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Genetic Variability and Heritability in Bitter Gourd for better Yield and Quality under Sodic Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Bitter Gourd (*Momordica charantia*) is a tropical and subtropical vine widely grown in Asian and African countries. This study evaluates thirty genotypes of bitter gourd for about eight quantitative characters under sodic soil during 2022-23. The evaluation was carried out using Randomized Block Design with three replications. All the parameters exhibited significant differences among the genotypes. The genotype MCPKM-04 recorded for the highest number of fruits and fruit yield while MCPKM-19 recorded superiority in terms of earliness. The quality parameters viz., ascorbic acid and phenol content observed highest in the genotype MCPKM-05. Yield parameters viz., number of fruits, fruit weight and fruit yield exhibited higher GCV, while close association of GCV and PCV were observed in all the studied parameters suggesting that the variations are only due to genetic differences and not due to environment.

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Keywords: Bitter gourd; earliness; sodic soil; variations.

1. INTRODUCTION

Bitter gourd (*Momordica charantia*) belongs to the Cucurbitaceae family is a unique tropical vegetable known for its distinctive bitter taste and impressive health benefits. The crop thrives in warm, humid climates and produces elongated fruits that range from green to yellow as they ripen. The fruits are rich in vitamins C, A and essential minerals like potassium. Bitter gourd is recognized for its medicinal properties particularly in traditional and herbal medicine. It has been associated with health benefits like supporting blood sugar regulation, aiding digestion and providing antioxidant protection (Nagarani et al., 2014). There are several species, including *Momordica charantia var. charantia*, commonly grown in Asia with long, green, bitter fruits; *Momordica charantia var. muricata*, found in the Caribbean and Africa with rounder, milder fruits; and *Momordica cochinchinensis*, popular in Southeast Asia for its slightly bitter, antioxidant-rich red arils. However, the genus Momordica consist of over 40 species differ in flavor, appearance, and culinary uses. Sodicity, the accumulation of sodium ions in soil is a significant soil degradation issue in India, particularly affecting arid and semi-arid regions. Sodic soils result from high levels of sodium relative to other cations, often leading to poor soil structure, reduced permeability and limited crop productivity (Sharma et al., 2016). In India, sodicity is prevalent in the Indo-Gangetic plains, parts of Rajasthan, Haryana, Uttar Pradesh, Punjab and certain areas in southern states such as Andhra Pradesh and Tamil Nadu. Bitter gourd traditionally grown for its nutritional and medicinal value shows potential as a crop that can tolerate moderate sodic conditions (Maurya et al., 2022). So, there exists a need to assess the variability in bittergourd genotypes under sodic soils. The present experiment was undertaken with a view to explore the genetic variability and heritability of bitter gourd under sodic soil.

2. MATERIALS AND METHODS

The study was conducted at the Horticulture College and Research Institute for Women, Tiruchirappalli during 2022–23 under a Randomized Block Design with 31 genotypes each replicated thrice. The experimental site consists of sandy loam soil with 9.2 pH, 0.52 EC, 28.00 ESP. The site experiences an annual rainfall of 841.90 mm while annual temperature ranging from 25°C to 32°C. The seeds of each genotype were sown under protrays and transplanted into main field. The spacing adapted in main field was about 2.00m × 1.50m. Irrigation was provided at alternate days and the fertilizers were provided at the rate of 200:100:100 kg NPK/ha. Various observations *viz*., vine length (cm), number of branches, days to first fruit harvest, number of fruits per plant, individual fruit weight (g), fruit yield per vine (kg), ascorbic acid content (mg $100g^{-1}$), and total phenol content (mg GAE g^{-1}) were recorded from the random plants. Vine length was recorded from the ground level to the tip of the plant while the yield parameters were computed using a standard weighing balance.

Vitamin C content was estimated through the titration method as per Ranganna (2001). The acid digested sample was titrated against indophenol dye until the colour changes to pale pink. Phenol content was determined using a spectrophotometer as per Horax et al. (2005). The obtained data was subjected to statistical analysis to identify significant differences among genotypes, as per Panse and Sukhatme (1985). Genetic variability parameters *viz*., environmental variance (EV), genotypic variance (GV), phenotypic variance (PV), environmental coefficient of variation (ECV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability (h^2) were analysed on the above observations through software package vardata in R studio.

