Mean performance of eight elite mulberry genotypes for different growth and leaf yield parameters in different seasons and their stability.

Abstract

An investigation was undertaken to study the mean performance of elite mulberry genotypes across different seasons at Department of Sericulture, UAS, GKVK, Bengaluru during 2023-24. Stability parameters was estimated and considered for testing the stability of the mulberry genotypes. A stable and promising genotype was identified based on a higher mean, unitary regression (b*i*) values and minimal or near-zero deviation from regression (S^2di). However, the majority of genotypes are less environmental sensitive and adapted to all seasons, thus it is possible to predict performance across all seasons. For vegetative growth parameters across winter, summer and rainy seasons, MI-0014 recorded superiority in almost all the traits studied, including leaf yield per plant, number of branches per plant and shorter internodal distance across three seasons. Genotypes MI-0014 and ME-0067 are considered stable across three seasons based on the G × E interaction and their consistent performance in leaf yield and vegetative trait.

Keywords: *Mulberry genotypes; G × E interaction; Stability; Growth parameters; Mean performance*

1.Introduction

Mulberry (*Morus* spp.) is a rapidly growing, woody, deciduous and perennial plant primarily cultivated as the only food for the silkworm (*Bombyx mori* L.) and is grown under varied climatic conditions, ranging from temperate to tropical. India is the world's second-largest silk producer and the largest consumer, heavily relies on this plant. Beyond its significance in sericulture, mulberry trees offer a wide range of benefits, including fruit production, nutritious fodder, medicinal value, landscaping, shade, sustainable agroforestry, timber and natural dye sources. These diverse contributions make mulberry trees indispensable in agriculture, animal husbandry, nutrition, traditional medicine and environmental conservation. In Hindu mythology, the mulberry is referred as "Kalpavruksha," a tree of divine origin, symbolizing its versatile utility in various aspects of life.

The productivity and profitability in sericulture solely depends on the quality and yield of mulberry leaves. In recent years, much emphasis has been given to produce superior quality of raw silk to compete in the international market. To achieve this goal, efforts are being made to increase the production of good quality mulberry leaves which directly influence on the quality and quantity of raw silk produced. Developing a variety, that performs equally well under different environmental conditions is a great challenge to plant breeders.

In order to develop a season insensitive variety with uniform pattern of growth and leaf yield throughout the year, attempts have been made to identify mulberry genotypes with less response to seasonal variations, from the germplasm and used them in rearing (Pillai and Jolly, 1985). The present scenario of sericulture industry demands new varieties suitable for various agro climatic conditions. Suitable parent material needs to be identified from large number of germplasm accessions for the purpose (Terefe *et al.,* 2018). Once the genotypes with probable contribution of maximum desirable traits are found or developed, testing the same in comparisons with the existing varieties form the second important step in improvement programmes which is termed as stability.

The productivity of a genotype is the function of its adaptability to a particular environment. Stability of a genotype depends on the ability to retain certain morphological and physiological characters along with its production efficiency steadily allowing others to vary resulting in predictable G × E interactions for yield. The yield stability in mulberry over a wide range of environments is one of the most desirable parameters to be considered for selecting a mulberry for large scale cultivation. Leaf yield of mulberry fluctuates with the season due to sensitivity of the genotypes to growing conditions. Exploitation of G x E interaction may prove useful in identifying stable genotypes for different environmental conditions.

The response of yield attributing characters to the various environmental conditions is particularly important for determination of their stability. Developing a variety, that performs equally well under different environmental conditions is a great challenge to plant breeders.

Hence the present studies were undertaken to mean performance and stability of elite mulberry genotypes in different seasons.

2.Materials and methods

Studies on stability of elite mulberry genotypes for growth and leaf yield parameters was carried out under rainfed condition in the Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru-65. The experimental material for the present study comprised of eight elite mulberry genotypes *viz.*, *Morus indica, M. cathayana, M. latifolia, M. macroura, M. alba, M. multicaulis, M. indica* (S-34) and *M. indica* (M-5) Standard check were used. Each genotype was planted with spacing of 4 x 4 feet. The stability for growth and yield parameters was conducted during three seasons *viz.,* winter, summer and rainy seasons of the 2023-24. The experimental plot was maintained as per the recommended package of practices for rain-fed mulberry (Dandin and Giridar, 2014). The performance of each elite genotype was evaluated by selecting randomly five competitive plants in each replication for growth and leaf yield. The genotypes were evaluated after 30^{th} and 60^{th} day after pruning for growth and leaf yield parameters during different seasons.

Stability analysis

Stability analysis was carried out by following Eberhart and Russell, 1966 linear regression model. The model employed is explained below:

Where,

$$Y_i = \mu i + \beta_i Ij + \delta_{ij}$$

Y_{ij}= The mean of the i^{th} genotype at j^{th} environment

μ_i = The mean of the i^{th} genotype over all environment

β_i= The regression co-efficient of the i^{th} genotype

β_i= The regression co-efficient of i^{th} genotype of the environmental index which measures the response of the i^{th} genotype to varying environments

I_j= The environment index obtained as deviation of mean of all the genotypes at

j^{th} = environment from the grand mean

δ_{ij}= Deviation from the regression of the i^{th} genotype at j^{th} environment

These parameters were estimated as follows:

i) $\mu = Y_i / n$

ii) $\beta i = \sum_J Y_{iJ} I_j / \sum_J I^2_J$

iii) $S^2di = \sum_j (\delta_{ij})/n\text{-}2)\text{-}S^2e/r$

Where n= Number of environments

Y_i = Total of genotype i over all the environment

Y_{ij} = Performance of i^{th} genotypes at the j^{th} environment

iv) Environment index (I_j) = (Y.J/V)- (Y.. /V_n)

Y..=Grand total of all genotypes over all environments

Y. J=Total of all genotypes at j^{th} location

V=Number of genotypes

v) $\sum S^2_{ij}$=Sum of squares due to deviation from the regression line obtained as

$\sum_j Y^2_{ij} - (Y_i^2../n) - (\sum_i Y_{ij} I_j)^2 / \sum_j I^2 J$

vi) S^2 e/r = Estimated pooled error or the variance of a genotype mean at the j^{th} environment.

