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Productivity and quality of tree mulberry (*Morus alba* L.) leaves

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Abstract
A study on productivity and quality of tree mulberry, *Morus alba* L. was undertaken in farmers' field condition by utilizing established five tree mulberry gardens of one-year-old and above and one bush mulberry garden as a control in each of the Chikkaballapura and Kolar Districts. There was a significant difference in number of shoots (36.06 and 67.93), shoot length (108.00 and 112.03 cm), number of leaves/shoot (23.06 and 21.92) and leaf yield/ tree (2167.00 and 3409.83 g per tree), respectively in Chikkaballapura and Kolar Districts. The leaf area in Chikkaballapura gardens showed significant difference (125.55 cm^2), but it was non-significant in Kolar District. The leaf moisture (73.24 and 72.34%) and leaf moisture after 6 hours of harvest of leaves (62.10 and 61.02%) were minimum in tree mulberry compared to the bush mulberry. The carbohydrates (17.44 and 17.89mg/100g), proteins (27.72 and 32.77mg/100g), phenols (3.02 and 3.22mg/100g), nitrogen (4.43 and 5.24%), phosphorous (0.36 and 0.42%), potassium (1.26 and 1.33%), calcium (1.92 and 2.11%), magnesium (0.49 and 0.54%) and sulphur (0.12 and 0.14%) were significantly maximum in tree mulberry compared to bush mulberry, respectively in Chikkaballapura and Kolar Districts except for calcium content in Kolar District.

Keywords: Tree mulberry, productivity of mulberry, mulberry yield

Introduction

Mulberry (*Morus* spp.) (Family: Moraceae) is believed to have originated at the foothills of the Himalayas and has been distributed in the warm and moist climatic zones between 50° N Lat. and 10° S Lat. (Koidzumi, 1917) [4]. Mulberry is the only source of food for the silkworm *Bombyx mori* L. under cultivated in three different forms i.e., bush, low-cut and tree (Qader *et al.,* 1991) [11]. It is a fast growing deciduous woody perennial plant, normally cultivated as bush or dwarf tree by repeated pruning. It has a tap root system with minimum superficial roots, good coppicing power and is tolerant to lopping and pruning (Koul *et al*., 1980) [5]. In sericulturally important countries like China, India and Japan, the major economic product of mulberry is its foliage, which is being used for rearing the silkworm *Bombyx mori* L. Thus, the studies on mulberry mainly focus on enhancing foliage production (Vijayan *et al*., 1997) [14]. For the enhancement of foliage the irrigation water is one of the major factors. Mulberry requires about 1.5-2.0 inch acre water per irrigation at an interval of 6-12 days, depending upon the soil type of and season. About eight irrigations are required per crop of 65-70 days duration to achieve the maximum leaf yield. Thus the annual requirement of irrigation water for five crops is about 75 inch acre which is equal to 1875 mm rainfall, distributed equally at 36 mm per week or 5-6 mm per day (Lal, 2001; Gupta and Deshpande, 2004) [7, 3]. Presently, the farmers are facing critical problems with unpredictable rainfall and depletion of underground water table day by day. Hence, there is a need to overcome this situation by cultivating mulberry in tree form.

Materials and Methods

In order to study the growth and yield parameters, five tree mulberry gardens of one-year-old and above and one bush mulberry garden as a control were identified in each of the Chikkaballapura and Kolar Districts. The tree mulberry gardens with the spacing of 10'×10' and bush mulberry gardens with the spacing of (5'×3') ×2' of V$_1$ variety were identified for the study. Each garden was again divided into five sub-plots and four plants were randomly selected in each sub-plot and labelled for recording the observations throughout the study. The growth and yield parameters *viz*., total number of shoots/tree or bush, shoot length, number of leaves/shoot, leaf area and leaf weight/tree or plant were recorded in each garden in fixed plots

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for two crops before commencement of the rearing (on 50th day of pruning). Leaf samples were randomly collected from labelled tree and bush plants in each sub-plot, fresh weight was recorded and air dried at room temperature then kept in hot-air oven at 60°C for 18 hours and then dry weight was recorded for the estimation of leaf moisture. The leaves then powdered and stored in polythene bags. These samples were analysed for total carbohydrates, total protein, total phenols, N, P, K, Ca, Mg and S contents. The paired t-test was used to compare population means of tree and bush mulberry in order to assess the growth and yield parameters and nutritional components of the tree and bush mulberry.