3. RESULTS AND DISCUSSION

Sodic soil is a significant agricultural challenge globally and identifying resistant crop varieties is critical for effective management. Bitter gourd moderately tolerant to sodicity was evaluated for growth, yield and quality traits under sodic soil conditions revealing significant genotypic variation across all the observed parameters (Table 1). The genotype MCPKM-12 exhibited the highest vine length (500.00 cm), while MCPKM-07 recorded the lowest vine length (268.50 cm). Number of branches exhibited maximum in HC&RI (W) Try-2 of 21.30 while the genotype MCPKM-04 exhibited the lowest number of branches (9.26). Earliness, a vital trait for adaptability showed variation with genotype MCPKM-19 recorded minimum days for first harvest (56.48) while MCPKM-18 recorded maximum days for first harvest (72.69). Similar findings were reported by Yadav et al. (2013) in bitter gourd and Saranyadevi et al. (2017) in mithipagal genotypes.

Yield components varied significantly with MCPKM-04 producing the highest number of fruits (16.67) and fruit yield per vine (2.24 kg) and MCPKM-26 showed the highest individual fruit weight of 130.37 g (Fig. 1). Conversely, the genotype MCPKM-26 recorded the minimum number of fruits (6.46) and MCPKM-22 recorded the minimum individual fruit weight (42.59 g) and fruit yield per vine (0.38 kg). The results obtained on yield characters were similar to the findings of Singh et al. (2017) in bittergourd and Prabha et al. (2007) in ridge gourd. The minimum yield obtained in MCPKM-22 might be due to minimum individual fruit weight (Sharma et al., 2019). Quality traits such as total phenol content and ascorbic acid content were highest in MCPKM-05 (31.59 mg GAE g^{-1} and 94.76 mg $100g^{-1}$, respectively) that significantly highlights the nutritional superiority. The genotype MCPKM-22 observed for the lowest total phenol content (12.26 mg GAE g^{-1}) and ascorbic acid content (62.26 mg $100g^{-1}$). These results underscore the potential for breeding bitter gourd varieties with improved performance under sodic conditions. Generally bitter gourd is rich in phenolic compounds and some of the key phenolic compounds found in bitter gourd include gallic acid, catechins, chlorogenic acid, epicatechin. The ascorbic acid content in bitter gourd makes it a great addition to diet through the improvement in overall antioxidant status (Hussain et al., 2024).

The genetic variability and heritability was estimated for the studied parameters (Table 2). The variance observed maximum for vine length, individual fruit weight while the number of branches, fruit yield per vine and total phenol content observed minimum amount of variance. Yield contributing traits *viz*., fruit yield per vine, number of fruits per plant and individual fruit weight recorded for the high GCV. This suggest a wide range of genetic expression for the trait, which provides more scope for selection and improvement through breeding. The same findings were also reported by Aftab et al. (2024), Bhati et al. (2023) in bitter gourd and Das et al. (2024) in bottle gourd. All the parameters vine length, number of branches, days to first fruit harvest, number of fruits per plant, individual fruit weight, fruit yield per vine, ascorbic acid content and total phenol content observed close difference between GCV and PCV. This was in accordance with the findings of Prasanth et al. (2020) in bitter gourd. This suggests that the trait is primarily influenced by genetic factors with minimal environmental influence. The observed variability is mainly due to genetic differences rather than environmental factors making the parameters ideal for targeted crop improvement programs.

