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RESEARCH ARTICLE

INFLUENCE OF TREE MULBERRY (*MORUS ALBA* L.) IN VARIED GEOMETRIES ON MULBERRY LEAF AND SILKWORM REARING

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ABSTRACT

A field experiment was carried out at Regional Seri cultural Research Station, Kodathi, Bangalore during 2013-2015 to evaluate the impact of tree mulberry in varied geometries of 8'x3', 8'x5' and 10'x10' comparing with the age old recommendation of paired row spacing [(3'x2')x5'] grown in low bush form on the quality and quantitative characters of mulberry and cocoon production. A total of 10 crops mulberry harvest and single crop bioassay with silkworm rearing was conducted. Pooled data of 10 crops under varied geometries 8'x3', 8'x5' & 10'x10' supplemented with 50% reduced levels of NPK & FYM compared with traditional paired row spacing [(3'x2')5'] as control maintained under recommended doses of NPK @ 350:140:140kg/ha/yr along with 20MT FYM/ha/yr. The results revealed that significantly increased levels of mulberry leaf yield was recorded under the spacing 8'x3' (13,414.36kg/ha/crop) followed by the paired row spacing (12,028.89 kg/ha/crop) and 8'x5' spacing (10,234.79kg/ha/crop). Similarly the plant growth and leaf nutrient parameters too showed significant improvement in respective of the wider spacing under tree farm cultivation. However, the wider spacing with 10'x10' has shown significantly reduced levels of mulberry leaf yield giving an indication that extremely reduced plant population i.e. 8% compared to recommended no of plants/ha (13,888) is not only un-economical but also incurring the wastage of potential cultivable land of the small as well as medium farmers compelling the reduction of brushing capacity. Chemo-assay of mulberry leaves also revealed the significantly increased levels of total chlorophylls reflecting its impact on the increased qualitative and quantitative parameters of silkworm cocoon characters in wider spacing. From the results it is evident that mulberry grown in tree farm with the use of economically viable irrigation methods as affordable micro irrigation technologies (AMITs) is not only viable but also have long term benefits even in combating with drought stricken conditions compared to the traditional paired row spacing practice.

Key words: Mulberry, wider spacing, silkworm, bioassay, leaf yield

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INTRODUCTION

In India, mulberry (*Morus alba* L.) is raised under a variety of conditions for sericultural purposes. While the huge existing trees are exploited by lopping the branches for collecting leaves in the state of Jammu and Kashmir it is mostly raised as a bush in the states of Karnataka and West Bengal, which together accounts for over 90% of silk production of the country. Even as bushes, they are raised under a variety of conditions in different agro-climatic regions. In Karnataka it is raised as pit system of plantation with 3'x3' spacing with entirely rainfed and paired row spacing ((3'x2') x5') in irrigated conditions. In parts of Karnataka like the Kolar Divisions, where intensive cultivation of mulberry is practiced under heavy manuring and irrigated conditions with closed system of planting (1'x2'). Besides spacing, there is also considerable difference in the method and frequency of pruning. Spacing of crop plants mainly depends on their growth habits; however, the magnitude of growth is governed by edaphic and climatic factors (Ramakant *et al.,* 2001). Singh and Singh (1991) reported significant effect on crop yield. Light plays an important role in photosynthesis of the plants and thus ultimately decides the dry matter accumulation and vegetative growth of the plants. Krishnaswami *et al.* (1971) reported that growth and

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development of silkworm larvae, *Bombyx mori* L. And the economic characters of their cocoons are greatly influenced by the nutritional content of mulberry leaves. Proper spacing and consequent plant population per hectare has been recognised as one of the important factor in determining leaf yield (Kasivis wanathan and Sitarama Iyengar, 1970). Mulberry (*Morus alba* L.) leaf production is often limited by the amount of available soil moisture and it can be increased by providing timely irrigation. Experimental findings reveal that irrigation increased leaf yield of mulberry plants by about 68%. Hence, increase in leaf yield and water productivity of mulberry is possible by improved methods of irrigation. The gap between water demand and supply is increasing year after year and declining in availability of ground water further aggravate the situation causing major threat to agriculture globally. Prolonged drought stricken atmosphere in Karnataka compelling the sericulturists in shrinking the mulberry cultivation and either preventing or reducing the silkworm rearing in summer seasons.