3.4.2 A joint consideration of three parameters *i.e.,*

i) The mean performance of genotypes over environment (x_i)

ii) The regression co-efficient (β_i) and

iii) The deviation from linear regression (S^2di), is used to define the stability of genotype, or in other words it an estimate of stability of the genotypes. The estimation of deviation from regression denotes the degree of reliance that should be predicted satisfactorily. When deviations are not significant, the conclusions are drawn by joint consideration of mean yield and regression (Eberhart and Russell, 1966) as below:

Regression	**Stability**	**Mean yield**	**Remarks**
$\beta = 1$	Average	$x > \mu$	Well adapted to all environment
$\beta = 1$	Average	$x < \mu$	Poorly adapted to all environment
$\beta > 1$	Below Average	$x > \mu$	Specifically adapted to favorable environments
$\beta < 1$	Above Average	$x < \mu$	Specifically adapted to unfavorable environments

Regression values of unity are interpreted as average stability since the average slope over the genotypes on the environmental index will be unity.

3.Results and discussion

The leaf yield and growth parameters of different elite mulberry genotypes differed significantly among different seasons. During rainy season, no single genotype was superior in respect of all the traits studied.

3.1. To determine the mean performance for growth and leaf yield parameters of elite mulberry genotypes to identify stable genotypes in three seasons.

3.1.1. Internodal distance (cm)

Among the eight mulberry genotypes evaluated for mean performance indicated that internodal distance varied from season to season at 30 DAP and 60 DAP. Eight mulberry genotypes, as indicated by varying environmental indices (-0.41 to 0.50). The environment mean and index was maximum at S3 (5.80 and 0.50) and the same was minimum in S1 (4.88 & -0.41) respectively. Considering overall mean, lowest internodal distance was recorded in ME-0067 (4.53 cm) followed by MI-0014 (4.55 cm) at 30 DAP. Whereas ME-0086 recorded highest internodal distance (6.97 cm) followed by ME-0006 (6.66 cm) and ME-0220 (6.15 cm) (Table 1).

At 60 DAP internodal distance in eight mulberry genotypes varied from season to season, as indicated by varying environmental indices (0.14 to -0.24). The environment mean and index was maximum at S3 (5.24 and 0.09) and the same was minimum in S1 (4.89 & -0.24) respectively. While considering overall mean, lowest internodal distance was recorded in ME-0014 (4.10 cm) followed by MI-0067 (4.17 cm). Whereas ME-0086 recorded highest internodal distance (6.29 cm) followed by ME-0006 (5.92 cm), MI-0516 (5.55 cm) and ME-0220 (5.55 cm) (Table 2).

The mean performance of internodal distance of ME-0086, ME-0006, MI-0516 and ME-0220 was lesser than the grand mean with non-significant regression coefficient and its value is equal to one indicating average stability hence these genotypes are specifically adapted to all seasons at 30 DAP and 60 DAP (Table 1 & 2). Whereas the deviation from regression was non-significant by indicating predictable performance over season. The mean performance of ME-0160, ME-0018, ME-0067 and MI-0014 was greater than the grand mean having non-significant regression co-efficient and it equals to one with average stability indicating that these genotypes are poorly adapted to all seasons at 30 DAP and 60 DAP. Whereas the deviation from regression was non-significant for all the genotypes studied indicating predictable performance across the seasons at 30 DAP and 60 DAP (Table 1, 2 and Fig. 1).

The results are in conformity with the findings of Raksha sharma (2015) who reported that the genotypes MI-142 (5.34 cm) and MI-139 (6.54 cm) had above average stability and were specifically adapted to an unfavorable environment because their mean performance was below the grand mean and their regression coefficient was less than unity. Internodal distance was studied by Ahalya *et al.* (2020) across many genotypes. The environment mean and index (5.64 and 0.36) were highest for S2. In addition to showing average stability and being well-suited to all favorable circumstances, V1 also had a mean that was higher than the grand mean and a significant divergence from regression, indicating subpar performance in all conditions.

3.1.2. Number of branches per plant

Among the eight mulberry genotypes evaluated for mean performance indicated number of branches per plant that varied from season to season at 30 DAP and 60 DAP. Eight mulberry genotypes as seen by different environmental indices (0.89 to -0.91). The environment mean and index maximum at S3 (10.00 and 0.89) and minimum found in S2 (10.12 & 0.008) respectively. Considering overall mean MI-0014 recorded the highest (11.48 cm), followed by ME-0220 (11.29 cm) and ME-0067 (11.00 cm). Smillarly, ME-0086 recorded less number of branches per plant (8.32 cm), followed by MI-0516 (8.96 cm) (Table 3).

At 60 DAP number of branches per plant in eight mulberry genotypes varied from season to season, as indicated by varying environmental indices (0.88 to -0.90). The environment mean and index was maximum at S3 (11.24 and 0.88) and minimum in S2 (10.36 & 0.01) respectively. While considering overall mean MI-0014 had highest number of branches per plant (11.78 cm) followed by ME-0220 (11.55 cm) and ME-0067 (11.18 cm). Whereas less number of branches per plant (8.62 cm) was recorded in ME-0086 followed by MI-0516 (9.20 cm) (Table 4).

These genotypes are specifically adapted to all seasons at 30 DAP and 60 DAP because the mean performance of the number of branches per plant of MI-0014, ME-0220, ME-0067 and MI-0160 was greater than the grand mean with a non-significant regression coefficient and its value was equal to one indicating average stability (Table 3 & 4). In contrast, the non-significant deviation from regression showed consistent performance. Based on the non-significant regression coefficient and average stability, the mean performance of ME-0086, MI-0516, ME-0006 and ME-0018 was less than the grand mean, suggesting that these genotypes are not well suited to all seasons at 30 and 60 DAP (Table 3 & 4). Simillarly, all genotypes recorded non-significant deviations from regression, suggesting consistent performance across seasons at 30 DAP and 60 DAP (Table 3, 4 and Fig. 2).