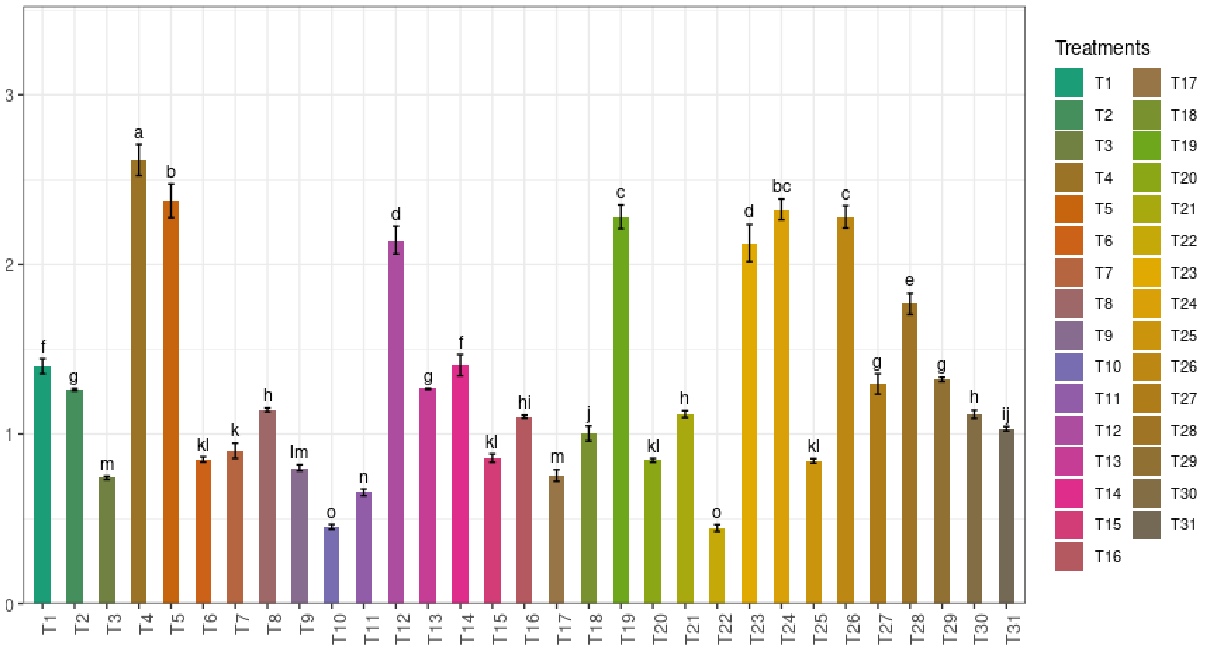

Fig. 1. Fruit yield of 30 genotypes under sodic soil

Table 1. Performance of bitter gourd genotypes under sodic soil

Source	Vine length (cm)	Number of branches	Days to first fruit harvest	Number of fruits per plant	Individual fruit weight (g)	Fruit yield per vine (kg)	Ascorbic acid content (mg $100g^{-1}$)	Total phenol content (mg GAE g^{-1})
MCPKM-01	320.37	14.81	65.93	14.81	75.00	1.20	26.03	83.65
MCPKM-02	326.85	14.81	64.44	11.11	90.20	1.08	22.62	80.39
MCPKM-03	372.22	15.74	67.59	8.33	70.68	0.64	19.56	80.76
MCPKM-04	377.78	9.26	62.04	16.67	124.63	2.24	28.19	92.37
MCPKM-05	394.44	11.11	61.57	14.81	127.31	2.04	31.59	94.76
MCPKM-06	371.30	16.67	66.94	8.33	81.02	0.73	17.36	68.06
MCPKM-07	229.63	14.81	64.26	9.26	77.31	0.77	14.31	65.44
MCPKM-08	372.22	12.96	65.00	7.41	122.53	0.98	18.62	73.25
MCPKM-09	405.56	19.44	65.83	6.48	98.15	0.69	22.14	77.08
MCPKM-10	362.96	16.67	63.89	6.48	55.56	0.39	23.82	76.46
MCPKM-11	308.33	13.89	64.81	8.33	62.50	0.56	15.84	72.13
MCPKM-12	500.00	10.19	60.19	13.89	122.52	1.84	29.00	90.39
MCPKM-13	336.11	18.52	66.94	8.33	120.68	1.09	23.25	83.47
MCPKM-14	366.67	19.44	69.72	12.96	86.11	1.21	18.99	82.91
MCPKM-15	336.11	15.74	67.22	7.41	91.97	0.74	20.75	79.37
MCPKM-16	345.37	20.37	70.19	9.26	94.44	0.94	24.75	81.57
MCPKM-17	362.04	16.67	66.02	12.96	46.30	0.65	22.82	70.21
MCPKM-18	310.19	16.67	72.69	8.33	95.68	0.86	26.95	73.56
MCPKM-19	395.37	11.11	56.48	14.81	122.22	1.96	30.06	89.35
MCPKM-20	338.89	16.67	64.81	8.33	80.56	0.73	27.24	85.28
MCPKM-21	314.81	13.89	66.94	7.41	119.91	0.96	19.43	78.55
MCPKM-22	336.11	13.89	68.61	8.33	42.59	0.38	12.26	62.26
MCPKM-23	449.07	11.11	56.94	13.89	121.60	1.82	27.77	64.92
MCPKM-24	380.56	12.04	62.50	14.81	124.63	1.99	27.79	83.81
MCPKM-25	273.15	14.81	65.93	12.04	55.56	0.72	13.79	71.22
MCPKM-26	391.67	12.04	62.96	13.89	130.37	1.96	26.62	84.02
MCPKM-27	314.81	13.89	65.74	9.26	111.11	1.11	24.91	81.57
MCPKM-28	263.89	17.59	67.59	12.04	116.67	1.52	23.64	74.74
HC&RI(W)Try-1	250.93	14.81	68.98	11.11	94.44	1.13	26.31	83.31