Result and Discussion
Growth and yield parameters of tree mulberry
All the parameters regarding growth and yield among tree and bush system of plantation showed significant difference in both the districts, except for leaf area in Kolar District. The tree mulberry recorded higher number of shoots (36.06 and 67.93) and leaf yield per tree (2167.00 and 3409.83 g) compared to bush mulberry which was recorded shoot of 18.63 and 18.70 per tree and leaf yield per plant of 1032.22 and 943.74 g, respectively in Chikkaballapura and Kolar Districts. The leaf area in Chikkaballapura District was recorded higher in tree mulberry (125.55 cm^2) compared to bush mulberry (158.67 cm^2), wherein it showed higher in bush mulberry (158.67 cm^2) compared to tree mulberry (167.12 cm^2) in Kolar district. There was an improvement in

number of shoots by 93.56 and 263.26 per cent and leaf yield per tree by 109.94 and 261.31g, respectively in Chikkaballapura and Kolar Districts in tree mulberry over bush mulberry, wherein leaf area in Chikkaballapura tree mulberry gardens showed an improvement by 5.21per cent over bush mulberry (Table 1). Similar findings were reported by Tewary et al. (2008) [13], wherein tree mulberry recorded 20.11 shoots per tree in S$_1$ variety as compared to 14.16 in bush mulberry. More number of shoots was found in tree mulberry, probably due to wider spacing (10'×10'). Ananya (2014) [1] had reported that the leaf area in V$_1$ mulberry as 274.1 and 132.8 cm^2 in 9'×9' and 3'×3' spacings, respectively. Ghosh (2009) [2] and Shyla (2012) [12] have recorded leaf area of 223.09 and 169.16 cm^2, respectively in V$_1$ bush mulberry. However, the literature related to the leaf area in tree mulberry is wanting. Pillai and Jolly (1984) [10] reported that under hilly situations, among S$_{54}$, K$_2$, MR$_2$, Roso and Kosen varieties which were raised as tree plantations with a spacing of 5'×5', S$_{54}$ gave highest yield (8500 kg/ha) followed by K$_2$ (7800 kg/ha), MR$_2$ (7000 kg/ha), Kosen (6000 kg/ha) and Roso (5000 kg/ha). Kour and Nazir (1998) [6] have also reported leaf yield of 10,439 kg/ha/ year in bush mulberry with a spacing 1.8 x 0.9 m and 4,084 kg/ha/year in tree mulberry with a spacing 2.7 x 2.7 m, which indicated that higher leaf yield can be obtained in tree mulberry (7.44 kg / tree/ year) than in bush mulberry (4.23 kg/ plant / year), which is supporting the results of the present investigation.

Table 1: Growth and yield parameters of tree mulberry *vis-à-vis* bush mulberry in Chikkaballapura and Kolar District

Parameter	Chikkaballapura District					Kolar District				
	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush
No. of shoots/tree or bush	36.06±17.84	18.63±2.98	9.15	*	93.56	67.93±19.27	18.70±4.25	22.91	*	263.26
Shoot length (cm)	108.00±13.32	145.71±18.24	8.76	*	-25.88	112.03±12.48	133.94±16.75	5.55	*	-16.36
No. of leaves per shoot	23.06±4.82	29.92±3.61	6.61	*	-22.93	21.92±2.91	25.58±3.89	3.98	*	-14.31
Leaf area (cm^2)	125.55±14.01	109.36±12.40	5.21	*	14.80	167.12±29.14	158.67±29.38	1.18	NS	-
Leaf yield (g/tree or bush)	2167.00±1080.69	1032.22±215.39	9.59	*	109.94	3409.83±1171.40	943.74±262.65	18.82	*	261.31

*Significant at 5%, NS- Non-significant, CBP- Chikkaballapura (*Each value is mean of two crops of five gardens)

Nutritional composition of tree mulberry
Significant difference was observed among tree and bush system of plantation in both districts in all the parameters regarding leaf quality parameters. The higher total carbohydrates (17.44 and 17.89 mg/100g), total protein (27.72 and 32.77 mg/100g) and total phenol (3.02 and 3.22 mg/100g) were recorded in tree mulberry compared to bush mulberry, which was recorded as total carbohydrates of 14.12 and 15.10 mg/100g, total protein as 24.93 and 30.86 mg/100g and total phenol as 2.85 and 3.00 mg/100g, respectively in Chikkaballapura and Kolar Districts. There was an improvement in tree mulberry regarding total carbohydrates by 23.51 and 18.48 per cent, total protein by 11.19 and 6.19 per cent and total phenol by 5.96 and 7.33 per cent, respectively in Chikkaballapura and Kolar Districts over bush mulberry. However, in the present findings, the tree mulberry had less leaf moisture (73.24 and 72.34%) and leaf moisture after six hours (62.10 and 61.02%) than those from bush mulberry which had leaf moisture of 77.01 and 76.50 per cent

