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Raksha Sharma CM
Ph.D. Scholar, Department of Sericulture, UAS, GKVK, Bengaluru, Karnataka, India

Lavanya V
M.Sc. Agricultue Entomology, Sam Higginbottom College of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Shyla PN
Assistant Professor, Contract Basis, Department of Sericulture, College of Sericulture, Chintamani, Bengaluru, Karnataka, India

Anil Kumar U
M.Sc. Sericulture, SK University, Anantpur, Andhra Pradesh, India

Rashmi S
M.Sc Agriculture in Sericulture, Department of Sericulture, UAS, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Raksha Sharma CM
Ph.D. Scholar, Department of Sericulture, UAS, GKVK, Bengaluru, Karnataka, India

Performance of elite mulberry genotypes in different seasons for leaf yield and yield contributing traits

Raksha Sharma CM, Lavanya V, Shyla PN, Anil Kumar U and Rashmi S

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Abstract
Mulberry is a woody perennial and heterozygous plant. The foliage is the sole food for the mulberry silkworm (*Bombyx mori* L.) which draws substantial amount of nutrient elements from soil for nourishment of the insect. The quality of mulberry leaves has a predominant role on the growth and development of silkworm larvae and subsequent cocoon production. Mulberry (*Morus* spp.) belongs to family Moraceae and grouped under Urticales.. Study on performance of elite mulberry genotypes (*Morus* spp), under rainfed during different season was carried at Department of Sericulture UAS, GKVK, Bengaluru-65. Among 15 elite mulberry genotypes evaluated, highest plant height was recorded by MI-79 (341.95 cm), followed by S-36 (336.56 cm) and MI-142 (327.37 cm). During three season rainy, winter and summer MI-79, S-36, ME-27, MI- 139 and ME-52 found superior for all most all the traits contributing traits *viz*., number of branches, internodal distance, number of leaves per plant, leaf yield per plant (g).

Keywords: Mulberry, genotypes, season, leaf yield

Introductions
Mulberry is a woody perennial and heterozygous plant. The foliage is the sole food for the mulberry silkworm (*Bombyx mori* L.) which draws substantial amount of nutrient elements from soil for nourishment of the insect. The quality of mulberry leaves has a predominant role on the growth and development of silkworm larvae and subsequent cocoon production. Mulberry (*Morus* spp.) belongs to family Moraceae and grouped under Urticales. It is usually associated with sericulture and production of silk with the silkworm (*Bombyx mori* L). Mulberry leaf quality is one of the key factors influencing the growth and development of silkworm, *Bombyx mori*
L. The silkworm being a monophagous insect derives all the nutrients from mulberry leaf. Since the production of good quality cocoons depends on providing good quality leaves to silkworm, the development of superior quality leaf has become one of the prime objective in mulberry breeding programme. Different quality traits such as leaf moisture content, proteins, carbohydrates, nitrogen, amino acids and chlorophyll are responsible for leaf quality. The leaf quality and yield in turn is determined by the number of factors *viz*., mulberry variety, ecological factors, agronomical practices, method of harvest and preservation etc. Bongale *et al.*, 1991, [3] Chaluvachari and Bongale, 1995 [4]. The total raw silk production in the country during 2022-23 was 40,800 MT, which was4.8% more than the production achieved during the previous year 2021-22 Anonymous (2023) [1]. To increase the silk production, there is a need to develop highly productive mulberry varieties and silkworm races and also silkworm races tolerant to adverse climatic conditions and diseases which can come mainly from the sericulture germplasm resources and also from the wild relatives of *Bombyx species* available in the natural habitats. India occupies second position in silk production among the silk producing countries. India is the second largest producer of silk in the world. Among the four varieties of silk produced in 2022-23, Mulberry accounted for 70.49% (28,760 MT), Tasar 9.43% (3,850 MT), Eri 19.36% (7,900 MT) and Muga 0.71% (290 MT) of the total raw silk production of 40,800 MT. (CSB 2023) [5]. The contributing factors for successful cocoon crop production are mulberry leaf (38.2%), climate (37.0%), rearing technique (9.3%), silkworm breed (3.1%) and other factors (8.2%) (Naidu, 2008) [9].