The reasons for low availability of irrigation water are irregular and inadequate rainfall, short spell down pouring >50% annual rainfall in single or multiple days heavy drowning and inadequate ground water are charge for bore wells leaving the recurrence of drought condition for prolonged period (Shankar and Shiva kumar, 2000). The South Indian seri cultural farming community have been recommended during 3-4 decades back the paired row system of cultivation with [(3'x2')x5'] spacing by accommodating 13,888 plants/hectare where the sufficient irrigation water was available to feed 1.5 to 2.5 lit/plant through channel irrigation was possible. But slowly the monsoon down pouring has come down to 50%, uncertain and untimed rain fall will be drenched in one month leaving the farming community thrive with drought stricken conditions for rest of the period. Further, due to insufficient irrigation, farmers are not able to harvest required quantity of quality leaf during drought stricken conditions leading to silkworm crop failures. The ground water level has gone down to >1500ft even though at times no water will be available if drilled more than the above depths. Further, man power availability has become a big crisis due to urbanization.

Narrow spacing minimized the mechanised ploughing leaving the mulberry gardens un ploughed even for years leading to superficial root system instead deep rooting restricting the poor quality with reduced leaf yields. Under the above difficult conditions some of the farmers in Karnataka are compelled to adopt tree mulberry in wider spicing such as 5'x5', 6'x6', 8'x3', 8'x5' & 10'x10' so on convenient for mechanized cultivation maintained either in rain fed conditions or semi irrigated system through the adoption of AMITs by providing plant wise manure, fertilizer & water and succeeding uniform quality of leaf with enhanced quality of cocoon. As there is no any recommended technology or package of practices for cultivation of mulberry in tree farm in ideal spacing with suitable training under required doses of manure and fertilizers for uniform and enhanced quality leaf for bivoltine sericulture. Hence attempt was made to establish and provide a suitable technology for tree mulberry farming to combat with the drought stricken conditions and to perform bivoltine sericulture in all the possible seasons in Southern part of India.

MATERIALS AND METHODS

Two years experimental trials (with ten mulberry crop harvests) was laid out at Regional Seri cultural Research Station , Kodathi, Bangalore mulberry farm during 2013-15 to study the impact of tree mulberry under affordable micro irrigation technologies (AMITs) to study quality and quantitative parameters of mulberry leaf yield and its impact on silkworm rearing. The experiment was undertaken in 4 years old well established V1 mulberry gardens planted in wider spacing such as 8'x3', 8'x5' and 10'x10' training in the farm of tree comparing with traditional recommended paired row spacing with low bush farm planted in [(3'x2')x5']. The low bush plantation was maintained with stump cut height (15cm) from ground level, whereas tree farms maintained with a height of 3 feet stumps training crown at the above 3' height. The experiment was designed in Randomized Block Design (RBD) consists with 4 treatments i.e. T1= With paired row spacing [(3'x2')x5'] in low bush farm with 13,888 plant population as control, T2= Tree farm in 8'x3' spacing with 4,547 plants, T3= Tree farm in 8'x5' spacing with 2,728 and T4= Tree farm in 10'x10' spacing with only 1,093 plants in tree farms in 3 replications.

Each replicated gross plot measuring with 1024 sq.ft. Accommodating 128 plants whereas net plot in 672 sq.ft with 84 observatory plants. The inorganic fertilizers @ NPK 350:140:140kg/ha/yr and farmyard manure (FYM) @ 20MT/ha/yr were applied in case of T1, whereas rest of the treatments were supplemented with 50% reduced doses of NPK and FYM. All the treatment replicated plots were maintained throughout the study period following recommended package of practices for irrigated mulberry (Dandin *et al*., 2003). The manure and fertilizers were applied to the respective plant basins in case of tree farms (T2, T3 & T4) of mulberry whereas the same were broad casted in paired row spacing (T1). Channel irrigation was imparted in paired row (low bush) plantation where as economic irrigation was adopted through the AMITs by the use of Drips in tree mulberry. The experimental replicated plots of T1-Paired row spacing in low bush farm maintained in irrigated conditions by giving 1.5 acre inch of water/irrigation in 3-4 days interval. Whereas, T2, T3 & T4 replicated plots were imparted drip irrigation methods in the farm of AMITs.

