Bangladesh J. Agri. 2025, 50(1): 36-46 *DOI: https://doi.org/10.3329/bjagri.v50i1.82914*

MORPHOLOGY, DISEASE AND PEST INFESTATION VARIATIONS IN DIFFERENT BETEL VINE GENOTYPES

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Abstract

Betel vine is one of the important cash crops that gaining popularity in recent time in Bangladesh. In the varietal improvement program, collection and evaluation of the germplasm from different parts of the country is crucial. Thus, the present experiment was conducted to collect, characterize and evaluate betel vine genotypes at Spices Research Centre, Shibganj, Bogura during 2021-2022 and 2022-2023. A total of 30 genotypes of betel leaf were collected from different places for characterization and evaluation. The experimental plots were arranged in a Randomized Complete Block Design (RCBD) with three replications. Data were collected three times annually during leaf harvests, encompassed a range of morphological traits. Four genotypes (BL0027, BL0018, BL0024 and BL0030) were found promising in terms of leaf quality and less susceptible to disease and pest infestation. This study is important for betel vine breeding, offering insights into its variation and potential for tailored cultivation. Future research should explore the morphological and environmental factors that affect these traits to improve betel vine cultivation and management.

Keywords: Betel vine, Disease, Germplasm collections, Insect.

Introduction

Betel vine (*Piper betle* L) is an important cash crop in Bangladesh belonging to the family *Piperaceae*. Betel vine is basically consumed in South Asia and world widely known as betel quid or paan, in combination with areca nut or tobacco (Shah *et al.*, 2021). The betel vine is believed to have originated in Central or Eastern Malaysia (Chattapdayay and Maity, 1967). Betel vine is a perennial, dioecious, evergreen vine cultivated in tropical and subtropical regions for its leaves utilized as a chewing stimulant. It is a spreading vine, rooting readily where trailing stems touch the ground. The betel vine plant is a perennial creeper that remains green throughout the year. It is characterized by its glossy heart-shaped leaves and white catkin. The leaves are alternate, entire, 5 to 10 cm long and 3 to 6 cm across. The flowers are small, produced on

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pendulous spikes 4 to 8 cm long at the leaf nodes, the spikes lengthening up to 7 to 15 cm as the fruit matures. Betel vine have antioxidant (Rathee *et al.*, 2006), anticarcinogenic (Bhide *et al.,* 1991), hypolipidemic (Gramza and Korczak, 2005), and antibacterial properties (Gramza and Korczak, 2005; Nalina and Rahim, 2007; Bissa *et al.*, 2007; Ramji *et al.*, 2002). Betel vine and stem possess a strong, fragrant aroma. Chewing betel vine is believed to be a dietary source of calcium. Betel oil is utilized for various medicinal purposes. The stem climbs using numerous short adventitious roots (Hassan and Shahadat, 2005).

Betel vine grows well under shade with low light intensity, mild temperature (15 to 30ºC), high humidity with 2250 to 4750 mm annual rainfall (Rahman *et. al.*, 2015). In an area with lower rainfall, however, betel vine can be grown with frequent irrigation throughout the year. Traditionally, betel vine is cultivated under shade in a structure called a boroj, which is a small hut standing at approximately two meters in height. Betel vine is cultivated almost in all areas of Bangladesh, however, the districts like, Cox's Bazar, Kushtia, Chittagong, Greater Khulna, Greater Barisal, Greater Faridpur, Greater Rajshahi are notable for its production. There are about 100 varieties of betel leaf (paan) across the world of which 40 are encountered in India and 30 in West Bengal and Bangladesh (Guha, 2006). The total betel vine production in Bangladesh in 2022-2023 was estimated at 206994 M. tons, and total cultivated area was about 21850 hectares (BBS, 2023). But the acreage of betel vine is decreasing fast because of some physical and socioeconomic barriers like unavailability of credit facilities, uncontrolled marketing system and infestation of diseases and pests (Islam, 2005). The leaf is usually plucked throughout the year, but maximum production obtained during the months of July to October. In order to enhance the production of betel vine in the nation, it is crucial to identify superior genotypes or germplasm that can be utilized for the development of a high-yielding variety of the crop. Based on the aforementioned information, the current study was conducted to identify appropriate cultivars/germplasm that can contribute to improve the yield and quality of betel vine in Bangladesh (Rahman *et al.,* 2020).