Source	Vine length (cm)	Number of branches	Days to first fruit harvest	Number of fruits per plant	Individual fruit weight (g)	Fruit yield per vine (kg)	Ascorbic acid content (mg $100g^{-1}$)	Total phenol content (mg GAE g^{-1})
HC&RI(W)Try-2	248.61	21.30	70.56	10.19	87.04	0.96	22.94	75.02
HC&RI(W)Try-3	250.19	13.89	71.30	9.26	88.52	0.89	28.70	78.85
S.Ed	8.74	0.27	1.68	0.29	2.59	0.03	0.39	4.25
CD(0.05)	17.492	0.56	3.37	0.59	5.19	0.07	1.09	3.36

Table 2. Genetic variability and heritability among the genotypes for growth and yield parameters

	EV	GV	PV	ECV	GCV	PCV	h^2
Vine length	114.71	4895.59	5010.29	2.68	17.53	17.74	0.977
Number of branches	0.11	5.0	5.22	2.22	14.75	14.93	0.977
Days for first harvest	4.27	17.75	22.01	2.69	5.50	6.13	0.806
Number of fruits per plant	0.13	11.92	12.05	2.90	27.76	27.91	0.989
Individual Fruit weight	10.09	914.72	924.81	2.87	27.36	27.51	0.989
Fruit yield per vine	0.01	0.38	0.38	3.25	47.26	47.37	0.995
Ascorbic acid content	4.25	85.49	89.74	2.25	10.07	10.32	0.952
Total phenol content	0.45	34.46	34.91	2.48	21.73	21.87	0.987

***ev** *- environmental variance, gv- genotypic variance, pv - phenotypic variance, ecv - environmental coefficient of variation, gcv - genotypic coefficient of variation, pcv - phenotypic coefficient of variation, h2 - heritability*

High heritability was associated with all the parameters in exception for days for first harvest (0.806). High heritability indicates that a large proportion of the observed variation in a trait was due to genetic differences among individuals rather than environmental influences. Mallikarjuna et al. (2024) reported that all the quantitative traits in bitter gourd exhibited high heritability. Traits with high heritability are strongly governed by genetic factors, making them more predictable and reliable targets for selection and breeding programs.

Genetically diverse genotypes play a crucial role in future crop improvement programs by providing a rich pool of traits that can be harnessed to develop resilient, high-yielding, and sustainable crop varieties. Diverse genotypes often possess unique traits for tolerating abiotic stresses like drought, heat, or salinity, which are increasingly important in the context of climate change. Genetic diversity ensures crops can adapt to poor soils and unpredictable weather conditions.

4. CONCLUSION

The findings of the present study concluded that yield parameters like number of fruits, individual fruit weight and fruit yield per vine should be given atmost priority in the superior genotype selection. Further the genotypes for the observed traits showed diverse nature and hence they could be utilized in the future crop improvement program in bitter gourd.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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