For studying the plant growth and leaf yield parameters 5 no. of plants were selected randomly from each treatment and replication and observations recorded on plant height, no. of branches, no. of leaves/plant and intermodal distance. The total leaf yield was assessed by harvesting all the plants available in net plot and converted to yield per hectare after 70 days after pruning of every crop i.e. for 5 crops in year. For leaf area, 10 healthy leaves were taken from 10 plants selected at random in each replicated plot and the area was calculated through the *regression equation area = -2.12+0.68 (LxB)* (Satpathy *et al*., 1992). Moisture in chawki ($2^{nd}/3^{rd}$) and medium leaves ($5^{th}/6^{th}$) and chlorophylls contents in $5^{th}/6^{th}$ leaves from the top were estimated (Rao *et al*., 1991). Bioassay with silkworm rearing was undertaken by feeding the different treatment leaves brushing with CSR_2xCSR_4 bivoltine breeds with 3 replications/ treatment during December, 2015. Cellular brushing was conducted up to Chawki by feeding uniform quality chawki leaf and late age rearing was conducted keeping 300 worms per replicate as per treatments. All the improved technologies as recommended for the Bivoltine silk worm rearing was followed (Dandin *et al.,* 2003). All the plant growth, yield, quality and silkworm rearing data were statistically analyzed using ANOVA with factorial analysis.

Paired row spacing [(3'x2')x5'] in low bush form

Tree mulberry in 8'x3' spacing

Tree mulberry in 8'x5' spacing

Tree mulberry in 10'x10' spacing

Fig. 1. Mulberry plantation in varied geometries with different form of cultivation grown under AMIT technologies

RESULTS AND DISCUSSION

During the period under the experimentation, 10 crops plant growth, leaf yield and leaf biochemical analysis recorded was compiled, pooled data was subjected to ANOVA and presented. The mulberry plant growth and leaf yield was responded significantly well to the tree farm of mulberry in wider spacing T2 (8'x3'), T3 (8'x5') and T4 (10'x10') compared to paired row spacing T1-[(3'x2')x5']. Significantly increased quantity of leaf was recorded under wider spacing 8'x3' (T2-13,414.36kg/ha/crop) where only 32% of plants were compared to traditional paired row spacing T1-12,028.89 kg/ha/crop maintained with 13,888 plants. However, T3 with 20% tree plants in 8'x3' and T4 with 8% tree plants in 10'x10' spacing raised were recorded significantly reduced levels of leaf yield (10,234.79 and 4,216.7 kg/ha/crop respectively) indicating that plant population is directly proportional to leaf yield (Table 1 and Fig 2). Tree farm of 10'x10' spacing plant population is very low (T4- tree farm with 1093 plants) as compared to T1 (paired row spacing with 13,888 plants), T2 (Tree farm with 4547 plants) and T3 (tree farms with 2728 plants). However, yield of foliage per plant was not reduced proportionately because of yield contributing factors viz. number of branches, length of shoot, number and weight of leaves per branch having been compensated to a considerable extent. It is understood that though plant wise yield and nutritive parameters are superior over paired row spacing in 10'x10' but plant population density is also important to achieve the sustained leaf yield.

The same was opined by Hasegawa (1967), stating that the relation of plant density and yield was variable (Fig 2). Similar trend of other plant growth parameters such as plant height, no. of branches, no. of leaves, leaf area and leaf shoot ratio also shown significant level of improvement over T1, however, intermodal distance have remained insignificant compared to the treatments with control (Table 1). Thus it can be inferred that with the increase in pruning height in tree farm plantation there was corresponding increase in the leaf yield compared to the low bush (15cm) pruning. Studies carried out elsewhere have indicated improved plant growth and increased leaf yield due to higher crown height against the low height (Choudhury *et al*., 1991; Fotadar *et al.,* 1995; Iwata, 1977; 1981; Katsuochiyamna, 1970; Katsuochiyamna *et al*., 1976; Satoh, 1968). Similar results were recorded in other plantations such as teak, *Solanum* sp. and *Coleus* sp. by several workers (Suresh *et al.,* 2010; Khandelwal *et al.,* 2004). Significant variation was observed in leaf quality parameters such as leaf moisture in the medium leaves and total chlorophylls compared to the control plots. Marked increase in moisture content was observed in T3 (80.34%) followed by T4 (80.31%) and T2 (78.56%) compared to the T1 (control-77.24%). Similar trend was observed in case of total chlorophylls. However, no identical variation was observed in leaf moisture content of chawki leaves (Table 2). Jelmoni (1943) has given a complete data on mulberry leaf yield obtained as a result of various kinds of agronomical practices. Among all, allowing mulberry plant to sprout at a height of 50cm from the ground level resulted in highest production per hectare.

