INFLUENCE OF *IN SITU* MOISTURE CONSERVATION METHODS AND FERTILISERS ON EARLY GROWTH OF TEAK (*TECTONA GRANDIS*)

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KOPPAD, A. G. & RAO, R. V. Influence of *in situ* moisture conservation methods and fertilisers on early growth of teak (*Tectona grandis*). An experiment was conducted in a farmer's field at Sugavi village in the hill zone of Karnataka, south India to study the effect of moisture conservation methods and fertilisers on the early growth of teak. Moisture conservation methods, fertilisers and their interactions influenced plant survival, height and collar diameter of teak. Among the moisture conservation methods, ring basin method resulted in higher plant survival (83%), plant height (178 cm) and collar diameter (3.2 cm) after 24 months of planting. Plants grown under chemical fertiliser (CF) + Farmyard manure (FYM) and CF + Vermicompost (VC) showed higher survival (85 and 86% respectively), plant height (205 and 196 cm respectively) and collar diameter (4.0 and 3.7 cm respectively) at the end of 24 months. During the rainy season (June to September), increment in plant height (140 cm) was highly influenced by the ring basin method with CF + FYM as compared with the dry season (October to January and February to May). During the dry season (Oct–Jan) maximum increment in plant height (50.3 cm) was observed under half ring basin with vermicompost (M2F3), while from Feb–May, increment in plant height was maximum in M3F3 (35.0 cm). During the dry season (Oct–Jan), half ring basin with CF + VC (M2F3) recorded highest plant height increment, whereas M1F2 recorded highest collar diameter increment. Plant survival, height increment and collar diameter increment in teak were attributed to better moisture and nutrient absorption.

Key words: Population – plant height – collar diameter – nutrients – season

KOPPAD, A. G. & RAO, R. V. 2004. Kesan kaedah pemuliharaan lembapan dan baja terhadap pertumbuhan awal pokok jati (*Tectona grandis*). Satu kajian dijalankan di ladang seorang petani di kampung Sugavi di zon berbukit di Karnataka, India Selatan untuk mengkaji kesan kaedah pemuliharaan lembapan dan baja terhadap pertumbuhan awal pokok jati. Kaedah pemuliharaan lembapan, baja dan interaksi antara mereka mempengaruhi kemandirian pokok, ketinggian pokok dan diameter bahagian pangkal pokok. Antara kaedah pemuliharaan lembapan, kaedah besen gelang memberi kemandirian pokok (83%), ketinggian pokok (178 cm) dan diameter bahagian pangkal pokok (3.2 cm) yang lebih tinggi 24 bulan selepas penanaman. Pokok yang ditanam menggunakan baja kimia (CF) + baja haiwan

(FYM) dan CF + vermikompos (VC) menunjukkan kemandirian (masing-masing 85% dan 86%), ketinggian pokok (masing-masing 205 cm dan 196 cm) serta diameter bahagian pangkal pokok (masing-masing 4.0 cm dan 3.7 cm) pada hujung 24 bulan. Semasa musim hujan (Jun hingga September), pertambahan dalam ketinggian pokok (140 cm) dipengaruhi oleh kaedah besen gelang bersama CF + FYM berbanding musim kering (Oktober hingga Januari dan Februari hingga Mei). Semasa musim kering (Okt–Jan), pertambahan ketinggian pokok adalah maksimum (50.3 cm) untuk kaedah besen separa gelang dengan vermikompos (M2F3). Dari Feb–Mei, pertambahan ketinggian pokok adalah maksimum untuk M3F3 (35.0 cm). Semasa musim kering (Okt–Jan), besen separa gelang dengan CF + VC (M2F3) merekodkan pertambahan ketinggian pokok yang tertinggi manakala M1F2 merekodkan pertambahan diameter bahagian pangkal pokok yang tinggi. Kemandirian pokok, pertambahan ketinggian dan pertambahan diameter pangkal pokok jati dipengaruhi oleh lembapan dan penyerapan nutrien.

Introduction

In the hill zone of Karnataka in south India, high rainfall together with poor management practices causes excessive erosion, leading to land degradation. In the hill zone, the land area has three distinct topo-situations, *viz* upland, midland and lowland. In uplands, arable crops are being grown, while in mid and lowlands, paddy and plantations are being cultivated. Most of these upland areas experience soil erosion and are uncultivable (Prasad & Singh 1994). In Karnataka, 9.165 million ha area is estimated to be non-forest and forest degraded wasteland (Anonymous 2000). Most of these upland areas are poor in fertility due to erosion. As such, growing of agricultural crops on such lands is non-remunerative. Proper soil conservation practices with vegetation are needed to bring such uplands from uncultivated to cultivated. Farmers are changing their cultivation practices from annual to perennial crops due to labour problems. Forest tree species are suited on such uplands. Teak is one of the important timber species, which farmers prefer to grow as it fetches additional income.