The mulberry production practices play a vital role in determining the cost of production of cocoons, quality and quantity of raw silk. It is estimated that about 60 percent of the cost of cocoon production goes to mulberry leaf production.

Material and methods

The experiments were carried out at the Department of Sericulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru-65. The experimental material for the present study comprised of 15 elite mulberry genotypes (Table 1) maintained at Department of Sericulture, UAS, GKVK, Bengaluru- 65 as semi-tree. These genotypes were planted during 2006 in red loamy soil. Theexperiment was conducted in three seasons *viz.*, rainy, winter and summer seasons. The genotypes were maintained with all the normal cultural practices like irrigation, weeding, fertilizer application measures as per the package of practices for rainfed mulberry (Dandin and Giridhar, 2010) [6]. Pruning was done at four feet height from the ground level and thereafter all the growth parameters were recorded on each genotype. Observations were recorded at 60th day after pruning for three seasons *viz.*, rainy, winter and summer.

Table 1: List of fifteen different elite mulberry genotypes used in study

Sr No	Genotypes	Source	Species
1	ME-52	CSGRC, Hosur	*Morus indica*
2	ME-27	CSGRC, Hosur	*Morus indica*
3	MI-32	CSGRC, Hosur	*Morus indica*
4	ME-012	CSGRC, Hosur	*Morus indica*
5	MI-142	CSGRC, Hosur	*Morus indica*
6	MI-79	CSGRC, Hosur	*Morus indica*
7	C-763	CSGRC, Hosur	*Morus indica*
8	SB-21	CSGRC, Hosur	*Morus indica*
9	C-20	CSGRC, Hosur	*Morus indica*
10	ME-144	CSGRC, Hosur	*Morus indica*
11	S-36(check)	CSGRC, Hosur	*Morus indica*
12	S-13(check)	CSGRC, Hosur	*Morus indica*
13	MI-139	CSGRC, Hosur	*Morus indica*
14	MI-520	CSGRC, Hosur	*Morus indica*
15	MI-506	CSGRC, Hosur	*Morus indica*

Observations recorded Plant height (cm)

The height of the main shoots from the base of the pruning of the plant to the tipwas measured in centimeters to work out the average height of the plant.

Number of branches per plant

All the branches of a bush arising from the base of the pruning and are measuringmore than 50 cm length were recorded.

Total shoot length (cm)

The length of all the branches was measured by using a meter scale. The shoot length was taken from the base of shoot that is from where the leaves start to its tip. Totalshoot length of all branches of each plant was recorded.

Internodal distance (cm)

Distance between two successive nodes was measured in scale of the main shootand expressed in centimeters and average internodal distance was calculated.

Number of leaves per plant

Total numbers of leaves were counted in each plant before each harvest andaverage numbers of leaves per plant were calculated.

Single leaf area (cm2)

Single leaf area was measured by taking the length and breadth of individual leaffrom accessions in different replications. Single leaf area is calculated by factor method.

$$SLA = L \times B \times 0.69$$

Where, SLA = Single leaf area
L = Length B = Breadth
0.69 = Correction factor

Leaf yield per plant (g)

Leaves harvested from each plant and their weight was recorded. The average leafyield per plant was estimated. The total leaf yield per plant was expressed in grams.

100 fresh leaf weight (g)

Randomly selected 100 leaves from different plants within the plot / row were weighed to record the fresh weight in grams.