and leaf moisture after six hours of 67.16 and 65.54 per cent, respectively in Chikkaballapura and Kolar Districts (Table 2). Qader et al. (1991) [11] reported that the leaves harvested from bush mulberry contained higher moisture (76.52%) than those of tree (72.49%) and low-cut system (74.83%). In the present findings, leaves from tree mulberry had less moisture content than those from bush mulberry, which corroborates with the earlier findings. This may be attributed to the fact that bush mulberry receives excess water through irrigation, as compared to tree mulberry, which is water deprived. Narayanaswamy et al. (2003) [9], Maribashetty et al., (1999) [8] and Tewary (2005), have reported that the tree mulberry leaves contain more carbohydrate of 32.33%, 17.69 and 12.01 g/100g and higher crude protein content of 13.55, 18.64 and 24.38 per cent, respectively than in the bush mulberry leaves. The wider spacing would facilitate the availability of more sunlight, which might have enriched the photosynthates, resulting in higher content of carbohydrates in tree mulberry leaves.

Table 2: Nutritional composition of leaf of tree mulberry *vis-à-vis* bush mulberry in Chikkaballapura and Kolar Districts

Parameter	Chikkaballapura District					Kolar District				
	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush
Leaf moisture (%)	73.24±2.38	77.01±0.85	6.19	*	-4.90	72.34±2.38	76.50±1.06	6.90	*	-5.44
Leaf moisture after 6 hours (%)	62.10±2.86	67.16±0.92	7.16	*	-7.53	61.02±2.20	65.54±0.98	7.26	*	-6.90
Total carbohydrates (mg/100g)	17.44±0.65	14.12±0.06	24.87	*	23.51	17.89±0.33	15.10±0.03	41.49	*	18.48
Total protein (mg/100g)	27.72±1.01	24.93±0.05	13.75	*	11.19	32.77±1.73	30.86±0.06	5.49	*	6.19
Total phenol (mg/100g)	3.02±0.02	2.85±0.02	18.43	*	5.96	3.22±0.03	3.00±0.02	23.65	*	7.33

*Significant at 5%, NS- Non-significant, CBP- Chikkaballapura (*Each value is mean of two crops of five gardens).

Elemental composition of tree mulberry
All the parameters regarding elemental composition of leaves among tree and bush system of plantation showed significant difference in both districts, except for calcium content in Kolar District. The nitrogen (4.43 and 5.24%), phosphorous (0.36 and 0.42%), potassium (1.26 and 1.33%), magnesium (0.49 and 0.54%) and sulphur (0.12 and 0.14%) contents were recorded higher in tree mulberry than bush mulberry leaves, which was recorded as nitrogen by 3.99 and 4.94%, phosphorous by 0.33 and 0.37%, potassium by 1.23 and 1.28%, magnesium by 0.44 and 0.44% and sulphur by 0.10 and 0.12%, respectively in Chikkaballapura and Kolar Districts. Whereas the calcium content was higher in tree mulberry leaves from Chikkaballapura District. Similar findings were reported by Tewary (2005), wherein the leaves harvested from tree mulberry contained 3.90 per cent of nitrogen which was more than that in bush mulberry (3.70 per cent). Narayanaswamy *et al.* (2003) [9] reported that tree mulberry leaves contained more nitrogen (2.21%), phosphorous (0.17%), potassium (2.05%), calcium (1.95%) and magnesium (0.76%) than the bush mulberry leaves which was recorded nitrogen as 2.11%, phosphorous as 0.15%, potassium as 1.80%, calcium as 1.83% and magnesium as 0.63% which are on par with the present study results.
It is summarized that the yield and quality parameters of tree mulberry were superior over bush mulberry; thus stressing the need for cultivation of tree mulberry under water stress conditions.

Table 3: Elemental composition of leaf of tree mulberry *vis-à-vis* bush mulberry in Chikkaballapura and Kolar Districts

Parameter	Chikkaballapura District					Kolar District				
	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush	Tree Mulberry	Bush Mulberry	t-value	t-test	Per cent deviation over bush
Nitrogen (%)	4.43±0.16	3.99±0.01	13.75	*	11.03	5.24±0.28	4.94±0.01	5.49	*	6.07
Phosphorous (%)	0.36±0.02	0.33±0.01	5.57	*	9.09	0.42±0.03	0.37±0.01	7.05	*	13.51
Potassium (%)	1.26±0.02	1.23±0.01	6.82	*	2.44	1.33±0.01	1.28±0.01	10.26	*	3.91
Calcium (%)	1.92±0.05	1.76±0.01	14.64	*	9.09	2.11±0.06	2.14±0.01	2.05	NS	-
Magnesium (%)	0.49±0.02	0.44±0.01	9.35	*	11.36	0.54±0.02	0.44±0.01	2.76	*	22.73
Sulphur (%)	0.12±0.02	0.10±0.00	8.27	*	13.89	0.14±0.01	0.12±0.01	3.11	*	16.67

*Significant at 5%, NS- Non-significant, CBP- Chikkaballapura (*Each value is mean of two crops of five gardens).

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