Bangladesh J. Agri. 2023, 48(2): 86-93 ***DOI: https://doi.org/10.3329/bjagri.v48i2.70434***

EXPLORING GENOTYPIC VARIATION IN GROWTH AND YIELD TRAITS OF BETEL VINE (*Piper betle* L.) GENOTYPE

M. A. Alam[1*], A. J. Obaidullah[2], S. Naher[3], M. A. Mottalib[4] and M. A. Rahman[3]

[1]Plant Breeding Division, Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Bogura; [2]Horticulture Division, Regional Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Magura; [3]Soil Science Division, Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Bogura; [4]Agricultural Engineering Division, Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Bogura. Bangladesh

Abstract

The present research spans two consecutive growing seasons (2021-22 and 2022-23) at the Spices Research Centre, Shibganj, Bogura to evaluate the growth and yield attributes of the betel vine genotypes. The inaugural season (2021-22) focused solely on line BL0027, while the following season (2022-23) included multiple betel vine lines, BL0025, BL0027, BL0028, BL0030, and BL0040, with BARI Pan-3 as check variety. Experimental plots were arranged in a Randomized Complete Block Design (RCBD) with three replications. Data were collected three times throughout the leaf harvesting period, encompassed fifteen morphological traits. The results highlight significant genotypic variations in vine growth, morphology, and yield characteristics. During season 1 (2021-22), genotypes exhibited varying vine lengths, daily growth rates, internode dimensions, and leaf traits, underscoring genetic diversity. BL0027 consistently displayed superior growth and yield attributes, and closely followed by BARI Pan-3 in the season 2 broad assessments. However, genotypic variations persisted, emphasizing the influence of genetics on betel vine attributes. These findings are crucial for betel vine breeding programs and agricultural practices, offering insights into genetic diversity and potential for tailored cultivation. Future research should explore the genetic and environmental factors underlying these traits to optimize betel vine cultivation and management.

Keywords: BARI Pan-3, Betel vine, Genetic diversity, Leaf production,Variability

Introduction

The betel vine, scientifically known as *Piper betle* L. belongs to the Piperaceae family, has held a unique cultural and economic significance across Asia for centuries (Bar *et al.,* 2020). The origin of betel vine is thought to be Central or Eastern Malayasia (Chattapadhyay and Maity, 1967). Bangladesh, a land deeply rooted in tradition and cultural heritage, has long embraced the betel vine as an integral part of its social tapestry. The vibrant green leaves of this plant, which are chewed for their stimulating and aromatic qualities, have been cherished across generations, gracing ceremonial

[*] Corresponding author: alam_83@yahoo.com; a.alam_83@bari.gov.bd

occasions and everyday life alike. It is primarily consumed in South Asia and worldwidely known as betel quid or paan, in combination with areca nut or fermented tobacco leaf (Saraswat *et al.*, 2020; Shah *et al.*, 2021). The leaves exhibit antioxidant, anticarcinogenic, anti-inflammatory, antibacterial, antifungal and nematicidal properties and its essential oils known for biological activities (Kumar *et al.*, 2010; Rai *et al.*, 2011). About 30% of adults chew betel quid in Bangladesh and the world context it is approximately 10-20% (Gupta and Warnakulasuriya, 2002; Flora *et al.*, 2012). Additionally, its numerous health benefits have been documented in traditional medicine systems, further enhancing its importance. It has the property of antacid, carminative, and tranquilizer which helps in digestion, removes the bad smell of the mouth, improves taste and appetite, and strengthens the teeth (Islam *et al.*, 2015). In recent years, the global demand for betel leaves and their associated products has surged, resulting in an increased need for the cultivation of this versatile plant. This heightened demand has prompted a growing interest in the genetic improvement of betel vine genotypes to meet both quantity and quality requirements. The total betel leaves production in Bangladesh in 2021-22 was estimated at 206993.70 (tons) and total cultivated area was about 21838.19 ha (BBS, 2022).