There are lot of problems faced in betel vine cultivation. It is not a major crop in Bangladesh, so there is a scarcity of appropriate technology, lack of proper education and access to information for its cultivation. Significant yield losses have been attributed to insect pests (Hossain *et al.,* 2020). Recently, Rahman (2019) recorded 12 insect species that cause damage to betel vines. Of the various insect pests, *Aleurocanthus rugosa Singh* (Hemiptera: *Aleyrodidae*) is one of the significant foliage pests of betel vine recorded in Bangladesh and India locally known as 'blackfly' (Raut and Nandi, 1984; Raut and Bhattacharya, 1999; Jana, 2006; Rahman, 2019; Hossain *et al.,* 2020). The white and black fly, red mite, and mealy bug have been identified as the major constraints in increasing the leaf yield of betel vine (Jana, 2006).

Disease damage to the crop is one of several known limiting factors. The betel vine is highly susceptible to diseases, pests and some natural climates (Sayeeduzzaman, 1988). Disease is one of the most important constraints for betel leaf cultivation. Among the diseases of betel vine, leaf rot caused by *Phytophthora parasitica var. piperina* and foot and root rot of betel vine caused by *Sclerotium rolfsii Sacc*., are the most devastating diseases which decrease the production of betel vine to a great extent. In 2004, Sixty percent betel vine damaged due to foot rot disease in 3 upazilla of Rajshahi (Islam, 2005). The crop is also infested by several insect-pests and diseases which is a major reason for reduced profit margin (Jana, 2017). Humid and moist shaded conditions are favorable for its growth and development. However, these humid and moist shaded conditions are also prone to root and foliage disease development of betel vine (Goswami *et al.*, 2002).

The precise evaluation of betel vine genotypes should be focused within its unique geographical context, signifying 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. To meet the increased demand for food over the years mostly research, technologies have focused mainly on annual crops rather than the perennial crops. But being the perennial crop, betel vine has a high demand and market value, especially for Asian people. So, forecasting betel vine production and prices will be truly beneficial for farmers, governments and agribusiness industries to understand its future potentialities and growth. The assessment of various betel vine genotypes in Bangladesh based on morphological characteristics is crucial for enhancing productivity, maintaining quality, and preserving traditional methods. This in-depth analysis aims to equip stakeholders with the necessary information to make well-informed choices and pave the way for a prosperous betel vine sector that not only sustains livelihoods but also honors the nation's cultural legacy. Considering this perspective, the present study was conducted to evaluate betel vine genotypes for identification of the potential genotype(s) in terms of leaf quality as well as less prone to disease and pest infestation.

Materials and Methods

Site and genotypes

The experiment was conducted at the Spices Research Centre, Shibganj, Bogura, spanning two consecutive growing seasons: 2021-2022 and 2022-2023. Thirty betel leaf genotypes collected from various regions across Bangladesh such as - BL0024, BL0025, BL0026, BL0027, BL0028, BL0029, BL0030, BL0031, BL0032, BL0034, BL0035 etc. were conserved and used for characterization and evaluation in this study (Supplementary Table S1). Throughout both seasons, we utilized BARI Pan-1, BARI Pan-2 and BARI Pan-3 were used as the reference or check variety to facilitate comparative analysis.

Experimental design

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 centimeters by 10 centimeters. 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 Internode length (IL), Internode diameter (ID), Peduncle length (PL), Peduncle diameter (PD), Leaf length (LL), Leaf width (LW) of the betel vine plants. In addition to these primary observations, also calculated some diseases and insect infestation data such as black fly (BF), Red spider mite (RSM), Foot rot (FR), Leaf rot (LR) and Leaf spot (LS). All other observations were averaged from the three data collection points within a year. These recorded data form the basis of subsequent analysis and findings. To analyze variance based on the extensive dataset obtained from these observations, employed the Rstudio platform which is widely recognized for its versatility and robust statistical analysis capabilities in statistical analysis (R Core Team, 2022).