Results and Discussion

Rainy Season

Among 15 elite mulberry genotypes evaluated, highest plant height was recorded by MI-79 (341.95 cm), followed by S-36 (336.56 cm) and MI-142 (327.37 cm). However, shortest recorded in ME-012 (211.39 cm) (Table 2). MI-79 (41.71) recorded more number of branches followed by S-36 (37.70) and C-763(35.21). Whereas, the number of branches found less in C-20(15.64) and MI-506 (15.20) (Table 2). Among all the genotypes evaluated the longest total shoot length exhibited in ME- 27 (6953.26cm), C-763 (5731.63cm) and MI-79(5031.63cm). However, the shortest total shoot length found in MI-524 (428.09cm) (Table 2). Internodal distance recorded shorter in the MI-142 (6.97cm), followed by ME-27 (7.99cm) and C-763 (7.86cm) and the same was longer in ME-52 (11.41cm) (Table 2). Internodal distance recorded shorter in the MI-142 (6.97cm), followed by ME-27 (7.99cm) and C-763 (7.86cm) and the same was longer in ME-52 (11.41cm) (Table 2). SB-21 (372.73 cm2) recorded broader leaf area in rainy season followed by S- 13(294.03 cm2) and ME-52 (262.45 cm2). On the other hand the lowest single leaf area was registered by ME-27 (62.33 cm2) (Table 2). S- 36 (2495.64 g/plant), yielded maximum leaf yield followed by MI-79 (2350.99g/plant), ME- 52 (2249.85 g/plant), and S-13(2247.94 g/plant). Whereas, leaf yield/plant recorded minimum in ME-27 (296.71g/plant) (Table 2). In rainy season 100 fresh leaves weight registered highest in ME-52(551.55g) followed by SB-21(548.38g) andMI-32 (490.73g) and the same was minimum in ME-27 (90.26g)(Table 2). S-36 (2495.64 g/plant), yielded maximum leaf yield followed by MI-79 (2350.99 g/plant),), ME-52 (2249.85 g/plant), and S-13(2247.94 g/plant). Whereas, leafyield/plant recorded minimum in ME-27 (296.71g/plant) (Table 2). Bari *et al.* (1988) [2] studied 64 accessions of mulberry and reported significant differences between the genotypes for various quantitative traits. The

branch height ranged from 65.04 to 110.36 cm, number of branches from 11.11 to 37.5, number of leaves per branch from 23.87 to 34.02, leaf size from 55.44 to 190.18 cm2, single leaf weight from 70 to 275g, internodal distance from 2.61 to 3.70 cm and leaf yield per plant from 101.44 to 402.11 g over four seasons. Variation in performance among the fifteen mulberry genotypes shows highly significant differences among four characters *viz*, total shoot length, plant height, number of branches per plant and leaf yield indicating presence of sufficient amount of variability with respect of all the characters studied in both the seasons. The genotypic differences were more in rainy season compared to winter season. Tikader and Roy (2006) [10] observed variation for different growth attributes with number of branches ranged from 25 to 97, intermodal distance (2.54 to 5.29 cm), leaf area (64.03 to 242.00 cm2), leaf yield (1.25 to 23.00 kg) per plant. Similar results were reported by Tikader *et al.* (2004) [11].

Table 2: Mean performance of 15 elite mulberry genotypes for different growth & yield parameters during Rainy season

Sr. No.	Genotypes	Plant height (cm)	Number of branches per plant	Total shoot length (cm)	Internoda l distance (cm)	Number of leaves per plant	Single leaf area (cm2)	Leaf yield per plant (g)	100 fresh leaves weight (g)
1	ME-52	296.88	28.44	3147.51	11.41	447.18	262.45	2249.85	551.55
2	ME-27	278.13	16.49	6953.26	7.99	445.00	62.23	296.71	90.26
3	MI-32	317.00	22.02	4311.97	9.68	624.55	217.67	1322.71	490.73
4	ME-012	211.39	26.40	2819.47	8.58	528.61	243.74	1563.30	447.09
5	MI-142	327.37	22.83	3613.18	6.97	692.75	159.37	1460.53	225.02
6	MI-79	341.95	41.71	5031.63	8.43	762.56	161.49	2350.99	490.31
7	C-763	316.91	35.21	5731.63	7.86	654.42	136.04	1582.74	192.01
8	SB-21	284.67	31.50	4411.07	9.21	530.94	372.73	1341.74	548.38
9	C-20	275.92	15.64	2951.81	8.50	303.44	202.10	2231.45	295.30
10	ME-144	285.13	21.69	4309.15	8.24	545.97	142.42	1336.46	353.32
11	S-36	336.56	37.70	3767.49	8.84	595.21	254.11	2495.64	474.14
12	S-13	265.83	31.73	3305.74	8.75	529.25	294.03	2247.94	473.84
13	MI-139	298.08	26.59	4704.06	8.27	674.17	154.42	983.84	183.70
14	MI-524	223.94	29.35	428.09	8.87	100.90	119.46	2243.93	304.58
15	MI-506	258.09	15.20	3905.14	7.86	759.55	131.80	1258.30	231.72
	Mean	287.86	26.83	3959.38	8.63	546.30	194.28	6797.74	356.80
	Environment index	15.79	1.61	299.32	1.72	27.50	7.53	3.33	47.95
	C.V.	4.33	6.20	1.15	14.22	1.26	17.62	50.95	1.43
	SEm±	10.17	1.35	37.34	1.00	5.63	27.96	28.03	4.19
	CD @ P=0.05	20.85	2.78	76.49	2.05	11.54	57.26	-	8.58
	CD @ P=0.01	28.12	3.75	103.19	2.77	15.57	77.25	-	11.58