The meticulous evaluation of betel vine genotypes should focus within this unique geographical context, emphasizing the importance of morphological traits as key indicators of the plant's adaptability and productivity. Bangladesh's varied climatic zones, ranging from the lush plains to the hilly terrain, provide a dynamic backdrop for the cultivation of betel vine, giving rise to a rich tapestry of genotypes with distinct morphological characteristics. Morphological traits, including leaf shape, size, color, vine structure, and flowering patterns, serve as crucial markers for discerning and classifying betel vine genotypes. These traits not only reflect the genetic diversity within the betel vine but also hold the key to optimizing cultivation practices for better yields, quality, and resilience to local environmental conditions. In a nation where betel vines play a vital role in cultural rituals, traditional medicine, and culinary traditions, the study of these morphological traits not only has economic implications but also preserves and enhances the cultural heritage of Bangladesh. As Bangladesh stands on the cusp of harnessing the full potential of betel vine cultivation, the evaluation of genotypes based on morphological traits becomes a vital tool for ensuring productivity, quality, and the conservation of traditional practices. This comprehensive exploration within the Bangladeshi context seeks to empower stakeholders with the knowledge needed to make informed decisions and forge a path towards a thriving betel vine industry that not only supports livelihoods but also celebrates the country's rich cultural heritage. Therefore, the present study has been undertaken, for understanding and evaluating the diverse betel vine genotypes through the lens of morphological traits takes on paramount significance in the Bangladeshi context.

Materials and Methods

Site and genotypes

The experiment was conducted at the Spices Research Centre, Shibganj, Bogura, spanning two consecutive growing seasons: 2021-22 and 2022-23. In the inaugural season (2021-22), the experiment was conducted an assessment solely on line BL0027 with check. Subsequently, during the ensuing season 2 (2022-23), a broader evaluation was undertaken, encompassing multiple betel vine lines, namely BL0025, BL0027, BL0028, BL0030, and BL0040. The genotypes were collected from betel vine growing region of Rajshahi, Bangladesh. Throughout both seasons, we utilized BARI Pan-3 was utilized as the reference or check variety to facilitate comparative analysis.

Experimental plan

The experimental plots were established with a standardized unit plot size of 3 square meters, each accommodating four betel vine plants per hill, while maintaining a consistent plant spacing of 10 cm by 10 cm. To optimize the experimental design for efficient management and data collection, nine hills were arranged within a single bed, with a one-meter gap separating adjacent beds. The study adopted a Randomized Complete Block Design (RCBD) with three replications. To ensure optimal growth and development, irrigation and various intercultural operations were executed as required during the experimental period.

Observations recorded and statistical analysis

Data were meticulously recorded three times annually, specifically during the leaf harvest periods. The parameters under evaluation encompassed a range of morphological traits, including vine length (VL), internode length (IL), internode diameter (ID), peduncle length (PL), peduncle diameter (PD), leaf length (LL), leaf width (LW), number of leaves (NL), and weight of leaves (WL) of the betel vine plants. In addition to these primary observations, calculated vine growth (VG) (difference between the base height and vine length after four months of growth), vine growth per day (VGD), weight of single leaf (WSL), number of leaves per meter vine (NLM), number of leaves per hectare per year (NLHY), and weight of leaves per hectare per year (WLHY) were based on the recorded data. NLHY and WLHY represent cumulative observations for leaves harvested three times in a single year, converted to leaves per hectare. All other observations were averaged from the three data collection points within a year. These recorded data form the basis subsequent analysis and findings. To analyze variance based on the extensive dataset obtained from these observations, employed the R platform for statistical analysis (R Core Team, 2022).