The present findings are in line with those of Raksha sharma (2015) who reported that the rainy season was the ideal period of the year to express higher number of branches per plant because it was accompanied by greater environmental mean and index. The winter months recorded the lowest environmental mean and index, indicating that the number of branches per plant was not appropriately expressed. Because MI-142 (25.24), MI-79 (37.87), C-763 (29.73), SB-21 (27.64), S-36 (26.77) and S-13 (28.77) all had mean performance greater than grand mean and significant regression coefficients with below average stability, these genotypes are specifically adapted to favorable environmental conditions.

3.1.3. Number of leaves per plant

Among the eight mulberry genotypes evaluated for mean performance number of leaves per plant that varied from season to season at 30 DAP and 60 DAP. Eight mulberry genotypes indicated by the different environmental indices (-15.30 to 18.74). The environment mean and index was maximum in S3 (117.13 and 18.74) and minimum in S2 (94.95 and -3.44). Whereas, ME-0067 had highest average number of leaves per plant (134.69) followed by MI-0014 (122.76) and MI-0160 (102.07) (Table 5).

At 60 DAP the eight mulberry genotypes had different leaf numbers per plant from season to season, indicated by different environmental indices (-10.84 to 16.33). The environment mean and index was maximum at S3 (127.38 and 16.33) and minimum in S2 (105.55 and -5.49). ME-0067 found the highest number of leaves per plant (152.38), followed by MI-0014 (132.18) and MI-0160 (114.09) (Table 6).

The mean performance of the number of leaves per plant for ME-0067, MI-0014, MI-0160 and ME-0220 was higher than the grand mean with a non-significant regression coefficient and its value is equal to one, indicating average stability that these genotypes are specifically adapted to all seasons at 30 DAP and 60 DAP. The mean performances of ME-0018, MI-0516, ME-0086 and ME-006 are less than the grand mean, exhibit a non-significant regression coefficient, and are comparable to an averagely stable performance. These findings imply that these genotypes at 30 and 60 DAP are not well adapted to any seasons. Conversely, every genotype evaluated in the study recorded non-significant deviation from regression, indicating uniform performance across all seasons (Table 5, 6, and Fig. 3).

Sushmitha and Murali (2024) reported similar outcomes, indicating that the rainy season provided an ideal setting for the expression of leaves on individual trees. They also noted that the number of leaves per plant in the environmental index peaked during this period. However, as indicated by the lowest environmental index (31.97) winter was unfavorable. With a non-significant regression coefficient equal to one with average stability, the genotypes ME-05 × MI-66 and S36 performed less well on an average than the grand mean, suggesting that these hybrids are not appropriate for any kind of environments.

3.1.4. Single leaf area (cm^2)

The single leaf area in eight mulberry genotypes fluctuated across seasons, as indicated by the environmental indices ranging from -13.47 to 15.58 at 30 DAP and 60 DAP. The highest environment mean and index were observed at S3 (108.21 and 15.58), while the lowest were at S2 (90.25 and -2.37) respectively. Considering the overall mean, ME-0006 recorded largest single leaf area (124.37 cm^2), followed by ME-0086 (118.15 cm^2) and MI-0014 (114.29 cm^2), while ME-0220 recorded the lowest (54.47 cm^2) at 30 DAP. Whereas ME-0006 found the highest mean leaf area (208.79 cm^2), followed by ME-0086 (201.31 cm^2) and MI-0014 (179.71 cm^2), while ME-0220 found the lowest at 60 DAP (137.37 cm^2) (Table 7&8).

These genotypes are adapted to all seasons at 30 DAP and 60 DAP, as the mean single leaf area of ME-0006, ME-0086, MI-0014 and MI-0516 was more than the grand mean, with a non-significant regression coefficient equal to one, indicating average stability. In contrast, the genotypes ME-0220, ME-0067, ME-0018 and MI-0160, which recorded lower mean performance than the grand mean showed non-significant regression coefficient less than one, indicating above-average stability and suggesting adaptation to unfavorable condition. Additionally, all genotypes displayed non-significant deviation from regression, indicating consistent performance across all seasons (Table 7, 8 and Fig.4).

The present results are in accordance with those of earlier studies of Doss *et al*., 2012, which shown that the leaf area in CT-159 stayed constant throughout all of the seasons. CT-15 demonstrated above-average leaf area stability and the capacity to maintain a high level of performance during adverse seasons. High b^i (2.10) and moderate S^2di (45.10) were seen on CT-44. In CT-11, CT-44, CT-210, and S-1635, the b^i was almost equal to unity, and their corresponding S^2di were similarly quite low. This implied that the canopy in these hybrids changed steadily even in the form of seasonal variations. Among the evaluated genotypes, Raksha (2015) reported leaf area measurements across different genotypes and found that ME-144 (121.29 cm^2), C-20 (186.12 cm^2), MI-79 (149.35 cm^2), and MI-506 (119.08 cm^2) exhibited average stability but poor adaptation across various environmental conditions. The genotype S54 was identified as both stable and promising in terms of leaf area. In contrast, higher mean performance but lower stability was observed in genotypes such as ME-52 (234.84 cm^2), MI-32 (202.74 cm^2), SB-21 (354.23 cm^2), ME-012 (261.23 cm^2), MI-142 (220.53 cm^2), S-36 (229.12 cm^2), and S-13 (272.51 cm^2), indicating that they are specifically adapted to more favorable environments.

3.1.5. Total shoot length (cm)

Among the eight mulberry genotypes evaluated for mean performance indicated total shoot length that varied from season to season at 30 DAP and 60 DAP. Eight mulberry genotypes as indicated by varying environmental indices (-6.24 to 75.82). The highest environment index and mean was recorded in S3 (72.51 and 7.58) and minimum in S2 (63.60 and -1.33) respectively. When overall mean was considering ME-0067 recorded highest total shoot length per plant (82.34 cm) followed by MI-0014 (80.67cm) and MI-0160 (70.12cm) (Table 9).

