.48	23.10	17.79
3	BRPG 12-8	11.92	146.83	6.70	2.93	5.66	359.66	96.33	3.87	33.95	11.44	5.30
4	BRPG 12-9	11.80	162.33	8.73	3.32	7.66	428.50	151.00	4.97	44.99	20.34	13.35
5	BRPG 12-10	12.24	154.50	6.56	2.74	5.16	397.33	102.50	3.16	32.85	20.65	15.42
6	BRPG 12-11	12.54	144.83	8.52	3.59	7.66	357.50	77.83	3.24	46.95	22.79	16.89
7	BRPG 12-13	13.19	168.00	5.36	2.64	4.83	433.33	85.00	2.67	33.15	19.22	12.83
8	BRPG 13-4	19.38	162.00	7.19	3.56	6.16	405.66	102.50	2.80	31.95	12.75	7.06
9	BRPG 13-5	13.80	147.83	8.12	2.60	7.66	360.66	63.16	1.99	38.65	22.37	16.94
10	BRPG 13-10	14.93	169.00	7.37	3.29	6.66	435.50	90.83	3.02	41.94	18.46	10.72
11	BRPG 13-13	14.96	162.83	5.31	3.08	4.16	406.50	87.00	2.73	37.98	21.31	14.88
12	BRPG 13-16	15.36	160.66	8.80	2.60	7.66	370.33	75.50	2.96	45.87	15.65	7.43
13	BRPG 13-19	13.94	160.00	7.51	2.97	5.16	403.66	72.83	2.56	38.31	22.21	16.49
14	BRPG 13-20	8.77	190.00	6.95	3.42	6.66	397.00	73.83	2.55	40.93	13.61	8.44
15	BRPG 13-22	13.19	157.00	8.60	2.93	7.66	422.33	69.66	2.29	43.25	16.29	7.67
16	BRPG 13-25	13.60	161.00	7.01	3.29	6.16	405.50	74.83	2.80	35.72	22.02	16.46
17	BRPG 13-26	10.98	164.33	6.10	3.42	3.66	374.00	116.33	2.89	24.44	21.89	15.89
18	BRPG 13-27	14.93	148.33	5.15	3.24	3.66	413.50	139.66	3.56	30.74	23.19	18.27
19	BRPG 13-28	8.49	161.83	7.52	2.97	6.16	404.66	88.16	2.80	34.41	16.54	9.48
20	BRPG 13-29	12.54	168.33	7.22	3.42	5.66	378.00	98.66	3.18	39.66	18.18	9.80
21	BRPG 13-30	19.09	172.00	8.15	2.60	7.66	438.33	75.00	2.29	33.96	18.16	10.49
22	BRPG 13-31	13.26	163.83	6.19	3.29	5.16	407.50	40.83	1.86	40.90	24.13	19.48
23	Nimia	12.40	161.33	7.63	3.42	5.66	376.00	82.83	2.65	40.62	20.29	14.16
24	RajendraParwal 1	16.30	157.50	6.48	2.70	6.66	360.66	127.50	3.21	35.39	25.16	21.46
25	RajendraParwal 2	14.36	160.50	7.32	2.64	5.16	408.50	109.33	3.48	33.44	17.69	10.33
Mean		13.75	160.68	7.25	3.07	6.14	398.70	93.13	3.04	37.71	19.24	12.90
C.V.		6.88	6.19	12.08	5.44	9.87	5.55	6.28	5.52	5.33	4.74	4.00
S.E.		0.38	4.06	0.35	0.06	0.24	9.03	2.39	0.06	0.82	0.45	0.26
C.D. 5%		1.08	11.38	1.00	0.19	0.69	25.30	6.69	0.19	2.30	1.26	0.73

row spacing of 1 m. Morphological observations were recorded following the guidelines outlined by the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), Government of India, in the Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) for pointed gourds. Data were collected from five randomly selected tagged plants per genotype per replication to ensure statistical reliability. The observed data were analysed statistically using analysis of variance (ANOVA) and covariance, following the procedure (12). Heritability (broad sense) was estimated using the formula, expressed as the ratio of genotypic variance to phenotypic variance (13). Heritability estimates were classified as low (< 30 %), moderate (30–60 %), or high (> 60 %) according to the categorisation (14). The expected genetic advance (GA) under selection was computed as per a previously described method (15).