Results and Discussion

The table 1 showes the summary performances of betel vine for different traits during 2021-2022 and 2022-2023 where leaf length ranges from 4 cm to 13.60 cm with an average length of 10.45 cm. Variance due to genotypes were significant for all the traits while variance due to G×Y were insignificant for all the traits except ID and PD. In case of leaf width, the range was between 6 cm to 11.80 cm with an average width of 8.71 cm. the lower mean values were found in case of insect and disease infestation for the studied genotypes of betel vine. The performance of individual betel vine genotypes is presented in table 2.

Table 1. Performances of betel leaf genotypes for different traits during 2021-2022 and 2022-2023

Traits	Min	Max	Mean	SD	SE	GV	CV	LSD	F (G)	F (G×Y)
IL	3.10	8.56	6.54	1.34	0.25	1.69	1.52	0.14	**	ns
ID	0.22	3.17	0.46	0.52	0.09	0.25	4.97	0.05	**	*
PL	3.20	10.60	6.64	1.90	0.35	3.40	1.16	0.14	**	ns
PD	0.20	2.35	0.43	0.50	0.09	0.27	3.49	0.04	**	*
LL	4.00	13.60	10.45	2.33	0.43	5.87	1.69	0.26	**	ns
LW	6.00	11.80	8.71	1.63	0.30	2.49	2.28	0.28	**	ns
BF	0.00	3.00	1.10	0.92	0.17	1.19	9.95	0.35	**	ns
RSM	0.00	3.00	2.00	1.05	0.19	1.09	9.08	0.46	**	ns
VR	0.00	2.00	1.03	0.85	0.16	0.84	7.15	0.25	**	ns
LR	0.00	3.00	1.63	1.03	0.19	1.27	7.49	0.33	**	ns
LS	0.00	10.00	3.80	1.92	0.35	3.87	3.45	0.26	**	ns

IL=Internode length; ID=Internode diameter; PL=Peduncle length; PD=Peduncle diameter; LL=Leaf length;LW=Leaf width; BF= Black fly; RSM=Red spider mite; FR=Foot rot; LR=Leaf rot; LS=Leaf spot; Min=Minimum; Max=Maximum; SD=Standard deviation; SE=Standard error; GV=Genotype variance; CV=Coefficient of variation; LSD=Least significant variation; F (G)=F-test for genotype; F (G×Y)=F-test for genotype × year.

Table 2. Performances of different betel leaf genotypes evaluated during 2021-22 and 2022-23

Name	IL	ID	PL	PD	LL	LW	BF	RSM	FR	LR	LS
BL0027	7	0.58	10.6	0.42	13.6	11.8	1	3	1	3	6
BARI pan3	7	0.55	9.5	0.35	13	11.12	0	2	2	2	3
BL001	6.16	0.44	6	0.22	11.1	8.5	2	2	2	2	3
BL003	5.76	0.4	5.96	0.2	11.2	9.5	1	2	2	1	2
BL0020	8.26	0.37	7.6	0.32	12.3	10.7	0	2	2	2	2
BL0021	7.36	0.37	6.24	0.232	12.3	10.5	0	3	1	1	2
BL0012	7.6	0.36	6.5	0.32	12.6	10.5	0	3	0	2	4
BL0022	6.4	0.34	5.6	0.22	11.54	8.9	2	3	0	0	10
BL0019	5.34	0.36	4.8	0.21	12.16	8.7	0	3	0	0	6
BL0018	6.7	0.3	5.92	0.28	13.37	8.54	0	0	0	1	1
BL0014	7.78	0.4	6.86	0.29	13.2	9.98	2	0	2	1	0
BL0016	5.8	0.36	6.8	0.26	12.12	10.8	0	1	2	2	2
BL0023	5.24	0.32	5.56	0.24	8	6.1	1	0	2	2	3
BL003	6.32	0.28	6.26	0.28	12.28	10.7	1	0	2	2	3
BL002	5.62	0.25	5.48	0.25	8.84	8.24	2	0	2	0	3
BL0011	4.76	0.26	3.2	0.24	7.9	6.15	1	3	2	3	3
BL0010	4.58	0.34	3.77	0.22	4	7.95	2	2	0	2	4
BL009	3.1	0.42	3.5	0.34	7.8	6.7	3	3	0	2	3
BL008	4.28	0.17	4.37	2.35	8.2	7.3	2	2	0	2	3
BL006	5.27	0.22	4.3	2.17	8.9	7.4	2	3	1	2	3
BL0024	8.2	0.38	8.4	0.34	11.8	9.8	2	2	1	3	4
BL005	8.56	0.34	6.2	0.3	9.04	7.8	1	3	2	2	3
BL004	7.48	0.32	6.4	0.32	9	8.06	0	2	1	3	5
BARI pan1	6.64	0.46	8.84	0.36	9.8	8.2	0	2	1	3	5
BARI pan2	6.8	0.44	8.76	0.38	9.4	7.6	0	2	0	3	5
BL0025	8.06	0.42	9.64	0.3	13.4	9.8	2	2	1	2	4
BL0028	6.76	0.34	8.14	0.33	8.46	6.2	1	2	1	1	5
BL0029	7.5	0.34	7.5	0.33	7.2	6	1	2	0	0	5
BL0030	7.96	0.36	8.7	0.34	10.9	9	2	3	0	0	6
BL0031	7.8	0.34	7.9	0.34	10	8.8	2	3	1	0	6