At 60DAP seasonal variations in environmental indices (-9.32 to 10.72) were observed among the genotypes, indicating differences in total shoot length per plant. S3 had the highest environment index and mean (96.04 and 10.72), whereas S2 had the lowest (83.60 and -1.39). Considering the overall mean considering ME-0067 recorded highest total shoot length per plant (112.00 cm), followed by MI-0014 (105.43 cm) and MI-0160 (92.56 cm) (Table 10).

The mean of total shoot length was higher than the grand mean and non-significant regression coefficients suggesting below-average stability, the mulberry genotypes ME-0067, MI-0014 and MI-0160. This implies that at 30 and 60 DAP, these genotypes are especially well-adapted to favorable seasons. Moreover, their non-significant departure from regression indicates consistent performance in various seasons. However, with mean shoot length below the grand mean and non-significant regression coefficients indicating above-average stability. Genotypes ME-0018, MI-0516, ME-0086, ME-0006 and ME-0220 were better suited to unfavorable seasons, additionally, their non-significant departure from regression implies that they function consistently across the seasons (Tables 9, 10, and Fig. 5).

Similar results were found by Raksha sharma (2015) who observed that environmental mean (3959.38 to 3378.61) varied, indicating that total shoot length per plant varied from environment to environment. During rainy season, the environment mean and index reached its highest values (3959.38 and 299.32, respectively). In contrast, it was at its lowest during the summer (3378.61 and -281.43, respectively). The highest total shoot length measured in ME-27 (6604.44 cm), C-763 (5402.56 cm), and MI-79 (4792.66 cm) was determined by averaging all of the performance data. With the exception of MI-524, the regression coefficient (bi) was very significant for almost all genotypes. According to Ahalya *et al*. (2020), selection indices showed that S6 (rainy season 2019) was more favorable for mulberry genotypes for good expression of shoot length. Further, Sushmitha and Murali (2024) reported that the environment mean and index were highest at S4 (174.73 and 26.39) and lowest in S2 (123.87 and -24.76, respectively). The hybrids ME-146 × MI-66 and ME-67 × V1 exhibit a non-significant regression coefficient and a value of one, indicating average stability and have a mean performance of more leaves per plant hybrid than the grand mean. These hybrids are specifically suited to all environment**.**

3.1.6. Leaf yield per plant (g)

Among the eight mulberry genotypes evaluated for mean performance indicated lraf yield per plant that varied from season to season. Eight mulberry genotypes shown by varying environmental indices (-38.04 to 46.53). S3 had the greatest environment mean and index (290.14 and 231.02), while S2 had the lowest (235.12 and -8.49), respectively. In terms of total leaf yield per plant, MI-0014 had the highest mean (363.66g), followed by ME-0006 (279.66g) and MI-0160 (265.79g). However, ME-0018 (137.32g) recorded lowest leaf yield per plant (Table 11).

With a non-significant regression coefficient and a value of one, which indicates average stability, the leaf yield per plant in the various mulberry genotypes like, ME-0014, MI-0006 and MI-0160 was higher than the grand mean. These genotypes are particularly adapted to all seasons. These genotypes are non-adaptive to all environments as evidenced by the mean performance of ME-0018, MI-0516, ME-0067, ME-0220 and ME-0086, which are lesser than the grand mean and equal to one with average stability and a non-significant regression coefficient. Simillarly, all mulberry genotypes showed non-significant deviation from regression for leaf yield per plant, suggesting consistent performance in all seasons (Table 11 and Fig. 6).

According to Sushmitha and Murali (2024) different mulberry hybrids have differing leaf yields per plant from season to season, as shown by fluctuating environmental indices (-264.42 to 231.02). The mulberry hybrids MI-79 × MI-66, ME-03 × MI-66, ME-68 × V1 and V1 all had leaf yields per plant that were higher than the grand mean, with a non-significant regression coefficient and a value of one indicating average stability. As a result, these hybrids are specifically suited to all environments.

4. Conclusion

The mean performance of eight yield and yield-contributing traits in each season were analyzed individually. The stability analysis of elite mulberry genotypes for vegetative parameters reveals valuable insights into their adaptability and performance across different environments. For growth and leaf yield parameters across winter, summer and rainy seasons, MI-0014 recorded superiority in almost all the traits studied, including leaf yield per plant, number of branches per plant and shorter internodal distance across all three seasons. Genotypes MI-0014 and ME-0067 are considered stable across three seasons based on the G × E interaction identifying genotypes that are not only high-yielding but also resilient to environmental fluctuations. The study revealed that the genotype MI-0014 was preferred better for growth and leaf yield parameters in different seasons. These findings are crucial for breeding programs aimed at developing adaptable and robust mulberry varieties, ultimately supporting sustainable sericulture practices by providing uniform and high-quality leaf production.

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 writing or editing of manuscripts.

5.References:

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Table 1. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for internodal distance at 30 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b_i**	**S^2d_i**
MI-0516	5.42	6	5.50	5	6.11	5	5.68	6	0.78	0.01
ME-0018	4.59	4	4.86	4	5.44	3	4.96	3	0.93	-0.01
ME-0067	3.86	2	4.23	2	4.53	1	4.21	2	0.70	0.00
ME-0220	5.21	5	5.55	6	6.15	6	5.64	5	1.03	-0.01
ME-0086	6.18	8	6.48	8	6.97	8	6.54	8	0.86	-0.01
ME-0006	5.52	7	6.10	7	6.66	7	6.09	7	1.20	0.01
MI-0160	4.56	3	4.87	3	6.05	4	5.16	4	1.67	0.03
MI-0014	3.76	1	4.19	1	4.55	2	4.17	1	0.83	0.01
Mean	4.88	-	5.22	-	5.80	-	5.31	-	-	-
Environmental index	**-0.418**	-	**-0.084**	-	**0.502**	-	-	-	-	-
C. V.	2.410	-	1.840	-	2.554	-	-	-	-	-
S.Em±	0.096	-	0.078	-	0.121	-	-	-	-	-