Results

The data obtained for all the parameters showed significant differences among the 25 pointed gourd genotypes studied, with $p < 0.01$ as revealed by the ANOVA. The mean number of nodes for female flower initiation was observed to vary from 8.49 for BRPG 13.28 to 19.38 for BRPG 13–4, with a combined average of 13.75. The days to first harvest ranged from 140.16 for BRPG 12–7 to 190 days for BRPG 13–20 and from 357.50 days for BRPG 12–11 to 439.16 days for BRPG 12–1 for the days recorded for the last harvest. Fruit length ranged from 5.15 cm (BRPG 13–27) to 8.80 cm (BRPG 13–16) and fruit width varied between 2.60 cm (BRPG 13–16, BRPG 13–20 and BRPG 13–30) to 3.59 cm (BRPG 12–11). The number of primary branches per plant varied from 3.66 (BRPG 13–26, BRPG 13–27) to 7.83 (BRPG 12–1). The number of marketable fruits per plant varied widely (40.83 for BRPG 13–31 to 151.00 in BRPG 12–9) and the corresponding marketable fruit yield ranged from 1.86 kg (BRPG 13–31) to 4.97 kg (for BRPG 12–9). The average fruit weight varied from 24.44 g (BRPG 13–26) to 46.95 g (BRPG 12.11). For the quality characters, chlorophyll 'a' varied from 11.44 mg/100 g (BRPG 12–8) to 25.16 mg/100 g (Rajendra Parwal 1) and chlorophyll 'b' fluctuated from 5.30 mg/100 g (BRPG 12–8) to 21.46 mg/100 g (Rajendra Parwal 1). The genetic parameter presented in Table 2 revealed high PCV and GCV for marketable fruit per plant (27.42 % and 26.69 %) and yield per plant (24.20 % and 23.56 %). High heritability (> 90 %) combined with high GA as a percentage of mean was observed for marketable fruits per plant, yield per plant and chlorophyll 'b', indicating predominance of additive gene action.

Table 2. Genetic parameter for yield component and quality traits in pointed gourd (Pooled analysis)

Characters	Range		GCV (%)	PCV (%)	H ² (Broad sense)	Genetic advance	Genetic advance (% of Mean)
	Lowest	Highest					
Node no. at which first female flower appears	8.49	19.38	19.36	20.55	89	5.17	37.58
Days to first fruit harvest	140.16	190.00	5.92	8.57	48	13.56	8.44
Fruit length (cm)	5.15	8.80	14.21	18.66	58	1.61	22.31
Fruit breadth (cm)	2.60	3.59	10.73	12.04	79	0.60	19.73
Primary branches/ plant	3.66	7.83	20.91	23.12	81	2.39	38.95
Days to last fruit harvest	357.50	439.16	6.17	8.30	55	37.72	9.46
Marketable fruits per plant	40.83	151.00	26.69	27.42	95	49.84	53.51
Yield of marketable fruits per plant (kg)	1.86	4.97	23.56	24.20	95	1.43	47.25
Average fruit weight (g)	24.44	46.95	14.48	15.43	88	10.56	28.00
Chlorophyll A (mg/100 g)	11.44	25.16	19.56	20.39	92	7.44	38.68
Chlorophyll B (mg/100 g)	5.30	21.46	35.71	36.06	98	9.40	72.85

Note: GCV = Genotypic coefficient of variation; PCV = Phenotypic coefficient of variation; H² = Broad-sense heritability (%); GA = Genetic advance; GAM = Genetic advance as percent of mean.