Winter season

Among 15 genotypes tested none of the genotypes found taller than S-36 (338.32 cm). However MI-32 (337.24 cm), MI-142 (313.20 cm) andC-763 (286.60 cm) found to be tallest plants. ME- 012 (196.53 cm) recorded minimum plant height (Table 3). Maximum number of branches were produced by MI-79 (36.87) followed by C- 763 (31.53) and S-13 (28.11). However minimum number of branches was recorded in ME-27 (11.92) (Table 3). ME-27 recorded longest total shoot length (6572.71cm) followed by C-763 (5284.24cm) and MI-79 (4755.32cm) and the lowest total shoot length was recorded in MI-524 (366.17cm) (Table 3). Among the 15 elite mulberry genotypes evaluated shorter internodal distance was recorded in MI-506 (4.45cm), MI-142 (4.76cm) and ME-27 (5.07cm) whereas longer internodal distance found in S-36 (6.29cm) (Table 3). Among the mulberry genotypes studied, the more number of leaves were recorded in MI-79 (743.93) followed by MI-506 (720.39) and MI-142 (620.96) and least number of leaves were recorded in MI-524 (77.48) (Table 3). In winter season single leaf area found maximum in SB-21 (351.49 cm2) followed by ME-012 (285.88cm2) and S-13(275.43 cm2). The minimum was observed in ME-27 (57.77 cm2) among the 15 elite mulberry genotypes (Table 3). In winter season MI-79 yielded maximum leaf yield (3119.42g/plant) followedby S-36 (2884.91g/plant) and ME-52 (2644.04g/plant). However, minimum was recorded in ME-27 (424.89g/plant) (Table 3). Among 15 mulberry genotypes, this trait was maximum in ME-52 (535.67g) followed by SB-21(513.66g), MI-32 (454.36g) and S-13(443.56g). ME-27 (88.97g) registered minimum 100 fresh leaves weight (Table 3). Vijayashekara (2009) [13] evaluated fifty mulberry accessions for morphological characters in rainy and winter season. It was reported that leaf yield per plant was maximum in C-763 (2888.68 g), C-20(2446.6 g) in rainy season. Whereas,in winter season ME-27 (1658.0 g) and S-13(1399.7 g) recorded maximum leaf yield per plant. During winter season also no single genotype was superior in respect of all the traits studied. Genotype ME-224 was superior in respect of different traits like plant height, number of branches per plant, number of leaves and leaf yield per plant. In contrast to this, total shoot length in ME-18. MI-143 was recorded highest single leaf area. More fresh leaf weight was recorded in ME-95, less intermodal distance was noticed in ME-06, in line with the findings of Saratchandra *et al.*, 1992 [12] recorded high leaf yield in S-36 (33.24 t/ha/yr) followed by RFS-135(32.93 t/ya/yr). Similar results were also reported by Masilamani *et al.*, 2000 [8]. Leaf yield of ME-224 (2689.37g) and (2642.27 g) was recorded per plant during rainy and winter season respectively, the leaf yield was more in rainy season compared to winter season. This may be due to presence of more number of branches, single leaf area, more total shoot length, plant height and other mulberry growth parameters. Kasiviswanathan and Iyengar (1969) [7] reported that, there is a difference in leaf yield during different seasons in a particular year is due to wide behavioural variation met with its growth. Variation in performance among the fifteen