CD @ P=0.05	0.206	-	0.168	-	0.260	-	-	-	-	-
CD @ P=0.01	0.286	-	0.234	-	0.361	-	-	-	-	-

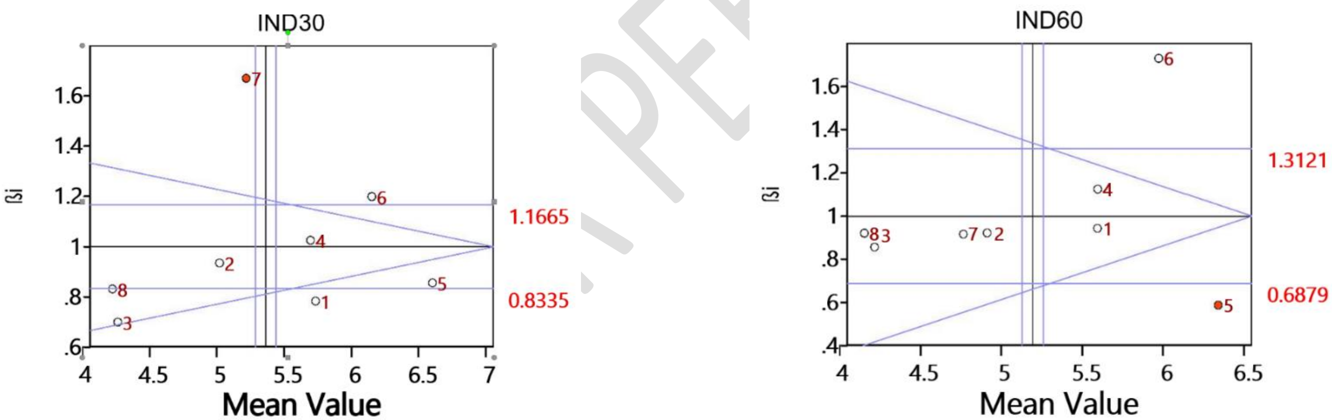
8. *Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression
9. S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

Table 2. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for internodal distance at 60 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	5.31	6	5.67	6	5.66	5	5.55	5	0.94	-0.01
ME-0018	4.64	4	5.03	4	4.92	4	4.86	4	0.92	-0.01
ME-0067	3.95	2	4.25	2	4.30	2	4.17	2	0.86	0.00
ME-0220	5.26	5	5.65	5	5.73	6	5.55	5	1.12	0.01
ME-0086	6.16	8	6.50	8	6.21	8	6.29	7	0.59	0.03
ME-0006	5.49	7	6.14	7	6.14	7	5.92	6	1.73	0.02
MI-0160	4.50	3	4.92	3	4.73	3	4.72	3	0.92	0.00
MI-0014	3.87	1	4.19	1	4.25	1	4.10	1	0.92	0.00

Mean	4.89	-	4.29	-	5.24	-	5.15	-	-	-
Environmental index	**-0.247**	-	**0.148**	-	**0.099**	-	-	-	-	-
C. V.	2.722	-	2.680	-	2.894	-	-	-	-	-
S.Em±	0.109	-	0.116	-	0.124	-	-	-	-	-
CD @ P=0.05	0.233	-	0.248	-	0.266	-	-	-	-	-
CD @ P=0.01	0.324	-	0.345	-	0.369	-	-	-	-	-

10. *Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression
11. S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)



IND: Internodal distance(cm)

Fig. 1. Relationship between the regression coefficient (b*i*) and the mean internodal distance (30th and 60th DAP) in three seasons for eight elite mulberry genotypes

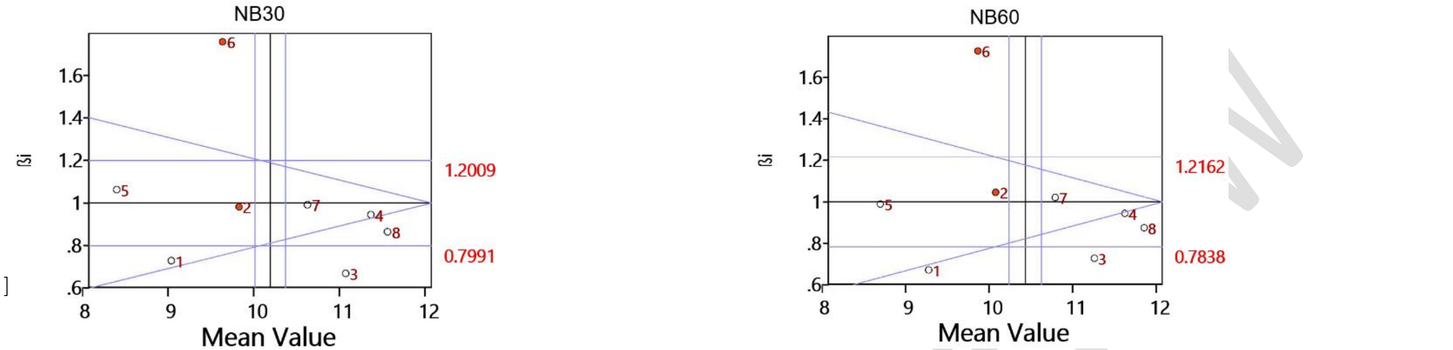


Fig. 2. Relationship between the regression coefficient (b*i*) and the mean number of branches (30th and 60th DAP) per plant in three seasons for eight elite mulberry genotypes

Table 3. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for number of branches per plant at 30 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	8.20	6	9.17	6	9.52	7	8.96	7	0.73	0.03
ME-0018	8.71	5	10.07	5	10.47	6	9.75	5	0.98	0.12
ME-0067	10.33	3	11.13	3	11.53	3	11.00	3	0.67	0.01
ME-0220	10.50	2	11.17	2	12.20	2	11.29	2	0.94	0.01

ME-0086	7.37	8	8.33	7	9.27	8	8.32	8	1.06	-0.03
ME-0006	8.17	7	9.17	6	11.33	5	9.56	6	1.76	0.21
MI-0160	9.72	4	10.43	4	11.50	4	10.55	4	0.99	0.02
MI-0014	10.70	1	11.50	1	12.25	1	11.48	1	0.86	-0.03
Mean	9.213	-	10.122	-	11.007	-	10.11	-	-	-
Environmental index	**-0.901**	-	**0.008**	-	**0.893**	-	-	-	-	-
C. V.	3.594	-	2.510	-	2.905	-	-	-	-	-
S.Em±	0.270	-	0.207	-	0.261	-	-	-	-	-
CD @ P=0.05	0.580	-	0.445	-	0.560	-	-	-	-	-
CD @ P=0.01	0.805	-	0.617	-	0.777	-	-	-	-	-