The phenotypic and genotypic correlation coefficients between the yield and quality traits of the pointed gourds are described in Table 3. Overall, the magnitudes of genotypic correlation coefficients were greater than those of phenotypic correlations, suggesting that genetic influences dominated trait associations and that environmental factors moderated these associations at the phenotypic level. The number of nodes to the first female flower was negatively associated with the number of days to first fruit harvest at the genotypic (–0.3018) and phenotypic (–0.1474) levels, indicating that early initiation of female flowers contributed to earlier fruit production. It showed weak positive correlations with fruit length and primary branches per plant, implying that genotypes with earlier flowering nodes may also have slightly longer fruits and more branches. The days to harvest of the first fruit showed a significant positive correlation with the days to last fruit harvest at both levels ($P = 0.6711$; $G = 0.4011$), indicating that genotypes that took a relatively long period for the first fruiting are observed to have a late final harvest. Negative correlations were also found between this trait and the number of marketable fruits per plant ($G = -0.2259$; $P = -0.0175$) and chlorophyll content (Chl A : $G = -0.4275$, $P = -0.2927$; Chl B : $G = -0.4371$, $P = -0.2968$), indicating that late-fruited types are less productive and biochemically less efficient. Fruit length showed a high positive genotypic correlation with primary branches per plant (0.9491), average fruit weight (0.6712) and marketable fruit yield, which manifested its direct role in the genotype performance of yield. Conversely, it exhibited a negative association with chlorophyll traits, implying that genotypes with longer fruits may not necessarily possess higher pigment content. Primary branches per plant showed positive associations with average fruit weight ($G = 0.6998$; $P = 0.5922$), indicating the importance of enhancing sink capacity and yield potential. Similarly, average fruit weight maintained a favourable correlation with fruit length but exhibited a negative association with chlorophyll traits, reflecting a trade-off between fruit size and biochemical quality. Chlorophyll a and chlorophyll b were highly and positively correlated both phenotypically (0.9316) and genotypically (0.9804), suggesting that selection for one will simultaneously improve the other because of their close physiological linkage. Overall, the results showed that fruit length, number of primary branches and average fruit weight were the most influential traits contributing positively to yield attributes, whereas delayed first fruit harvest tended to reduce productivity and chlorophyll content.

Table 3. Phenotypic and genotypic correlation matrix in pointed gourd

Character		Node no. at which first female flower appears	Days to first fruit harvest	Fruit length (cm)	Fruit breadth (cm)	Primary branches/plant	Days to last fruit harvest	Marketable fruit per plant	Average fruit weight	Chlorophyll A (mg/100 g)	Chlorophyll B (mg/100 g)
Node no at which first female flower appears	P	1.0000	-0.1474	0.1033	-0.2152	0.2001	0.1485	0.1101	-0.0821	0.1300	0.1271
	G	1.0000	-0.3018	0.0661	-0.3027	0.1582	0.1225	0.0942	-0.1277	0.1436	0.1301
Days to first fruit harvest	P		1.0000	0.1559	0.2878	-0.0092	0.6711	-0.0175	0.2772	-0.2927	-0.2968
	G		1.0000	-0.1477	0.2284	0.0062	0.4011	-0.2259	0.0615	-0.4275	-0.4371
Fruit length (cm)	P			1.0000	0.0698	0.6426	0.1576	-0.0091	0.5863	-0.2141	-0.2802
	G			1.0000	-0.0805	0.9491	-0.0797	-0.1226	0.6712	-0.2885	-0.3888
Fruit breadth (cm)	P				1.0000	-0.0313	0.1251	0.1220	0.2163	-0.0483	-0.0312
	G				1.0000	-0.1583	-0.0225	0.0758	0.1732	-0.0747	-0.0460
Primary branches/plant	P					1.0000	0.0064	-0.1325	0.5922	-0.2294	-0.2735
	G					1.0000	0.0160	-0.1472	0.6998	-0.2580	-0.3080
Days to last fruit harvest	P						1.0000	0.1679	0.2313	-0.1529	-0.2111
	G						1.0000	0.0437	0.0042	-0.2088	-0.2867
Marketable fruit per plant	P							1.0000	-0.1908	0.0545	0.0606
	G							1.0000	-0.2849	0.0515	0.0607
Average fruit weight	P								1.0000	-0.1127	-0.1929
	G								1.0000	-0.1228	-0.2067
Chlorophyll A (mg/100 g)	P									1.0000	0.9316
	G									1.0000	0.9804
Chlorophyll B (mg/100 g)	P										1.0000
	G										1.0000

Discussion

The significant genotypic differences observed among the 25 pointed gourd accessions for all traits confirmed the presence of ample genetic variability, thus providing a strong basis for effective selection and crop improvement. The variation recorded for earliness traits, such as node number for first female flower appearance (8.49–19.38) and days to first fruit harvest (140.16–190.00 days), highlights the scope for selecting early-flowering and early-fruited genotypes, which are desirable for ensuring prolonged harvesting windows and higher cumulative yields. Extended variation in days to last fruit harvest (357.50–439.16 days) further suggests the possibility of identifying genotypes with longer productive spans, which is advantageous for smallholders seeking staggered and sustained market supply. Pollination dynamics influence productivity in dioecious crops, such as pointed gourds (16, 17).