Table 1. Influence of tree mulberry in varied geometries on the plant growth and leaf yield of mulberry.

Treatment	Plant height (cm)	No of branches/ plant	No of leaves/ plant	Inter-nodal distance (cm)	Leaf Area (cm^2)	L:S Ratio (%)	Leaf Yield (kg/ha/cr)
T1-Paired row in [(3'x2')x5']	200.15	11.68	292.45	5.91	215.70	60.66	12028.89
T2-Tree in 8'x3' spacing	219.74	18.99	395.58	5.98	235.68	62.96	13414.36
T3-Tree in 8'x5' spacing	231.68	22.79	487.03	5.80	237.28	63.53	10234.79
T4-Tree in 10'x10' spacing	240.21	26.56	575.99	5.85	241.15	61.93	4216.74
F value	***	***	***	--	***	**	***
CD at 5%	7.20	0.85	40.01	NS	5.81	1.26	317.64
CV%	6.87	27.57	24.35	4.15	4.46	1.94	35.24

*Paired row/ IJ spacing in low bush as control; **Data presented are mean values of 2 years or 10 seasonal crops.

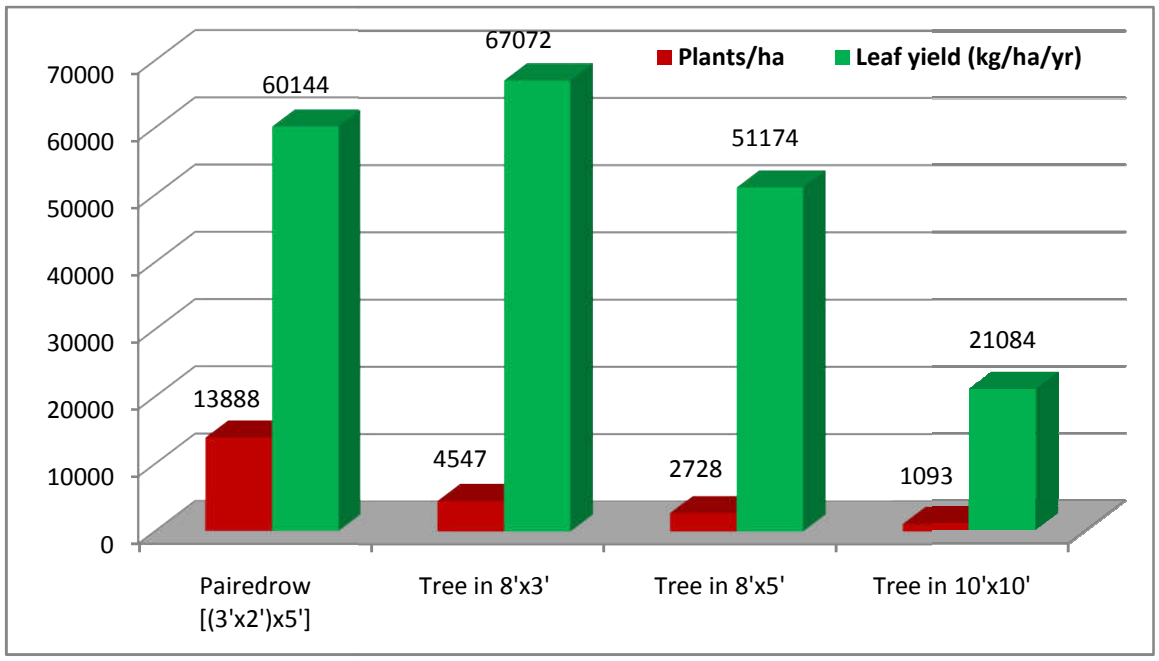

Fig. 1. Annual mulberry leaf yield as influenced by the plant population under varied spacing

Sato (1968) has shown the mulberry plants cut to a height of about 40cm above the top of stump (Kabuage training) gave more leaf yield than the one which was cut at the base of shoots (Negari training). Later studies by Iwata (1978, 1981) have also proved that between two pruning methods viz. cutting of plants to a height of 10cm and 35cm from the ground level, the latter gave better branching, better branch growth and also more leaf yield as compared to farmer. Biochemical analysis has revealed that there was a significant increase in soluble sugar and starch contents in the leaf of high stem pruning (35cm above the ground level) as compared to basal pruning (Anonymous, 1987).