*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S^2di=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

Table 4. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for number of branches per plant at 60 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	8.50	6	9.40	6	9.70	7	9.20	7	0.67	0.03
ME-0018	8.87	5	10.40	5	10.73	6	10.00	5	1.05	0.20
ME-0067	10.47	3	11.31	3	11.77	3	11.18	3	0.73	-0.01
ME-0220	10.72	2	11.51	2	12.41	2	11.55	2	0.94	-0.02
ME-0086	7.73	8	8.63	7	9.50	8	8.62	8	0.99	-0.03
ME-0006	8.43	7	9.40	6	11.53	5	9.79	6	1.73	0.22
MI-0160	9.87	4	10.57	4	11.70	4	10.71	4	1.02	0.01
MI-0014	11.03	1	11.70	1	12.60	1	11.78	1	0.87	-0.02
Mean	9.453	-	10.365	-	11.243	-	10.35	-	-	-
Environmental index	**-0.900**	-	**0.011**	-	**0.889**	-	-	-	-	-
C. V.	3.122	-	2.133	-	3.129	-	-	-	-	-
S.Em±	0.241	-	0.181	-	0.287	-	-	-	-	-

CD @ P=0.05	0.517	-	0.387	-	0.616	-	-	-	-	-
CD @ P=0.01	0.717	-	0.537	-	0.855	-	-	-	-	-

12. *Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression
13. S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

Table 5. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for number of leaves per plant at 30DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	64.40	7	72.33	7	94.53	7	77.09	7	0.90	2.00
ME-0018	54.60	8	64.80	8	87.40	8	68.93	8	0.97	-1.29
ME-0067	113.80	1	131.80	1	158.47	1	134.69	1	1.30	1.59
ME-0220	84.20	4	96.33	4	120.33	4	100.29	4	1.06	-2.13
ME-0086	74.93	6	86.20	6	103.13	6	88.09	6	0.82	-0.91
ME-0006	76.93	5	90.20	5	112.53	5	93.22	5	1.04	-1.78
MI-0160	87.67	3	97.27	3	121.27	3	102.07	3	1.00	0.60

MI-0014	108.20	2	120.67	2	139.40	2	122.76	2	0.91	-0.61
Mean	83.09	-	94.95	-	117.13	-	98.39	-	-	-
Environmental index	**-15.301**	-	**-3.441**	-	**18.741**	-	-	-	-	-
C. V.	2.929	-	2.392	-	2.682	-	-	-	-	-
S.Em±	1.987	-	1.854	-	2.565	-	-	-	-	-
CD @ P=0.05	4.262	-	3.977	-	5.501	-	-	-	-	-
CD @ P=0.01	5.915	-	5.519	-	7.635	-	-	-	-	-

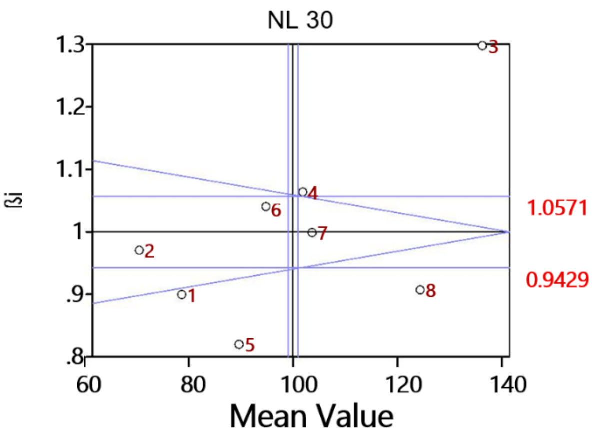
14. *Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression
15. S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March -April) S3=2024 Rainy season (May-June)

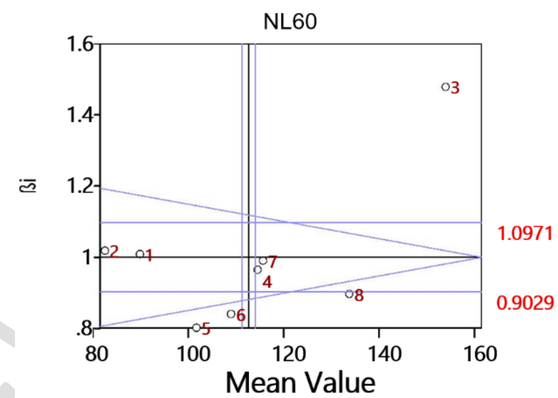
Table 6. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for number of leaves per plant at 60 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	75.33	7	85.27	7	104.27	7	88.29	7	1.01	6.91
ME-0018	69.67	8	75.67	8	97.53	8	80.96	8	1.02	-3.63
ME-0067	135.27	1	145.60	1	176.27	1	152.38	1	1.48	-0.76

ME-0220	103.60	4	106.33	4	129.00	4	112.98	4	0.96	-0.73
ME-0086	91.60	6	95.53	6	113.27	6	100.13	6	0.80	-3.72
ME-0006	99.67	5	101.07	5	121.47	5	107.40	5	0.84	1.18
MI-0160	105.00	3	106.60	3	130.67	3	114.09	3	0.99	3.29
MI-0014	121.53	2	128.40	2	146.60	2	132.18	2	0.90	-1.58
Mean	100.20	-	105.55	-	127.38	-	111.05	-	-	-
Environmental index	**-10.841**	-	**-5.493**	-	**16.334**	-	-	-	-	-
C. V.	3.493	-	2.735	-	2.969	-	-	-	-	-
S.Em±	2.858	-	2.357	-	3.088	-	-	-	-	-
CD @ P=0.05	6.129	-	5.055	-	6.623	-	-	-	-	-
CD @ P=0.01	8.507	-	7.016	-	9.192	-	-	-	-	-