Considerable diversity in fruit size, along with fruit length ranging from 5.15 to 8.80 cm and fruit breadth from 2.60 to 3.59 cm. Genotypes such as BRPG 13–16 and BRPG 12–11, which combine favourable fruit dimensions with higher fruit weight, appear promising for consumer preference and yield potential. Primary branches per plant also varied widely, with values extending up to 7.83, indicating that branching capacity could serve as a useful selection index, given its positive association with yield-related traits. Yield components displayed the largest magnitude of variability, as seen in the wide range of marketable fruits per plant (40.83–151.00) and yield per plant (1.86–4.97 kg). The high phenotypic and genotypic coefficients of variation for these traits, coupled with high heritability and high genetic advancement, strongly suggest the predominance of additive gene action. Thus, direct selection for a higher fruit number and yield per plant is likely to be effective in improving productivity. Notably, chlorophyll 'b' also exhibited high heritability with substantial genetic advance, implying its potential as a reliable biochemical marker for selection in quality improvement programmes (18). Correlation analysis also revealed significant inter-associations among the characteristics. In general, genotypic correlations were higher than phenotypic correlations, indicating a greater environmental influence obscuring the genetic relationships. Earliness, expressed as the low number of nodes to

first female flower and days to first harvest, was positively correlated with higher yield (and pigment content), supporting selection for an early-maturing genotype. In contrast, delayed first fruit harvest was positively correlated with a long harvesting period but negatively correlated with the number of fruits and chlorophyll, indicating trade-offs between prolonged harvesting span and total yield. Fruit length was recognised as a main determinant trait and was positively correlated with primary branches and average fruit weight, indicating that its effects on potential yield were also direct. However, its negative correlation with chlorophyll content implies a probable tradeoff between fruit size and biochemical quality, supporting the idea that breeders would have to reconcile trait-value pairs depending on breeding goals. The strong and positive association between chlorophyll 'a' and 'b' indicates their close physiological linkage, implying that an improvement in one will simultaneously enhance the other (1, 19).

The presence of variability in both yield and quality traits in pointed gourd revealed that early flowering, higher branching, number of marketable fruits and fruit length were identified as key contributors to yield, while chlorophyll content may serve as a useful criterion for quality improvement. The predominance of additive gene effects for major yield components further enhances the scope of effective genetic gains through direct selection.

Conclusion

The present study showed substantial genetic variability among the evaluated pointed gourd genotypes for yield, earliness and quality traits. Early flowering and early fruited genotypes were of particular interest for enhancing productivity and extending the harvest duration, whereas differences in fruit size and branching type may offer additional avenues for yield improvement. Fruit length, number of primary branches and average fruit weight were most consistently associated with yield and could therefore be considered reliable selection variables for the improvement of new varieties.

High estimates of heritability and genetic advancement for key characteristics, such as marketable fruits per plant, yield per plant and chlorophyll 'b', indicate the predominance of additive

gene action, suggesting that direct selection would be effective for genetic gain. The correlation analysis further highlighted the importance of early maturity and fruit size in determining yield, while also revealing trade-offs between larger fruit dimensions and chlorophyll content. Nevertheless, the simultaneous improvement of yield and quality is feasible through strategic selection. Emphasis on early maturity, branching ability and higher fruit number, along with targeted improvement in chlorophyll content, can accelerate the development of high-yielding and nutritionally superior pointed gourd cultivars.

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Authors' contributions

MA conducted field experimentation, trait recording, and data validation. RBV provided guidance, supervision, and critical review of the manuscript. MAN performed data analysis and assisted in manuscript preparation. VK carried out statistical analysis, interpreted the results, and participated in manuscript drafting. AA undertook the literature review, editing, and provided technical support for data interpretation. SMR was responsible for data acquisition and manuscript revision. LK participated in data analysis and manuscript revision. RK oversaw the overall analysis and approved the final version of the manuscript. RKV assisted with data analysis and manuscript revision. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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