mulberry genotypes shows highly significant differences among four characters *viz*, total shoot length, plant height, number of branches per plant and leaf yield indicating presence of sufficient amount of variability with respect of all the characters studied in both the seasons. The genotypic differences were more in rainy season compared to winter season. Tikader and Roy (2006) [10] observed variation for different growth attributes with number of branches ranged from 25 to 97, intermodal distance (2.54 to 5.29 cm), leaf area (64.03 to 242.00 cm2), leaf yield (1.25 to 23.00 kg) per plant. Similar results were reported by Tikader *et al.* (2004) [11]. The results on evaluation of fifteen mulberry genotypes for the different growth parameters during rainy season revealed that, variation was recorded among genotypes in respect of plant height ME-224 (247.50 cm), total shoot length ME-224 (10603.00 cm), number of leaves per plant ME-95 (911.50), single leaf area MI-143 (292.07 cm2), 10 fresh leaf weight MI-143 (27.83 g), and leaf yield per plant ME-224 (2689.37 g), intermodal distance ME-03 (5.87 cm), number of branches per plant ME-224 (62.75). Same trend was noticed in winter season. This may infer that considerable improvement in mulberry could be achieved through selection based on these parameters.

Table 3: Mean performance of 15 elite mulberry genotypes for different growth & yield parameters during winter season

Sr. No.	Genotypes	Plant height (cm)	Number of branches per plant	Total shoot length (cm)	Internoda l distance (cm)	Number of leaves per plant	Single leaf area (cm2)	Leaf yield per plant (g)	100 fresh leaves weight (g)
1	ME-52	249.87	23.82	2723.23	9.07	423.50	237.51	2644.04	535.67
2	ME-27	268.92	11.92	6572.71	5.07	451.27	57.77	424.89	88.97
3	MI-32	337.24	20.50	4185.27	6.55	556.33	203.48	1241.18	454.36
4	ME-012	196.53	23.38	2426.47	5.44	445.62	285.88	1582.75	430.20
5	MI-142	313.20	26.15	3421.79	4.76	620.96	115.38	1470.29	196.51
6	MI-79	267.98	36.87	4755.32	5.40	743.93	148.36	3119.42	177.56
7	C-763	286.60	31.53	5284.24	5.57	587.61	129.59	1542.59	171.70
8	SB-21	273.09	25.71	4134.62	6.83	457.68	351.49	1322.25	513.66
9	C-20	275.40	11.99	2566.07	5.74	280.40	185.18	2478.50	267.63
10	ME-144	266.77	26.25	3874.88	5.40	516.33	126.16	1357.01	236.93
11	S-36	338.32	24.30	3287.42	6.29	562.70	226.43	2884.91	260.48
12	S-13	263.36	28.11	3256.08	5.84	504.36	275.43	2637.03	443.56
13	MI-139	282.22	24.71	4293.74	5.85	605.51	152.08	981.00	147.49
14	MI-524	221.34	25.78	366.17	5.51	77.48	111.70	2245.66	281.91
15	MI-506	276.62	26.91	3484.44	4.45	720.39	113.93	1246.06	211.23
	Mean	274.50	24.53	3642.16	5.85	503.60	181.34	1811.84	294.52
	Environment index	2.43	-0.69	-17.88	-1.05	-15.19	-5.41	-1608.56	-14.32
	C.V.	0.81	7.61	0.12	4.04	0.75	1.87	1.06	15.44
	SEm±	1.81	1.52	3.52	0.19	3.11	2.77	15.74	37.14
	CD @ P=0.05	3.72	3.12	7.22	0.39	6.36	5.68	32.24	76.08
	CD @ P=0.01	5.02	4.21	9.74	0.53	8.58	7.66	43.50	102.63

Summer season

S-36 (313.06 cm), MI-32 (302.74 cm), MI-142 (292.93 cm) and C-763 (273.54 cm) found to be taller. Whereas, ME-52 (164.56 cm) found shortest plant (Table 4). Number of branches per plant were found to be maximum in MI-79 (35.05) followed by MI-524 (33.58), and ME-012 (29.56). Whereas C-20 recorded lowest (9.63) number of branches per plant (Table 4). Among all genotypes, longer shoot was found in ME-27 (6287.35cm) followed byC-763 (5191.82cm) and MI-79 (4591.58 cm). MI-524 (309.26cm) recorded shorter shoot length (Table 4). Among evaluated genotypes shorter intermodal distance indicated in the genotypeMI-79(2.03cm) and C-763(4.16cm) and it was longer in the ME- 52 (8.51cm) (Table 4). Maximum number of leaves per plant was recorded in genotype MI- 506 (732.93) followed by MI-79 (714.69) and MI-142 (674.11) whereas MI-524 (83.96)