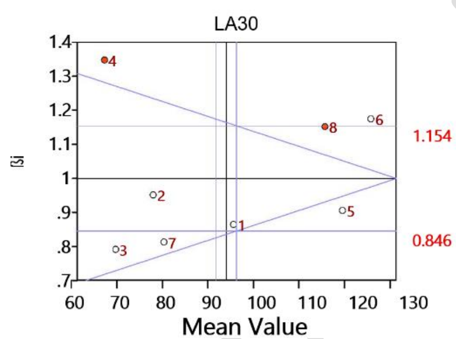
16. *Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S^2di=Deviation from regression
17. S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March -April) S3=2024 Rainy season (May-June)

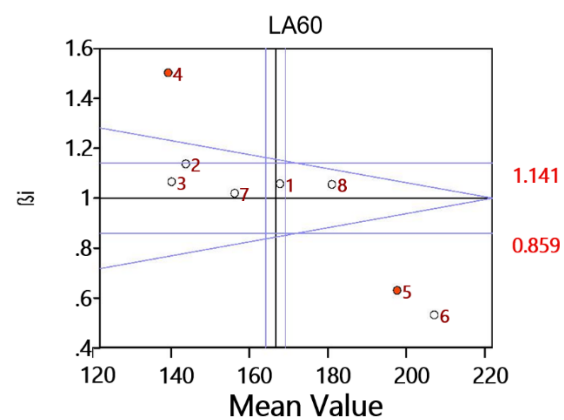




NL: Number of leaves per plant

Fig. 3. Relationship between the regression coefficient (b*i*) and the mean number of leaves per plant (3oth and 60th DAP) in three seasons for eight elite mulberry genotypes





LA: Single leaf area (cm^2)

Fig. 4. Relationship between the regression coefficient (b*i*) and the mean single leaf area (30th and 60th DAP) in three seasons for eight elite mulberry genotypes

Table 7. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for single leaf area at 30 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	81.75	4	93.89	4	107.07	4	94.24	4	0.86	2.25
ME-0018	64.71	6	73.35	6	91.84	6	76.63	6	0.95	-0.62
ME-0067	57.33	7	67.52	7	80.36	8	68.40	7	0.79	-0.70
ME-0220	51.56	8	57.37	8	89.01	7	54.47	8	1.35	42.53
ME-0086	105.51	2	117.07	2	131.86	2	118.15	2	0.91	-0.45
ME-0006	107.81	1	123.25	1	142.04	1	124.37	1	1.17	2.07
MI-0160	69.60	5	74.93	5	92.47	5	79.00	5	0.81	4.78
MI-0014	97.13	3	114.66	3	131.07	3	114.29	3	1.15	12.58
Mean	79.426	-	90.254	-	108.21	-	91.19	-	-	-
Environmental index	**-13.205**	-	**-2.377**	-	**15.582**	-	-	-	-	-

C. V.	3.281	-	2.247	-	2.795	-	-	-	-	-	-
S.Em±	2.128	-	1.656	-	2.470	-	-	-	-	-	-
CD @ P=0.05	4.564	-	3.551	-	5.297	-	-	-	-	-	-
CD @ P=0.01	6.334	-	4.928	-	7.353	-	-	-	-	-	-

*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S^2di=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June

Table 8. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for single leaf area at 60 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	148.53	4	162.97	4	185.95	4	165.82	4	1.06	-8.91
ME-0018	124.11	6	137.38	6	164.03	7	141.84	6	1.14	-6.66
ME-0067	120.60	7	135.69	7	158.41	8	138.23	7	1.07	-8.58
ME-0220	116.68	8	127.07	8	168.36	6	137.37	8	1.50	46.52
ME-0086	182.29	2	198.86	2	205.79	2	201.31	2	0.63	29.40

ME-0006	195.39	1	205.33	1	214.64	1	208.79	1	0.53	-4.39
MI-0160	137.95	5	150.99	5	173.92	5	154.29	5	1.02	-8.71
MI-0014	161.73	3	176.29	3	199.11	3	179.71	3	1.06	-8.85
Mean	79.426	-	90.254	-	108.214	-	165.92	-	-	-
Environmental index	**-13.205**	-	**-2.377**	-	**15.582**	-	-	-	-	-
C. V.	3.281	-	2.247	-	2.795	-	-	-	-	-
S.Em±	2.128	-	1.656	-	2.470	-	-	-	-	-
CD @ P=0.05	4.564	-	3.551	-	5.297	-	-	-	-	-
CD @ P=0.01	6.334	-	4.928	-	7.353	-	-	-	-	-

*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

Table 9. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for total shoot length at 30 DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***

MI-0516	50.12	7	53.21	7	64.83	6	56.05	7	1.09	1.95
ME-0018	42.56	8	46.6	8	53.32	8	47.49	8	0.78	-0.99
ME-0067	74.09	2	80.42	1	92.52	1	82.34	1	1.34	-0.99
ME-0220	59.23	4	64.26	4	67.32	5	63.60	4	0.56	1.98
ME-0086	52.13	6	58.23	6	64.32	7	58.23	6	0.86	1.00
ME-0006	53.25	5	60.51	5	69.15	4	60.97	5	1.13	0.65
MI-0160	63.12	3	67.13	3	80.12	3	70.12	3	1.26	1.67
MI-0014	74.98	1	78.46	2	88.56	2	80.67	2	1.00	0.15
Mean	58.68	-	63.60	-	72.51	-	64.93	-	-	-
Environmental index	**-6.249**	-	**-1.333**	-	**7.582**	-	-	-	-	-
C. V.	2.051	-	3.198	-	2.847	-	-	-	-	-
S.Em±	0.983	-	1.661	-	1.686	-	-	-	-	-
CD @ P=0.05	2.108	-	3.561	-	3.615	-	-	-	-	-

CD @ P=0.01	2.926	-	4.943	-	5.018	-	-	-	-	-

*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

Table 10. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for total shoot length at 60DAP

