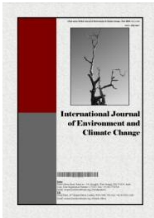

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Genotype x Environmental Interaction for Growth and Yield Parameters of Tree Mulberry Genotypes in Different Seasons

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BNA and Chikkalingaiah designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author Chikkalingaiah managed the analyses of the study. Author HDJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To identify the stable genotypes across the seasons for different yield and its contributing traits.
Study Design: Field experimental design was used
Place and Duration of Study: The experiment was conducted in different seasons during 2017-19 at Department of Sericulture, University of Agricultural Sciences, GKVK, Bangalore.
Methodology: The present study comprised of six mulberry genotypes *viz.,* MI-012, MI-79, MI-21, MI-139, MI-516, ME-05 and two popular check varieties V1 and M5.
Results: The mean squares due to seasons was significant for total shoot length (cm), number of leaves per plant, leaf yield per plant (g), ten fresh leaf weight (g), leaf moisture content (%) at harvest, leaf moisture retention capacity (%) at 6 and 9 hrs after harvest. Analysis of variance indicated high significance of mean sum of squares due to season for number of branches per plant, number of leaves per plant, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Further, it could be observed that

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variance due to seasons (linear) were highly significant for number of branches per plant, total shoot length, number of leaves per plant, ten fresh leaf weight, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Whereas, variance due to G x S (linear) was non significant for shoot height, internodal distance, number of leaves per plant, ten fresh leaf weight, leaf yield per plant, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Variance due to pooled deviation was highly significant for shoot height, number of branches per plant, total shoot length, internodal distance, number of leaves per plant, ten fresh leaf weight, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Whereas, variance due to pooled deviation was non significant for leaf yield per plant.

Keywords: Mulberry; Genotype; seasons; yield parameters.

1. INTRODUCTION

Mulberry leaf is a major economic component in sericulture since the quality and quantity of leaf produced per unit area have a direct bearing on cocoon harvest [1]. Hence, the growth and development as well the quality and quantum of cocoons produced are largely influenced by leaf quality [2]. The farmers with small land holdings with limited rainfalls besides grazing of animals in bush or dwarf system of plantations, especially in non-rainy seasons, the farmers are practicing sericulture a lot of amidst constraints [3]. In view of these constraints tree mulberry cultivation has become imperative to overcome the drought situation. Being a perennial hardy plant, mulberry is capable of thriving under varied of agro-climatic conditions [4]. At the same time, it is also a sensitive crop responding extremely well to optimum agricultural inputs but practically showing no growth when plant nutrients and moisture begin to operate as limiting factors. This is evident from the fact that under the poor rainfall conditions of 25-30" (625-750 mm) prevailing in South India, the current leaf yield is decreasing day by day [5].

Mulberry is perennial, deciduous, deep rooted, fast growing and high biomass producing tree. The quantity and quality of the silk is directly proportional to the quality of mulberry leaves fed to the silkworm larvae thereby positively affecting the overall cocoon production [6]. The nutritional quality of mulberry leaves plays an important role in nutrition of silkworm and in turn cocoon. The mulberry leaves alone contribute 38.20 per cent for quality cocoon production [7].

Keeping in view, as 50 per cent of the area under mulberry is rain dependent for its moisture requirement, growing mulberry as a high bush/low tree helps the root system to develop more extensively and deeper into the soil. Problem of cultivation of large area of non-available areable land in hilly terrains of the country. Regular inter cultivation can be reduced when compared to bush form, since the tree is perennial, root growth is deep hence it can be mitigating the long moisture stress condition with normal foliage yield. Wider spacing in tree mulberry helps to free movement of air and sunlight hence there is a less chance of pest and diseases in the crop, good quality leaf can be obtained. Mechanization of intercultural operation is also easy. There is no spoilage of the leaf during harvesting and inter cultivation [8].

The genotype (G) x environment (E) interaction (G x E) is an important parameter for plant breeding programme to identify the stable genotypes that are widely adapted to unique environment [9]. G x E interaction also affects the gains, recommendation and selection of cultivars with wider adaptability [10]. On the other hand, different genotypes have different performances in each region that can be capitalized to maximize the productivity [11]. Stability of genotypes over wide range of environments is desirable and depends upon G x E interaction. To understand the structure and nature of G x E interaction is very important in crop improvement programs because the significant G x E can seriously impairs the efforts in selecting the superior genotypes [12].

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. Sarkar et al. [13] and Bari et al. [14] have emphasized that knowledge of the nature and relative magnitude of the genotype-environment interaction has great importance for selecting superior genotypes to be used commercially in diverse environmental conditions. Leaf yield of mulberry fluctuates with the season due to sensitivity of the genotypes to growing conditions. A genotype x environment interaction exists where the relative performance of varieties changes from environment to environment. Exploitation of G x E interaction may prove useful in identifying stable genotypes for different environmental conditions.