recorded minimum number of leaves per plant in summer season (Table 4) Among 15 genotypes, the single leaf area registered maximum in MI-142 (386.85cm2) followed by SB-21 (338.49cm2) and S-13(248.33cm2). On the other hand the lowest single leaf area recorded in ME-144 (95.30cm2) and ME-27 (52.35cm2) (Table4). Among 15 genotypes maximum leaf yield recorded in MI-79 (2367.27g) per plant followed by S-36 (2350.99g/plant) and S-13(2294.38g/plant) in the mean while ME-27 (390.80g/plant) recorded lower leaf yield/plant (Table 4). ME-52 recorded maximum 100 fresh leaf weight (496.27g) followed by SB- 21(475.24g) and MI-32 (422.96g) on the other hand, MI-39 (147.44g) and ME-27 (70.42g) recorded less 100 fresh leaves weight.

Table 4: Mean performance of 15 elite mulberry genotypes for different growth & yield parameters during summer season

Sl. No.	Genotypes	Plant height (cm)	Number of branches per plant	Total shoot length (cm)	Internoda l distance (cm)	Number of leaves per plant	Single leaf area (cm2)	Leaf yield per plant (g)	100 fresh leaves weight (g)
1	ME-52	164.56	22.24	2381.44	2381.44	375.53	204.59	2273.42	496.27
2	ME-27	253.04	20.30	6287.35	6287.35	407.22	52.35	390.80	70.42
3	MI-32	302.74	27.17	3861.44	3861.44	594.05	187.07	1126.55	422.96
4	ME-012	191.40	29.56	2295.44	2295.44	495.11	254.11	1567.46	391.06
5	MI-142	292.93	26.74	3159.28	3159.28	674.11	386.85	1451.40	180.54
6	MI-79	248.19	35.05	4591.58	4591.58	714.69	138.18	2367.27	171.03
7	C-763	273.54	22.47	5191.82	5191.82	639.44	119.73	1561.03	159.80
8	SB-21	255.45	25.71	3764.84	3764.84	481.51	338.49	1343.78	475.24
9	C-20	256.14	9.63	2272.50	2272.50	239.12	171.09	2238.66	239.88
10	ME-144	258.23	21.75	3592.76	3592.76	521.01	95.30	1338.32	295.05
11	S-36	313.06	18.30	3088.61	3088.61	525.64	206.83	2350.99	237.10
12	S-13	258.70	26.46	3058.56	3058.56	469.38	248.33	2294.38	421.53
13	MI-139	268.56	22.01	3863.63	3863.63	643.62	144.17	972.60	147.44
14	MI-524	219.07	33.58	309.26	309.26	83.96	110.80	2239.04	244.86
15	MI-506	251.93	23.52	2960.72	2960.72	732.93	111.53	1258.72	175.10
	Mean	253.83	24.30	3378.61	3378.61	506.49	184.63	1651.62	275.22
	Environment index	-18.22	-0.92	-281.43	-281.43	-12.30	-2.12	-1768.77	-33.62
	C.V.	12.55	6.52	0.41	0.41	0.65	69.83	0.259	0.76
	SEm±	26.01	1.29	11.19	11.19	2.67	105.26	3.492	1.71
	CD @ P=0.05	53.28	2.65	22.92	22.92	5.48	215.62	7.153	3.51
	CD @ P=0.01	71.88	3.58	30.92	30.92	7.39	290.86	9.65	4.74

Summary

An experiment was conducted to know the performance of elite mulberry genotypes for growth and yield parameters during different seasons *viz*., rainy, winter and summer season The important findings of the investigation on "Study on performance of elite mulberry genotypes (*Morus* spp) under different season" was carried out at Department of Sericulture. The leaf yield of different elite genotypes differed significantly among different seasons. During rainy season, no single genotype was superior in respect of all the traits studied. Among 15 elite mulberry genotypes evaluated, highest plant height was recorded by MI-79 (341.95 cm), followed by S-36 (336.56 cm) and MI-142 (327.37 cm). During three season rainy, winter and summer MI- 79, S-36, ME-27, MI-139 and ME-52 found superior for all most all the traits contributing traits *viz*., number of branches, internodal distance, number of leaves per plant, leaf yield per plant (g).

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