Results and Discussion

In this study, the result of an extensive study aimed at characterizing the growth and yield attributes of vine genotypes during the season 1 (2021-22) and season 2 (2022-2023), respectively. Summary of the individual genotype's performances for the growing season 1 and 2 were presented in Table 1 and 2, respectively. From the table 1 it was indicated that the studied genotypes were significantly varied except for ID, LL, LW, NL and NLM. The coefficient of variation was ranged from 3.21 to 13.32 for different studied traits. On the other hand, during season 2, all the genotypes were significantly varied for the studied traits. The range of coefficient of variation for different studied traits was 0.86 to 13.4 (Table 2).

Vine growth

In season 1, the average vine length for BARI Pan-3 was 169.34 cm, in which between the leaf harvests a total vine growth was 104.06 cm at four-month tenure. The daily growth rate for this genotype was approximately 1.11 cm per day. On the contrary, the average vine length for BL0027 was 174.57 cm. The daily growth rate for this genotype was approximately 1.16 cm per day which in turn extended on an average to a total vine growth of 109.16 cm during four months periods.The average internode length measured for BARI Pan-3 was 7.54 cm while average diameter of internodes in this genotype was 0.71 cm. In case of BL0027, average internode length and diameter were 8.31 and 0.70 cm, respectively. In betel vines, having longer vines with shorter gaps between the nodes is considered desirable because it leads to a higher leaf count, thanks to more nodes (Rahman *et al.*, 2020). On the other hand, during season 2, BARI Pan-3 exhibited the highest vine length at 188.72 cm, while BL0040 had the shortest vine length at 169.62 cm. These variations highlight genotypic differences in vine elongation potential. Similar to the vine length BARI Pan-3 displayed the highest mean vine growth, reaching 123.72 cm, while BL0040 had the lowest growth at 103.59 cm. This variation in vine growth underscores the importance of genetic diversity in determining vine development. Quite the similar, BARI Pan-3 exhibited a mean daily growth rate of 1.03 cm, as did BL0025 and BL0027, while BL0028, BL0030, and BL0040 had slightly lower daily growth rates. These findings indicated that certain genotypes exhibit faster daily growth rates than others. Variations in vine length likely stemmed from a combination of factors, including seasonal fluctuations in temperature and atmospheric humidity, as well as inherent genetic diversity among the different cultivars (Pariari and Imam, 2012). BL0030 had the longest average internode length at 9.09 cm, while BARI Pan-3 had the shortest at 7.02 cm. Differences in internode length can influence vine structure and overall growth. BL0025 displayed the smallest internode diameter (0.38 cm), whereas BL0030 had the largest (0.44 cm). This parameter reflects genotypic variations in stem thickness.

Leaf size

In season 1, peduncles of BARI Pan-3 had an average length of 7.56 cm and diameter was approximately 0.38 cm. The leaf length and width were 15.21 and 11.23 cm, respectively. Alternatively, peduncles of BL0027 had an average length of 10.24 cm and the diameter was approximately 0.52 cm. Leaves of the genotypes had an average length of 16.01 cm whereas average width was 11.91 cm. Rahaman *et al.*,1997 was found that variation in leaf length between 6.2 cm to 15.3 cm among 27 genotypes of betel vine. For the season 2, BL0027 exhibited the longest peduncles with an average length of 9.88 cm, while BL0040 had the shortest peduncles at 8.50 cm. On the other hand, BL0025 had the smallest peduncle diameter (0.34 cm), while BL0030 had the largest (0.77 cm). Peduncle length and diameter are crucial for nutrient transport and leaf development and varies among these genotypes. BL0027 exhibited the longest leaves (14.88 cm) and widest leaves (11.18 cm) on average. Leaf dimensions contribute to the photosynthetic capacity and overall productivity of the vines. Pariari and Imam (2012) reported the result which indicated that leaf width ranged from 8.65 - 10.45 cm which was supported to present study.