Teak grows well on sandy to clay loam soils and good growth was found with adequate moisture and nutrient availability (Tewari 1992). Teak is found to respond well to irrigation and fertilisers (Mutanal 1998, Jeyamala & Soman 1999). Providing irrigation to forest tree species is not possible by farmers due to high initial cost. Simple method to provide moisture for longer duration is one of *in situ* moisture conservation technique. The *in situ* moisture conservation is shown to increase yield of agricultural crops (Velayuthum *et al.* 1994). In the hill zone of Karnataka, since the rainfall is high (1846 mm), there is a lot of scope to conserve moisture *in situ*. In this region, not much work has been done on the response of plantation crops to *in situ* moisture conservation. Hence an attempt was made to study the effect of *in situ* moisture conservation techniques and fertilisers on the early growth of teak.

Materials and methods

The experiment was conducted in a farmer's field at Sughavi village (14° 30' N latitude and 75° 20' E longitude), Uttara Kannada district of Karnataka. The soil of the experimental site is well drained and lateritic with poor fertility. The experimental site is upland having 3% slope and situated at an altitude of 600 m from mean sea level. The average (15 years) annual rainfall in the experimental area is 1846 mm. The rainfall values received during the year 2000–2001 and 2001–2002 were 2015 and 1594 mm respectively. More than 90% of rainfall is received between June and October.

Teak stumps (1–2 cm collar diameter, 12–15 cm root length and 2–3 cm shoot length) were prepared from 1-year-old seedlings. The stumps were planted at 2 × 2 m spacing on pits (30 × 30 × 30 cm) in slanting position. The experiment was laid out in a split plot design with moisture conservation methods as main plots and fertilisers as subplots and replicated thrice. Each treatment consisted of 16 plants (64-m^2 area) having four rows and four plants in each row.

The main plot treatments as moisture conservation methods were
(i) No moisture conservation (M0),
(ii) Trenching (1.2 × 0.6 × 0.6 m) (M1)
(iii) Half ring basin (0.6 m radius) (M2),
(iv) Ring basin (0.6 m radius) (M3)

The subplot treatments as fertilisers were
(i) No fertilisers (F0)
(ii) Chemical fertiliser (CF) (100:50:100 and 200:100:200 kg N, P_2O_5 and K_2O/ha in the first and second year respectively (F1)
(iii) CF + Farmyard manure (FYM) 10 t ha^{-1} (F2)
(iv) CF + vermicompost (VC) (F3)
(v) CF + leaf litter (LL) (F4)

Trenches were dug out in between the teak rows; each trench with dimension of 1.4 m length, 0.6 m width and 0.6 m depth. A gap of 0.6 m was left between the trenches in a row, such trench row was repeated for alternate teak rows. Ring basins were prepared whereby soil was removed and a 1.2-m diameter circular bund was placed around each plant so that the rain water is allowed to stand in the basin. Similarly, half ring basins with 0.6 m radius were prepared towards the land slope or along the land slope for all plants in half ring basin treatment. For ring and half ring basins, a small channel was provided at the centre of the bund at about 5 cm above the ground level to remove excess water during the rainy season, which could avoid breaching of the bunds.

The organic fertilisers (FYM and VC) were thoroughly mixed with soil before planting. The leaf litter was spread around the plant after planting. Half the dose of chemical fertilisers was applied during the second week of July: urea (92.22 and 180.43 kg ha^{-1} for first and second year respectively), diammonium phosphate (52.08 and 104.16 kg ha^{-1} for first and second year respectively) and muriate of potash (58.33 and 116.66 kg ha^{-1} for first and second year respectively) to teak plants in a small circular trench made around each plant (30 cm away from the teak stem) and covered with soil. The remaining half dose of chemical fertiliser was applied two months after first dose of application.

The growth parameters, i.e. plant height and collar diameter (10 cm above ground level), were recorded using metallic tape and Verneer calipers respectively every four months. Soil samples from different treatments were taken at 0–15 and 15–30 cm soil depth, 30 cm away from teak plants towards land slope (but not against land slope) using the screw auger. The soil samples were oven dried and the moisture content (%) was estimated. The data collected from the experiment were statistically analysed under M-STAT-C Program. The mean values of the treatments were separated and subjected to Duncan's multiple range test at the 0.05 probability level.