Table 2. Influence of tree mulberry in varied geometries on qualitative characters of mulberry leaf

Treatment	Leaf Moisture (%)		Total Chlorophylls (ppm)
	Medium(%)	Chawki(%)	
T1-Paired row in [(3'x5')2']	77.24	82.87	2.58
T2-Tree in 8'x3' spacing	78.56	84.22	3.32
T3-Tree in 8'x5' spacing	80.34	83.38	3.35
T4-Tree in 10'x10' spacing	80.31	82.76	3.20
F value	*	--	***
CD at 5%	1.88	NS	0.08
CV%	2.00	1.18	10.14

The bioassay results with CSR_2xCSR_4 silkworm rearing feeding with 9th crop (Nov-Jan) treatment wise mulberry leaves revealed that no marked variation was observed due to wider pacing with tree farm of cultivation (T2, T3 & T4) compared with paired row spacing have shown no significant variation compared to the traditional paired row spacing (T1) in case of silkworm rearing quality parameters such as ERR no & ERR weight and SR% confirming the observations recorded by Zubayri (1993) and Vinod Kumar and Benchamin (1990). However, marked variation was noticed in T2 indicating an edge over the other treatments (T1, T3 & T4) pronouncing that tree farm of cultivation with 8'x3' spacing under 50% reduced levels of manure and fertilizers has its superiority in improving not only yield and plant growth parameters but also encouraging the superior quality of commercial rearing performance (Table 3).

Table 3. Influence of tree mulberry in varied geometries on qualitative and quantitative characters of silkworm rearing

Treatments	Silkworm rearing quality parameters				
	ERR/ 10000 larvae		SCW (g)	SSW (g)	SR (%)
	No	Weight g)			
T1-Paired row in [(3'x2')x5']	9655.33	16.57	1.754	0.369	20.30
T2-Tree in 8'x3' spacing	9744.00	17.33	1.836	0.381	21.03
T3-Tree in 8'x5' spacing	9144.00	17.07	1.826	0.371	20.53
T4-Tree in 10'x10' spacing	9510.67	16.33	1.791	0.369	20.67
CD at 5 %	*N.S.*	*N.S.*	*N.S.*	*N.S.*	*N.S.*

SCW=Single cocoon weight, SSW= Single Shell weight

Table 4. Cultivation cost and cost of production of bivoltine cocoon production under varied geometries of mulberry

Sl No	Activity/ Inputs/ Materials	Quantity (No/MT/kg/ha/yr		Rate (Rs)	Varied Geometries of plantation			
		Paired row	Tree Farm		Paired row [(3'x2')5']	Tree farm (8'x3')	Tree farm (8'x5')	Tree farm (10'x10')
Mulberry Cultivation Cost/ hectare:								
1	No. of Plants/ha	--	--	--	13,888	4,547	2,728	1,093
2	Farmyard Manure (FYM)/ MT/ha	20MT	10MT	1250.0	25,000	12,500	12,500	12,500
3	Fertilizers: (@ NPK 350:140:140kg/ha/yr)							
	Ammonium Sulphate (AS) (100 & 50%)	1750	875	13.2	23100.0	11550.0	11550.0	11550.0
	Single Super Phosphate (SSP) (100 & 50%)	875	438	8.4	7350.0	3675.0	3675.0	3675.0
	Muriate of Potash (MOP) (100 & 50%)	240	120	11.58	2779.2	1389.6	1389.6	1389.6
4	Application of FYM (Rs 250/- per MD)	16MD	10MD	250/-	4,000.0	2,500.0	2,500.0	2,500.0
5	Application of Chemical fertilizers	10MD	6MD	250/-	2,500.0	1,500.0	1,500.0	1,500.0
6	Tractor Plough (by cultivator) (Rs/ha)	5 times	5 times	2500/once	12,500.0	10,000.0	10,000.0	10,000.0
7	Channel making by tractor (@Rs 2000/-ha)	5 times	--	2000/once	10,000.0	--	--	--
8	Irrigation: (Channel / Drip)	100MD	50MD	250/-	25,000.0	12,500.0	12,500.0	12,500.0
9	Shoot harvest	200MD	200MD	250/-	50,000.0	50,000.0	50,000.0	50,000.0
10	Tax Paid on Land (Rs. 100/ha)	--	--	100.0	100.0	100.0	100.0	100.0
	TOTAL			--	1,62,329.2	1,05,714.6	1,05,714.6	1,05,714.6
11	Leaf yield (kg/ha/yr)	--	--	--	60,145.0	67,072.0	51,174.0	21,084.0
12	Cost of leaf (@ Rs. 5/- per kg)	--	--	--	3,00,725.0	3,35,360.0	2,55,870.0	1,05,420
13	Net Gain through leaf production	--	--	--	1,38,395.8	2,29,645.4	1,50,155.4	-294.6
14	Cost: benefit Ratio of leaf production	--	--	--	1 : 1.9	1 : 3.2	1 : 2.4	1 : 1.0
Silkworm Rearing/ Hectare:								
15	No. of DFLs to be brushed/ha/yr	--	--	--	4375	3125	2500	1250
16	Cost of DFLs (chawki worms/100DFLs)	2000/-	2000/-	--	875000	62500.0	50000.0	25000.0
17	Cocoon Yield (kg/100DFLs)	60kg	80kg	--	2625	2500	2000	1000
18	Cost of Cocoon/ha/yr (Avg. Market Rate Rs/kg)	350/-	500/-	--	9,18,750.0	12,50,000.0	10,00,000.0	5,00,000.0
19	Input cost of each rearing (@ 25%)	--	--	--	2,29,687.0	1,64,062.0	1,31,249.7.0	52,499.9
20	Net Gain due to rearing	--	--	--	6,89,063.0	10,85,938.0	8,68,751.0	4,47,500.1
21	Comparative gain over paired row spacing:	--	--	--	--	157.6%	126.1%	-35.1%
22	C : B Ratio of varied spacing	--	--	--	1 : 2.3	1 :4.6	1 :4.2	1 : 3.2