IL=Internode length; ID=Internode diameter; PL=Peduncle length; PD=Peduncle diameter; LL=Leaf length; LW=Leaf width; BF= Black fly; RSM=Red spider mite; FR=Foot rot; LR=Leaf rot; LS=Leaf spot.

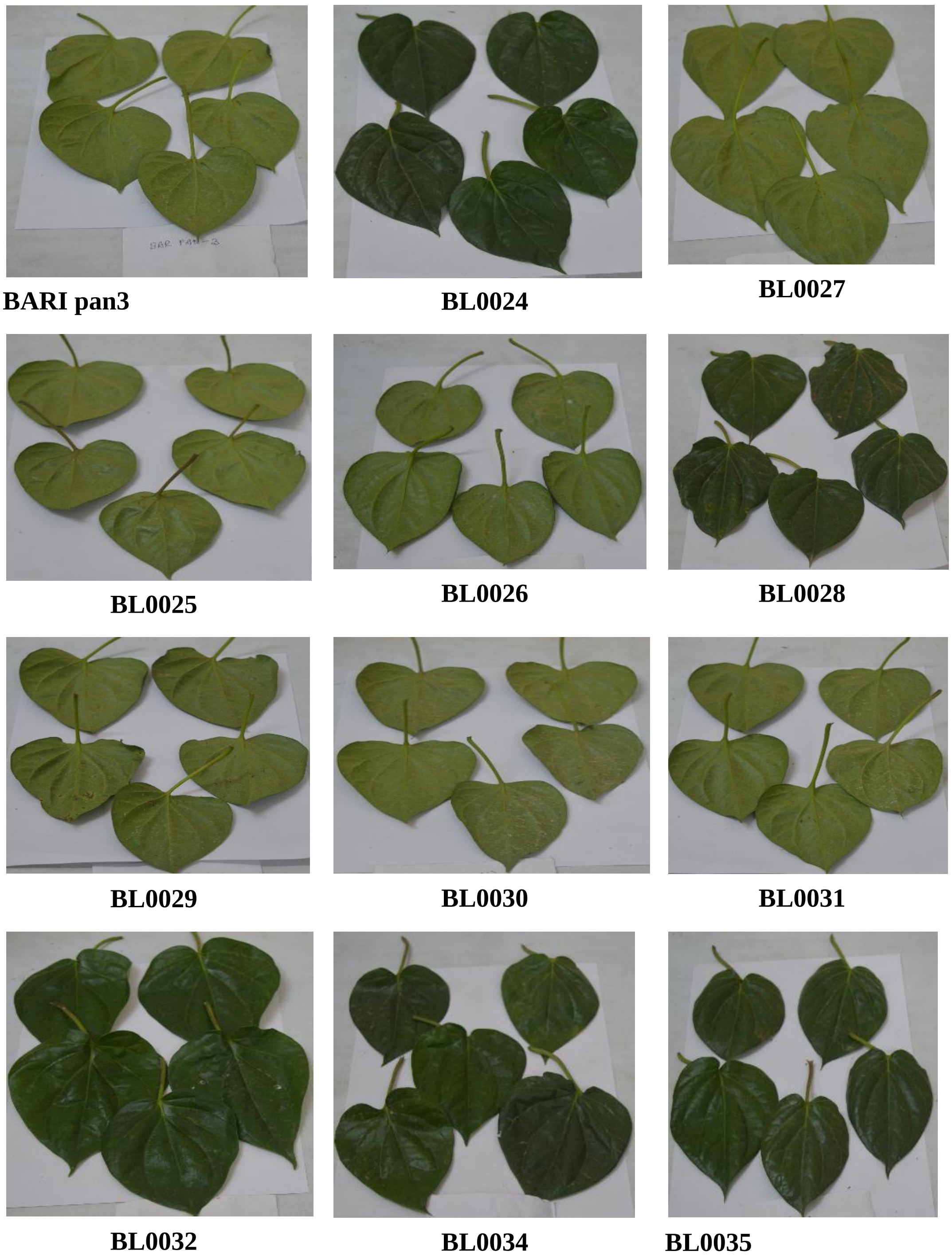

Fig. 1. Morphological variations of leaves in different betel vine genotypes.

The Individual performances of the betel vine genotypes were presented in table 2. The findings of table 2 are described below-

Vine growth

Among the evaluated betel vine genotypes, significant variation was observed in vine growth characteristics, particularly internode length and diameter (Table 2). The genotype BL005 exhibited the longest average internode length (8.56 cm), followed by BL0026 (8.26 cm) and BL0025 (8.06 cm). In contrast, BL009 demonstrated the shortest internode length at 3.10 cm, closely followed by BL008 (4.28 cm). These differences in internode length can influence the vine's structural development and overall growth potential. According to Rahman *et al.* (2020), a longer vine with shorter internodes is considered desirable as it can increase the number of leaves produced due to a higher number of nodes. Notably, BL0027 showed the thickest internode diameter (0.58 cm) combined with an internode length of 7 cm, indicating its potential for higher yield, as thicker vines are often associated with improved nutrient transport and productivity.

Peduncle growth

Peduncle growth, as indicated by peduncle diameter (PD) and length (PL), reflects structural robustness and support capacity. The length and diameter of the peduncle are vital for transporting nutrients and developing leaves (Alam *et al.,* 2023). Higher PD values (e.g., BL0027 at 0.42) indicate stronger, thicker peduncles suited for heavier inflorescences, while lower values (e.g., BL008 at 0.17) suggest a more delicate structure. Longer peduncles (e.g., BL0027 at 10.6) elevate inflorescences, potentially enhancing pollination and display, while shorter peduncles (e.g., BL0011 at 3.2) keep fruit closer to the plant. Varieties with high PD and PL (e.g., BL0027) exhibit robust, elevated growth, ideal for supporting larger clusters, whereas lower values suggest suitability for smaller inflorescences.

Leaf size