Results and discussion

In all treatments, teak seedlings established well during the first four months of growth (Table 1). All moisture conservation methods recorded significantly higher plant survival at 12 and 24 months after planting as compared with the control. Ring basin method showed highest plant survival from 12 to 24 months after planting. Highest seedling mortality occurred at 24 months in the control. The higher per cent of plant survival found under moisture conservation methods was mainly due to higher available soil moisture.

Application of fertiliser resulted in significantly higher plant survival as compared with the control (Table 1). Among the fertiliser treatments, CF + FYM and CF + VC registered significantly higher plant survival from 12 months onwards and maintained highest plant population at the end of 24 months. The higher per cent of plant survival in these fertiliser treatments was perhaps due to organic fertilisers, which helped plants to absorb more nutrients from the soil (Fernando 1966).

Table 1 Seedling survival of teak at different intervals as influenced by moisture conservation methods and fertilisers

Treatment	Plant survival (%) at different intervals					
	4 months (Oct 2000)	8 months (Feb 2001)	12 months (June 2001)	16 months (Oct 2001)	20 months (Feb 2002)	24 months (June 2002)
Main plot treatment						
No moisture conservation	98.7 a	86.3 a	79.8 b	79.3 b	75.9 a	73.2 b
Trenching	99.2 a	86.5 a	85.5 ab	81.2 b	79.8 a	78.9 ab
Half ring basin	97.1 b	89.4 a	83.5 ab	85.7 a	80.6 a	82.5 a
Ring basin	95.6 c	88.9 a	86.9 a	85.9 a	85.4 a	83.1 a
LSD	1.1	5.88	4.0	3.2	9.1	6.5
Sub-plot treatment						
No fertiliser	97.3 ab	82.5 e	77.4 c	77.8 b	68.5 c	69.2 c
CF	97.9 a	84.8 d	81.0 b	79.2 b	77.4 b	77.9 b
CF + FYM	97.9 a	90.8 b	88.9 a	88.9 a	87.7 a	85.2 a
CF + VC	96.5 b	93.2 a	91.0 a	89.2 a	87.4 a	85.9 a
CF + LL	98.4 a	87.8 c	83.5 b	81.0 b	81.2 ab	79.0 b
LSD	1.1	2.1	3.2	3.6	6.7	3.4

CF = Chemical fertiliser, VC = Vermicompost, FYM = Farm yard manure, LL = Leaf litter
Means followed by the same letter in the same column are not significantly different at the 0.05 probability level.

Among the interaction treatments, the ring basin method with CF + FYM significantly influenced plant survival at all the intervals and at the end of 24 months it maintained the highest (95%) plant population (Table 2). Minimum plant survival was recorded in the control. Higher plant survival in interaction treatment was attributed to more moisture available to plants and also more nutrient absorption by the plants.

Plant height and collar diameters were significantly influenced by ring basin method from 4 to 24 months (Tables 3 & 4). The half ring basin and trenching methods recorded significantly similar plant height to ring basin but significantly higher values at 8 months as compared with the control (Table 3). Ring basin method recorded highest plant height (178.2 cm) and collar diameter (3.2 cm) at 24 months. This could be due to more soil moisture available for the plants.

Table 2 Plant survival (%) due to interaction effect at 24 months

Moisture conservation method/ Fertiliser	M0	M1	M2	M3
F0	62.2 h	64.8 gh	73.3 ef	76.5 b-f
F1	72.0 b-f	80.5 c-e	79.6 c-e	76.4 d-f
F2	77.0 b-f	82.5 b-d	86.0 bc	95.3 a
F3	81.7 b-d	86.2 bc	88.7 ab	87.0 bc
F4	70.3 fg	80.3 c-e	84.8 bc	80.3 c-e
LSD	6.78			

M0 = No moisture conservation
M1 = Trenching
M2 = Half ring basin
M3 = Ring basin

F0 = No fertiliser
F1 = CF
F2 = CF + FYM
F3 = CF + VC
F4 = CF + LL

Table 3 Plant height of teak at different intervals as influenced by moisture conservation methods and fertilisers

Treatment	Plant height (cm) at different intervals					
	4 months (Oct 2000)	8 months (Feb 2001)	12 months (June 2001)	16 months (Oct 2001)	20 months (Feb 2002)	24 months (June 2002)
Main plot treatment						
No moisture conservation	8.1 c	9.4 b	19.4 c	73.7 b	77.6 d	97.9 c
Trenching	12.1 b	14.9 a	27.7 b	76.1 b	90.6 c	130.9 b
Half ring basin	12.3 b	15.2 a	29.4 b	77.6 b	101.9 b	131.9 b
Ring basin	16.5 a	19.3 a	40.4 a	123.2 a	149.4 a	178.2 a
LSD	3.6	4.5	6.0	8.4	9.2	9.4
Sub-plot treatments						
No fertiliser	6.9 b	8.2 b	14.8 d	57.2 d	65.4 b	72.0 d
CF	9.9 b	11.3 b	18.4 c	57.6 d	65.8 b	84.3 c
CF + FYM	16.8 a	20.1 a	43.3 a	136.6 a	154.2 a	205.0 a
CF + VC	18.3 a	22.6 a	43.8 a	117.6 b	152.3 a	195.8 a
CF + LL	9.4 b	11.4 b	25.9 b	69.2 c	86.8 b	116.3 b
LSD	3.4	3.9	3.3	3.8	41.7	11.1
F test	S	S	S	S	S	S