Man Day (MD) = Rate per MD is @ Rs. 236/- rounded of to 250/- per MD; *Tractor ploughing: @ Rs. 2,500/ ha for paired row spacing low bush farm, Whereas Rs.2,000/ tree mulberry farm; Irrigation: For flood: @3MD/ irrigation x10times per crop x 5crops); Drip: @1MD per irrigation x 10 times x 5 crops; Fertilizers: Rec. dose of AS, SSP & MOP & FYM (350:140:140kg/ha/yr & 20mt/ha/yr) applied in IJ spacing; whereas the same reduced to 50% in tree mulberry; ** DFLs brushing: IJ spacing @875DFLs/ha/crop; 8'x3' spacing @625DFLs/ha/crop; 8'x5' spacing @ 500DFLs/ha/crop; 10'x10' spacing @250DFLs/ha/crop.

Further the impact of tree farm of cultivation in varied geometries was also assessed their impact on the cost benefit ratio of leaf as well as cocoon production. It was noticed that tree farm of mulberry with reduced number of plant population (T2 with 4547 & T3 with 2728 plants) compared to T1 (13,888) under paired row spacing imparted with full doses of NPK & FYM recorded reduced cost of production (maintained even under 50% reduced application of inorganic fertilizers and manure exhibited the increased benefit in case of leaf as well as cocoon in case of T2 (1:3.2 & 1:4.6) followed by T3 (1:2.4 & 1:4.2) followed by T1 (1:1.9 & 1:2.3), respectively) (Table 4). However, though the lower level of benefit was recorded in case of leaf production in T4 but cocoon production shown an edge over T1 indicating that plant population has its own importance in the production of sustainable quality leaf as pronounced by Hasegawa (1967) statement as '*decline in yield with a decline in plant population density'.*

Conclusion

It could be inferred that the plant population play an important role in production of sustainable leaf production. Economic level of plant population to sustain with available water resource without compromising the quantum of DFLs brushing (250-300DFLs) and performing rearing in all most all the crops without fail will be the main objective. The above results have generated a hope that through the tree mulberry farming under 8'x3' spacing with 4547 plants supplemented with 50% reduced doses of fertilizers, manure and limited water supply is an ultimate to the South Indian farming community and to the other drought stricken atmosphere prevailing areas of India.

Further, the tree farm of mulberry farming has shown its resistance and tolerance level to the extreme drought prone situations because of its deep root system with strong and well established firm aerial stem promoting silkworm rearing in all the seasons, whereas the same was proved not possible in case of paired row spacing with more number of plants (13,888) indicating difficult to maintain under scarce water availability and also showing wilting symptoms in summer crops forcing the farming community to with draw silkworm rearing crops. Therefore, tree farm of mulberry is an imperative to not only for enhanced and assured leaf production but also to combat with acute drought stricken climatic conditions.

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