Leaf size is a crucial determinant of photosynthetic efficiency and overall yield in betel vine. BL0027 produced the largest leaves, with an average length of 13.60 cm, followed by BL0018 (13.37 cm), while the smallest leaves were produced by BL0010 (4 cm) and BL0023 (8 cm). In addition to leaf length, BL0027 also exhibited the widest leaves, measuring 11.80 cm, highlighting its superior photosynthetic capacity (Fig. 1). Previous studies by Pariari and Imam (2012) have indicated leaf widths ranging from 8.65 to 10.45 cm, which aligns with the present findings. Similarly, Rahaman *et al.* (1997) reported significant variation in leaf length among 27 betel leaf genotypes, ranging from 6.2 cm to 15.3 cm. Several other genotypes, including BL0018, BL0016, BL003, BL0024, BL0025, BL0014, and BARI Pan-3, were also found to produce relatively larger and wider leaves, contributing to higher photosynthetic potential and increased yield.

Pest infestation

The infestation of black fly, a common pest in betel vine cultivation, was recorded in varying degrees across the studied genotypes. BL009 had the highest mean black fly population, with an average of three insects per vine, while other genotypes exhibited infestation levels ranging from 0 to 2 insects per vine, indicating minor damage overall (Table 2). Black fly infestation affects leaf quality by causing curling, discoloration, and reduced size of leaves, along with stunted plant growth. The damage also results in the development of sooty mold, which further diminishes the market value of the leaves. Hossain *et al.* (2020) reported higher black fly populations, ranging from 3.2 to 22.7 per vine, with peak infestations occurring in October and May. Red spider mite infestation was relatively low among the studied genotypes, with infestation levels ranging from 0 to 3 mites per vine. This pest colonizes the ventral surface of leaves under a protective web, sucking the sap and causing yellow blotches that eventually lead to desiccation. Severe infestations reduce leaf quality and market value. Hossain *et al.* (2020) reported higher red spider mite populations, reaching up to 16.1 per vine during peak seasons. The minimal infestation observed in this study suggests that the genotypes evaluated have some level of resistance to red spider mites.