Leaves number and weight

In case of season 1, on average, there were 12.56 leaves per plant while total weight of leaves of BARI Pan-3 was 39.67 g during a single harvest. An individual leaf from this genotype had an average weight of 3.16 g. Considering average potentials, BARI Pan-3 exhibited an average of 12.11 leaves per meter of vine. The total number of leaves produced by BL0027 was 12.94 leaves per plant which was equivalent to 43.01 g. The individual leaf weight was 3.32 g. This genotype exhibited the potential of producing an average of 11.87 leaves per meter of vine. Rahman *et al.*(2020) reported that Gayasur pan produced significantly highest number of leaves (16.35 no.) per meter vine. In season 2, BL0027 had the highest mean number of leaves (17.50), while BL0028 had the lowest (11.83) during a single harvest. It also exhibited the highest average number of leaves per meter of vine (14.21), while BL0040 had the lowest (10.46). Contrary to this, BARI Pan-3 produced the heaviest leaves (49.90 g on average), whereas BL0040 had the lightest leaves (23.26 g). Similarly, BARI Pan-3 had the highest mean weight per single leaf (2.89 g), while BL0030 had the lowest (2.14 g). Leaf number plays a vital role in canopy development and light interception, while, leaf weight directly influences the biomass and potential yield of the vines. This parameter provides insights into vine canopy density and nutrient allocation. Das *et al.*(1995) recorded that maximum fresh weight (380.75 g) and dry weight (44.60 g) in Ghanagette cultivar and produced highest number of leaves (88) per vine.

Fresh yield

Results of season 1 revealed that, the estimated leaf yield for BARI Pan-3 was 43.59 lakhs leaves/ha in terms of number which was approximately 13.77 t/ha in a year. The estimated number of leaves for BL0027 was 46.60 lakhs/ha in a year which was approximately 15.45 t/ha. Season 2 result exhibited that, BL0027 had the highest estimated number of leaves per hectare per year (51.16 lakhs) closely followed by BARI Pan-3 (50.19 lakhs), while BL0040 had the lowest (37.65 lakhs). Quite the similar BL0027 produced the highest estimated weight of leaves per hectare per year (15.67 t/ha) followed by BARI Pan-3 (14.52 t/ha), while BL0040 had the lowest (8.08 t/ha). Guha (2006) reported that annual yield of a good crop of betel vine was 60-70 leaves/ plant and 6 -7 millions/ha. The number and weight of leaves per hectare is a critical factor in determining overall productivity. This parameter directly impacts the potential yield and economic value of the betel vine. Sheet (2002) reported that the highest number of leaves (62.66 lakh ha^{-1}) in cv. Chandrakona. Rahman *et.al.* (2020) reported that the cultivar PB 006 (Misti pan) and PB 009 (BARI Pan-1) produced significantly higher yield as 23.77 t/ha and 23.82 t/ha, respectively.

These comprehensive results highlighted significant genotypic variations in vine growth, morphology, and yield characteristics among the studied betel vine genotypes, offering a comprehensive understanding of its variability and potential for agricultural applications. This information is valuable for betel vine breeding programs, management practices, and the selection of suitable genotypes for specific agricultural contexts. Further research into the genetic and environmental factors influencing these traits is recommended for a more in-depth understanding of vine variability and potential improvements in viticulture.

Table 1. Performances of betel vine genotypes evaluated during 2021-22

Genotype	VL	VG	VGD	IL	ID	PL	PD	LL	LW	NL	WL	WSL	NLM	NLHY	WLHY
BARI Pan-3	169.34	104.06	1.11	7.54	0.71	7.56	0.38	15.21	11.23	12.56	39.67	3.16	12.11	43.59	13.77
BL0027	174.57	109.16	1.16	8.31	0.70	10.24	0.52	16.01	11.91	12.94	43.01	3.32	11.87	46.60	15.45
SE	5.51	5.57	0.06	0.58	0.04	0.51	0.05	1.71	1.54	1.06	4.57	0.11	1.18	4.25	1.68
T-test	*	*	*	**	NS	**	**	NS	NS	NS	*	**	NS	**	**