The present study has been undertaken to know the impact of genotype x season interaction for growth and yield parameters of tree mulberry genotypes in different seasons.

2. MATERIALS AND METHODS

The experimental material for the present study comprised of six mulberry genotypes *viz.,* MI-012, MI-79, MI-21, MI-139, MI-516, ME-05 and two check varieties V1 and M5. The mulberry genotypes were selected from the germplasm unit maintained in the Department of Sericulture. These were selected as elite genotypes based on their growth and yield parameters. The cuttings of these genotypes were prepared and raised in nursery in polythene covers and saplings were developed. Two and half months old saplings were transferred to main field during 2015-16 only one sapling per pit was planted with a spacing of 6 X 6 feet with RCBD design with three replications. These mulberry genotypes as tree were allowed to grow tall with a crown height of 5 feet from the ground level side branches were removed. The experimental plot is maintained as per the recommended package of practices for rain-fed mulberry. The genotypes were evaluated on 60th day after pruning for different growth and yield parameters during rainy, winter and summer season. The mean data of each genotype for each season were subjected to analysis of variance in order to study the genotype × season interaction and genotypes stability following the Eberhart and Russell model (1966) by using linear regression model [15].

3. RESULTS AND DISCUSSION

3.1 Pooled Analysis of Variance for Different Yield and Yield Contributing Traits at Different Seasons in tree Mulberry Genotypes

Identification and confirmation of the presence of environmental influence and genotype x environmental interaction is prime step in stability analysis. In the present study the magnitudes of genotype × season interaction as well as the influence of season on genotypes were assessed for all the characters over season by using the pooled data over environments. The mean squares due to seasons was significant for total shoot length (cm), number of leaves per plant, leaf yield per plant (g), ten fresh leaf weight (g), leaf moisture content (%) at harvest, leaf moisture retention capacity (%) at 6 and 9 after harvest. Whereas, mean squares due to seasons was non-significant for shoot height (cm), intermodal distance (cm) and moisture retention capacity at 12 hrs. While mean squares due to G × S interaction was non-significant for all the yield contributing traits (Table 1). These results are in line with the findings of earlier workers. Genotype x environment interaction was found to be significant for plant height, number of branches, total length of branches, leaf yield per plant, shoot weight per plant and aerial biomass. The genotype mean squares were found to be significant when tested against the pooled error, indicating that means of genotypes differed from each other [16]. Linear component of Genotype × Environment interaction was significant for leaf yield and Partitioning of mean squares due to genotype × environment interaction into linear and residual components revealed that major portion of interaction was due to linear component [17]. These two indicate the genotypes not only exhibited difference in their overall yield performance and high response to different seasons but a good prediction can also be made for performance across the seasons. Ghosh et al. [18], reported pooled analysis of variance showed that there were highly significant differences among ten mulberry genotypes for leaf yield over seven different environments, which indicated presence of wide variation among the genotypes for leaf yield.

3.2 Analysis of Variance for Stability of Yield and Yield Contributing Traits at Different Seasons in Tree Mulberry Genotypes

Analysis of variance indicated high significance of mean sum of squares due to season for number of branches per plant, number of leaves per plant, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. While it is moderately significant for total shoot length and ten fresh leaf weight. Whereas non significant for shoot height, intermodal distance and moisture retention capacity at 12 hrs. Analysis of variance for mean sum of squares due to genotype × season was non significant for all the characters.

Table 1. Pooled analysis of variance for different yield and yield contributing traits at different seasons in tree mulberry genotypes

Sl. no.	Trait	Genotype (MS_G) (8)	Season (MS_s) (6)	G × S MS $_{(G×s)}$(48)	Pooled error (MS_E)(168)
1	Shoot height (cm)	179.62	711.73	605.27	43.73
2	Number of branches	8.131	46.67***	11.97	0.933
3	Total shoot length (cm)	79244.14	315177.57**	93888.45	7004.58
4	Internodal distance (cm)	0.242	0.656	0.544	0.049
5	Number of leaves per plant	2118.06	45525.70***	4838.26	75.18
6	Leaf yield per plant (g)	52494.21	433716.12***	100797.47	53266.47
7	Ten fresh leaf weight (g)	10.07	164.93	30.96	0.657
8	Single leaf area (cm^2)	2081.47	4147.54	2769.81	408.21
9	Moisture content (%)	13.67	224.84***	16.53	5.80
10	Moisture retention capacity at 6 hrs (%)	27.18	248.16***	17.04	6.262
11	Moisture retention capacity at 9hrs (%)	47.12	198.35***	23.19	5.30
12	Moisture retention capacity at 12 hrs (%)	43.04	14.58	21.05	6.94

Note: Values in parenthesis indicate degrees of freedom
** Significant at 5%   ** Significant at 1%*

Table 2. Analysis of variance for stability of yield and yield contributing traits at different seasons in tree mulberry genotypes