Disease incidence

Foot rot, caused by *Phytophthora parasitica* and *Pythium vexans*, was observed at low levels, with incidences ranging from 0 to 2 plants per vine (Table 2). This disease, commonly referred to as wilt, leads to wilting, leaf drop, and eventual desiccation of the vine. The subterranean parts of the plant decay, reducing the overall productivity of the crop. The disease becomes most severe during or after the rainy season (Jana, 2017). Previous research by Haider *et al.* (2013) and Rahman *et al.* (2021) has highlighted the devastating impact of foot rot on betel leaf production, with *Sclerotium rolfsii* being identified as a major pathogen responsible for yield losses. Leaf rot, primarily caused by *Phytophthora parasitica var. piperina*, was another disease observed among the genotypes. The disease, prevalent during the rainy season, manifests as water-soaked lesions that quickly expand, leading to leaf decay. In the present study, the incidence of leaf rot ranged from 0 to 3 leaves per vine, indicating minor severity (Table-2). Jana (2017) described leaf rot as a serious threat to betel vine, particularly during the rainy season, when the pathogen is most active. Leaf spot disease, caused by *Fusarium semitectum*, along with other pathogens like *Colletotrichum capsici*, was moderately severe in the studied genotypes, with incidences ranging from 0 to 10 leaves per vine (Table-2). The highest disease incidence was recorded in BL0022, with an average of 10 leaves affected per vine. This disease, characterized by circular black lesions with a yellow halo, significantly reduces leaf quality and marketability. Severe infections can cause premature leaf drop, leading to yield losses. The findings of this study are consistent with earlier reports by Singh and Shanker (1971), Maiti and Sen (1979), Patra and Pradhan (2018), and Jana (2017), who described similar symptoms and impacts of leaf spot disease in betel vine.Therefore, the study highlighted the variability in growth, leaf size, pest infestation, and disease incidence among the betel vine genotypes evaluated. The genotypes BL0027 and BL005 exhibited superior growth and leaf size, while pest infestations and disease incidences were generally low across the genotypes, indicating their potential resilience and suitability for cultivation.

Conclusion

The results of this study revealed that significant variations in vine growth, leaf size as well as other characteristics among the studied betel vine genotypes. Considering various morphological traits, the genotypes BL0027, BL0018, BL0024, and BL0030 were found as promising among these studied genotypes. Moreover, minor infestation of black fly and red spider mite was observed in all of the studied genotypes. In case of disease incidence, foot rot and leaf rot took place at a lower rate, whereas leaf spot occurred at moderately severe rate referring devastating loss of betel leaf production. The genotype BL0027 consistently demonstrated superior vine growth, leaf characteristics, and ento-pathological attributes when compared to the other genotypes. Further research and breeding efforts could focus on enhancing these desirable traits to improve betel leaf productivity and quality.

Acknowledgment

The authors are grateful to the authority of Bangladesh Agricultural Research Institute for providing the research facilities and also recognizing the funding from the project ‘Strengthening the Spices Crop Research in Bangladesh.

Author’s contributions

Abu Jafor Mohammad Obaidullah: conceptualization, methodology, validation; M. A. Alam, M. R. Islam,: reviewing and editing; M. A. Alam: data analysis; A. J. M. Obaidullah, S. Naher: original draft preparation; A. J. M. Obaidullah, M. A. Rahman: reviewing and final editing; M. A. Alam, M. R. Islam, S. Naher: investigation, supervision; A. J. M. Obaidullah, M. A. Alam: software, S. Naher, R. Islam: methodology; M. A. Alam, M. A. Rahman: formal analysis. All authors reviewed the findings and accepted the final version of the manuscript.

Conflicts of Interest

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

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