VL=Vine length; VG=Vine growth; VGD= Vine growth per day; IL=Internode length; ID=Internode diameter; PL=Peduncle length; PD=Peduncle diameter; LL=Leaf length; LW=Leaf width; NL=Number of leaves; WL=Weight of leaves; WSL=Weight of single leaf; NLM=Number of leaves per meter vine; NLHY=Number of leaves per hectare per year; WLHY= Weight of leaves per hectare per year; SE=Standard error;

Table 2. Performances of betel vine genotypes evaluated during 2022-23

Genotype	VL	VG	VGD	IL	ID	PL	PD	LL	LW	NL	WL	WSL	NLM	NLHY	WLHY
BARI Pan-3	188.72	123.72	1.03	7.02	0.61	8.28	0.39	10.72	8.90	17.25	49.90	2.89	13.94	50.19	14.52
BL0025	187.03	121.03	1.01	7.87	0.38	7.88	0.34	9.79	7.89	15.08	45.25	3.00	12.46	44.86	13.46
BL0027	189.13	123.13	1.03	7.00	0.54	9.88	0.41	14.88	11.18	17.50	53.62	3.06	14.21	51.16	15.67
BL0028	166.81	100.81	0.84	8.21	0.37	7.04	0.31	9.54	6.18	11.83	25.37	2.14	11.74	42.25	9.06
BL0030	166.58	100.58	0.84	9.09	0.44	8.78	0.77	10.50	6.74	10.75	25.80	2.40	10.68	38.45	9.23
BL0040	169.62	103.59	0.86	9.05	0.42	8.50	0.38	9.47	7.77	10.83	23.26	2.15	10.46	37.65	8.08
Mean	177.98	112.14	0.93	8.04	0.46	8.39	0.43	10.82	8.11	13.88	37.20	2.61	12.25	44.09	11.67
SE	2.53	2.53	0.02	0.37	0.05	0.82	0.04	0.94	1.06	0.71	1.83	0.02	0.57	2.04	0.50
CV	1.42	2.26	2.14	4.57	10.44	9.71	8.33	8.71	13.04	5.12	4.92	0.86	4.64	4.64	4.30
LSD	2.06	2.06	0.02	0.30	0.04	0.67	0.03	0.77	0.86	0.58	1.50	0.02	0.46	1.66	0.41
F-TEST	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

VL=Vine length; VG=Vine growth; VGD= Vine growth per day; IL=Internode length; ID=Internode diameter; PL=Peduncle length; PD=Peduncle diameter; LL=Leaf length; LW=Leaf width; NL=Number of leaves; WL=Weight of leaves; WSL=Weight of single leaf; NLM=Number of leaves per meter vine; NLHY=Number of leaves per hectare per year; WPHY= Weight of leaves per hectare per year; SE=Standard error; CV=Coefficient of variation; LSD=Least significant difference;

Conclusion

In this research, was conducted an extensive study to assess the growth and yield attributes of various betel vine genotypes. The results of this study revealed significant genotypic variations in vine growth, morphology, and yield characteristics among the studied betel vine genotypes. Notably, different genotypes exhibited varying levels of performance across these traits, highlighting the importance of genetic diversity in determining betel vine development and productivity. In season 1 (2021-22), BARI Pan-3 and BL0027 exhibited distinct growth patterns, with varying vine and leaf characteristics. During season 2 (2022-23), the expanded assessment involving additional genotypes further emphasized the influence of genetics on betel vine attributes. The genotype BL0027 consistently demonstrated superior vine growth, leaf characteristics, and yield potential when compared to the other genotypes. But genotypic differences continued, with BARI Pan-3, in particular, showing unique characteristics including yield and daily growth rates and vine length. These differences underscored the genetic variability within the betel vine species. This research contributes valuable insights into the growth and yield attributes of betel vine genotypes, shedding light on their genetic diversity and potential for agricultural applications. The findings of this study have significant implications for betel vine breeding programs and agricultural practices. Future studies should delve deeper into the genetic and environmental determinants of these traits to further refine betel vine cultivation and management practices.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Bar, A., Pariari, A., Biswas, P., Karmakar, M., and Saha, G. 2020. Comparative studies on leaf yield, quality and economy of three cultivars of betel vine (*Piper betle* L.) as Influenced by Integrated nitrogen management. *Int. J. Curr. Microbiol. App. Sci*. 9(11):3137-3147.