Sl. no.	Source of variance	Mean sum of squares due to							
		D.f.	Shoot Height (cm)	Number of branches /tree	Total shoot length (cm)	Internodal distance (cm)	Number of leaves per tree	Ten fresh leaf weight	Leaf yield per tree (g)
1	Replication with in season	24	592.82	17.97	172771.15	1.17	2434.05	0.42	1123015.11
2	Genotypes (G)	7	1257.35	56.91	554709.01	1.69	14826.47	10.07	367459.48
3	Season,+ (G × S)	40	24743.20	652.46*	4861983.72*	22.35	396967.78*	47.71	5696492.31*
4	Seasons	5	3558.66	233.35***	1575887.88**	3.28	227628.50***	164.93	2168580.62***
5	G × S	35	21184.53	419.10	3286095.84	19.07	169339.27	30.96	3527911.69
6	Seasons (Lin)	1	3558.66*	233.35***	1575887.88***	3.28*	227628.50***	824.69	2168580.62***
7	G × S (Lin)	7	3130.35	171.76*	1117927.95*	2.68	26096.47	43.88	998032.22
8	Pooled deviation	32	18054.17***	247.33***	2168167.88***	16.38***	143242.79***	24.26	2529879.46
9	Pooled Error	168	7347.92	156.75	11176769.78	8.25	123630.61	0.65	8948768.03

**Significant @ p=0.05   ** Significant @ p=0.01*

Table 2. Continued

Sl. no.	Source of variance	Mean sum of squares due to					
		Df	Single leaf area (cm^2)	Moisture content (%)	MRC at 6 hrs (%)	MRC at 9 hrs (%)	MRC at 12 hrs (%)
1	Replication with in season	24	293.90	84.23	100.25	116.22	110.89
2	Genotypes (G)	7	2081.47	95.74	190.30	329.85	301.32
3	Season,+ (G × S)	40	117681.19	1703.06***	1849.96**	1803.57*	809.85
4	Seasons	5	20737.71	1124.23***	1240.80***	991.76***	72.94
5	G × S	35	96943.48	578.82	609.16	811.80	736.91
6	Seasons (Lin)	1	20737.71	1124.23***	1240.80***	991.76***	72.94
7	G × S (Lin)	7	7052.86	142.03	98.80	63.66	52.80
8	Pooled deviation	32	89890.61	436.79***	510.35***	748.14***	684.11***
9	Pooled Error	168	68580.17	975.43	1052.12	891.91	1165.98

** Significant at 5%   ** Significant at 1%*

Further, it could be observed that variance due to seasons (linear) were highly significant for number of branches per plant, total shoot length, number of leaves per plant, ten fresh leaf weight, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6,9 and 12 hrs after harvest of leaf. While, it is moderately significant for shoot height and internodal distance and non significant for moisture retention capacity at 12 hrs. Variance due to G x S (linear) were moderately significant for number of branches per plant, total shoot length and single leaf area. Whereas, variance due to G x S (linear) was non significant for shoot height, internodal distance, number of leaves per plant, ten fresh leaf weight, leaf yield per plant, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf.

Variance due to pooled deviation was highly significant for shoot height, number of branches per plant, total shoot length, internodal distance, number of leaves per plant, ten fresh leaf weight, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Whereas, Variance due to pooled deviation was non significant for leaf yield per plant (Table 2). The present results are agreement with the findings of earlier reports. The varieties significantly interacted with additive environments for all the growth characters and leaf yield. This GE interaction was due to the both linear and non-linear components as evident from the significance of variety × environment (linear) and pooled mean squares, respectively. However, the linear component was more pronounced for leaf/m, leaf area and single leaf weight, as the magnitude of variety × environment (linear) component was much higher than the corresponding pooled deviation for these characters. For rest of the characters both the linear and nonlinear components were almost equally important as the magnitude of these two components were almost similar [19].

Linear component was found to be greater magnitude than the non-linear components for six characters *viz*., plant height, number of primary branches per plant, total length of primary branches per plant, leaf yield per plant, weight of shoot per plant and biomass per plant which were found to be significant when tested against pooled deviation. The mean squares for pooled deviation were also significant for plant height and leaf yield.

4. CONCLUSION

Poled analysis of mean squares due to seasons was significant for total shoot length (cm), number of leaves and leaf yield per plant (g). Ten fresh leaf weight (g), leaf moisture content (%), leaf moisture retention capacity (%) at 6, 9 and 12 after harvest. Analysis of variance indicated high significance of mean sum of squares due to season for number of branches per plant, number of leaves per plant, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf. Analysis of variance for mean sum of squares due to genotype × season was non significant for all the characters. Further, it could be observed that variance due to seasons (linear) were highly significant for number of branches per plant, total shoot length, number of leaves per plant, ten fresh leaf weight, leaf yield per plant, single leaf area, moisture content and moisture retention capacity at 6 and 9 hrs after harvest of leaf.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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