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	61.32	7	68.31	7	83.76	7	71.13	7	1.13	0.67
ME-0018	53.86	8	61.22	8	76.12	8	63.73	8	1.12	-0.30
ME-0067	104.22	1	108.82	1	122.95	1	112.00	1	0.95	3.49
ME-0220	76.31	4	84.31	4	89.57	5	83.40	4	0.64	3.33
ME-0086	65.14	6	77.15	6	85.25	6	75.85	6	0.98	9.17
ME-0006	67.12	5	78.54	5	89.91	4	78.52	5	1.12	2.14
MI-0160	82.24	3	89.25	3	106.18	3	92.56	3	1.21	2.30
MI-0014	97.81	2	103.83	2	114.65	2	105.43	2	0.84	-1.39

Mean	76.003	-	83.929	-	96.049	-	85.33	-	-	-
Environmental index	**-9.324**	-	**-1.398**	-	**10.722**	-	-	-	-	-
C. V.	2.424	-	3.048	-	2.551	-	-	-	-	-
S.Em±	1.504	-	2.088	-	2.001	-	-	-	-	-
CD @ P=0.05	3.226	-	4.479	-	4.291	-	-	-	-	-
CD @ P=0.01	4.478	-	6.217	-	5.956	-	-	-	-	-

*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S²d*i*=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)

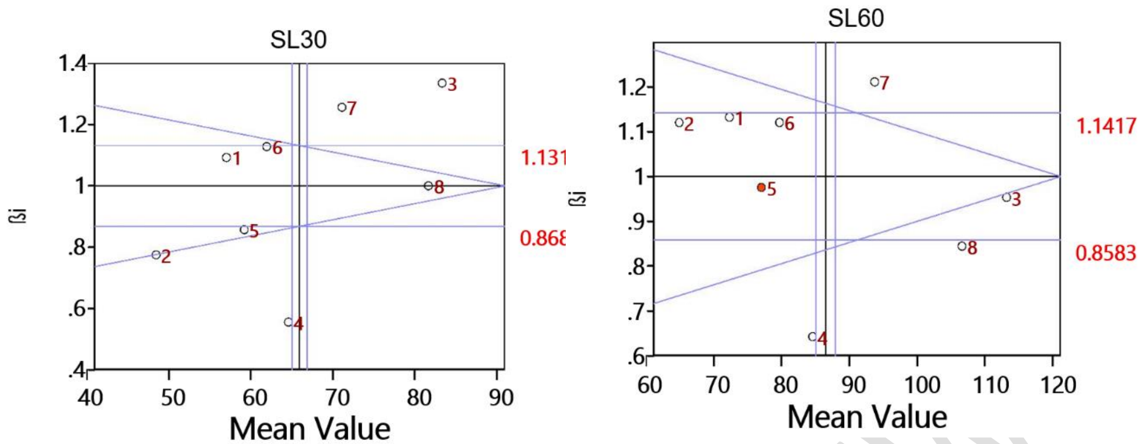
Table 11. Mean performance of eight elite mulberry genotypes for three seasons and their stability parameters for leaf yield per plant

Genotypes	**S1**	**Rank**	**S2**	**Rank**	**S3**	**Rank**	**Mean**	**Overall Rank**	**b*i***	**S²d*i***
MI-0516	160.6	7	180.4	7	235.7	7	192.22	7	0.90	10.34
ME-0018	108.8	8	129.1	8	174.1	8	137.32	8	0.73	-12.40
ME-0067	205.2	4	228.8	5	264.3	6	232.75	6	0.69	-10.84

ME-0220	199.4	6	228.1	6	284.9	4	237.44	5	1.01	-15.48
ME-0086	204.1	5	234.8	4	280.9	5	239.95	4	0.90	-6.81
ME-0006	230.8	2	270.6	2	337.6	2	279.66	2	1.26	-12.49
MI-0160	228.3	3	253.3	3	315.8	3	265.79	3	1.05	3.60
MI-0014	307.3	1	355.9	1	427.9	1	363.66	1	1.41	10.57
Mean	205.576	-	235.125	-	290.149	-	243.60	-	-	-
Environmental index	**-38.041**	-	**-8.492**	-	**46.533**	-	-	-	-	-
C. V.	2.335	-	2.226	-	3.346	-	-	-	-	-
S.Em±	3.920	-	4.273	-	7.926	-	-	-	-	-
CD @ P=0.05	8.407	-	9.164	-	16.999	-	-	-	-	-
CD @ P=0.01	11.668	-	12.719	-	23.594	-	-	-	-	-

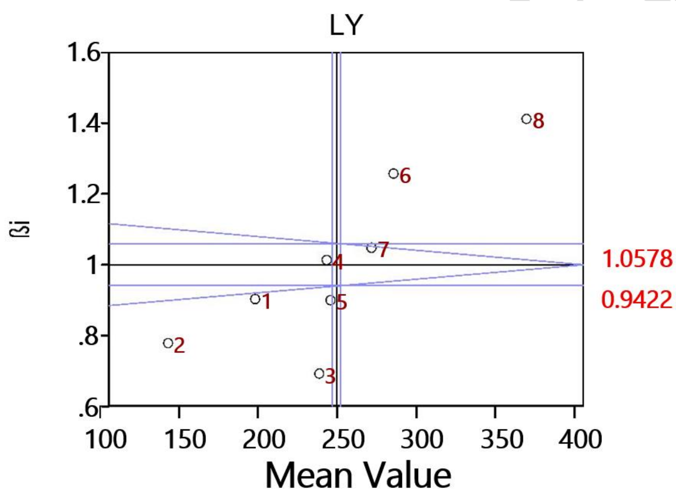
*Significant @ 0.05 level ** Significant @ 0.01 level, b*i*=regression co-efficient, S^2di=Deviation from regression

S1=2023 winter season (Dec-Jan), S2=2024 Summer season (March-April) S3=2024 Rainy season (May-June)



SL: Total shoot length (cm)

Fig. 5. Relationship between the regression coefficient (b*i*) and the mean total shoot length (30th and 60th DAP) in three seasons for eight elite mulberry genotypes



LY: Leaf yield per plant (g)

Fig. 6. Relationship between the regression coefficient (b*i*) and the mean leaf yield per plant in three seasons for eight elite mulberry genotypes