BBS. 2022. Year Book of Agricultural Statistics of Bangladesh-

2022, 34th Series. Bangladesh bureau of statistics, statistics and informatics division, ministry of planning, government of the peoples' republic of Bangladesh, 207-208.

Chattapdayay, S. P., and Maity, S. 1967. Diseases of betel vine and species. *ICAR New Delhi*.

Das, J. N., Das, S. C., Mohanty, C. R., & Nayak, B. B. 1995. Relative performance of some Bangla varieties of betel vine at Bhubaneswar. *Orissa J. Hort*. 23:104-107.

Flora, M. S., Mascie-Taylor, C. G., and Rahmanc, M. 2012. Betel quid chewing and its risk factors in Bangladeshi adults. *WHO South-East Asia J. Public Health*. 1(2):169-181.

Guha, P. 2006. Betel leaf: the neglected green gold of India. *J. Human Ecology*. 19(2):87-93.

Gupta, P. C., and Warnakulasuriya, S. 2002. Global epidemiology of areca nut usage. *Addiction Biology*. 7(1):77-83.

Islam, Q. M. S., Matin, M. A., Rashid, M. A., and Hoq, M. S. 2015. Profitability of betel leaf (*Piper betle* L.) cultivation in some selected sites of Bangladesh. *Bangladesh J. Agri. Res.* 40(3):409-420.

Kumar, N., Misra, P., Dube, A., Bhattacharya, S., Dikshit, M., and Ranade, S. 2010. *Piper betle* Linn. a maligned Pan-Asiatic plant with an array of pharmacological activities and prospects for drug discovery. *Current Sci*. 922-932.

Pariari, A., and Imam, M. N. 2012. Evaluation of betel vine (*Piper betle* L.) cultivars in the gangetic alluvial plains of West Bengal, India. *J. Spices and Aromatic Crops*. 21(1).

R Core Team. 2022. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna. https://www.R-project.org

Rahaman M, Hossain M., and Das N D. 1997. Genetic divergence in betel vine (*Piper betle* L.). *J. Plantn. Crops*. 25:57-61.

Rahman, M. H., Islam, M. R., Aminuzzaman, F. M., Latif, A., and Rahman, H. 2020. Physio-morphological study of betel vine (*Piper betle* L.) cultivars available in Bangladesh. *The Agriculturists*. 18(1):56-65.

Rai, M. P., Thilakchand, K. R., Palatty, P. L., Rao, P., Rao, S., Bhat, H. P., and Baliga, M. S. 2011. *Piper betel* Linn (betel vine), the maligned Southeast Asian medicinal plant possesses cancer preventive effects: Time to reconsider the wronged opinion. *Asian Pac. J. Cancer Prev*. 12(9):2149-2156.

Saraswat, N., Pillay, R., Everett, B., and George, A. 2020. Knowledge, attitudes and practices of South Asian immigrants in developed countries regarding oral cancer: an integrative review. *BMC Cancer*. 20:1-16.

Shah, S., Boucree, T. S., and Chang, E. I. 2021. Betel quid chewing in the Mid-Atlantic United States: any consequence. *Res. Rep. Oral Maxillofac. Surg*. 5:049.

Sheet, S. K. 2002. Evaluation of betel vine (*Piper betle* L.) germplasm for quality. *MSc (Ag) thesis, Bidhan Chandra Krishi Viswa Vidyalaya, West Bengal*.