CF = Chemical fertiliser, VC = Vermicompost, FYM = Farm yard manure, LL = Leaf litter
Means followed by the same letter in the same column are not significantly different at the 0.05 probability level.

Among the fertiliser treatments, CF + FYM recorded significantly higher plant height from 4 to 24 months (Table 3) and collar diameter from 12 to 24 months (Table 4). However, CF + VC was also found to influence plant height similar to CF + FYM at all the intervals (from 4 to 24 months) of plant growth except at 16 months. CF + VC recorded significantly higher collar diameter at 4 and 8 months.

Interaction effects were more significant than the individual treatment effects. Ring basin with CF + FYM (M3F2) significantly influenced plant height (Table 5) and collar diameter (Table 6) at 24 months. The higher plant height and collar diameter in the interaction treatment were mainly due to maximum soil moisture availability in these treatments. Sufficient available soil moisture would help the plant to absorb nutrients resulting in higher plant height and collar diameter. Plant growth was enhanced by moisture and organic fertilisers (Fernando 1966). The growing period of teak may have been prolonged due to

Table 4 Collar diameter of teak at different intervals as influenced by moisture conservation methods and fertilisers

Treatment	Collar diameter (cm) at different intervals					
	4 months (Oct 2000)	8 months (Feb 2001)	12 months (June 2001)	16 months (Oct 2001)	20 months (Feb 2002)	24 months (June 2002)
Main plot treatment						
No moisture conservation	0.18 b	0.86 c	1.20 c	1.62 c	1.99 d	2.10 c
Trenching	0.27 c	1.18 b	1.69 a	1.95 b	2.37 c	2.71 b
Half ring basin	0.36 b	1.17 b	1.41 b	2.06 b	2.55 b	2.84 b
Ring basin	0.46 a	1.46 a	1.72 a	2.35 a	2.76 a	3.18 a
LSD	0.06	0.06	0.16	0.19	0.12	0.14
Sub-plot treatment						
No fertiliser	0.21 d	0.65 e	1.02 d	1.20 c	1.29 e	1.49 e
CF	0.26 c	0.91 d	1.14 d	1.57 b	1.70 d	1.80 d
CF + FYM	0.39 b	1.58 b	2.06 a	2.87 a	3.66 a	4.00 a
CF + VC	0.45 a	1.65 a	1.87 b	2.73 a	3.37 b	3.72 b
CF + LL	0.29 c	1.05c	1.42 c	1.61 b	2.08 c	2.53 c
LSD	0.05	0.06	0.12	0.15	0.14	0.13

CF = Chemical fertiliser, VC = Vermicompost, FYM = Farm yard manure, LL = Leaf litter
Means followed by the same letter in the same column are not significantly different at the 0.05 probability level.

Table 5 Plant height (cm) due to interaction effect at 24 months

Moisture conservation method/ Fertiliser	M0	M1	M2	M3
F0	56.4 hi	60.8 hi	47.9 i	123.0 fg
F1	76.3 h	78.5 h	72.8 h	109.5 g
F2	130.4 fg	216.3 cd	196.3 de	276.8 a
F3	115.7 fg	187.5 e	235.2 bc	245.0 b
F4	110.6 g	111.2 g	107.1 g	136.5 f
LSD	22.2			

M0 = No moisture conservation F0 = No fertiliser
M1 = Trenching F1 = CF
M2 = Half ring basin F2 = CF + FYM
M3 = Ring basin F3 = CF + VC
F4 = CF + LL

Table 6 Collar diameter (cm) due to interaction effect at 24 months

Moisture conservation method/ Fertiliser	M0	M1	M2	M3
F0	1.14 k	1.80 i	2.00h i	1.03 k
F1	1.42 j	1.86 i	1.76 i	2.16 h
F2	2.54 fg	3.85 d	4.27 c	5.36 a
F3	2.70 fg	3.58 e	4.02 cd	4.57 b
F4	2.70 gf	3.58 e	4.02 ed	4.57 b
LSD	0.26			

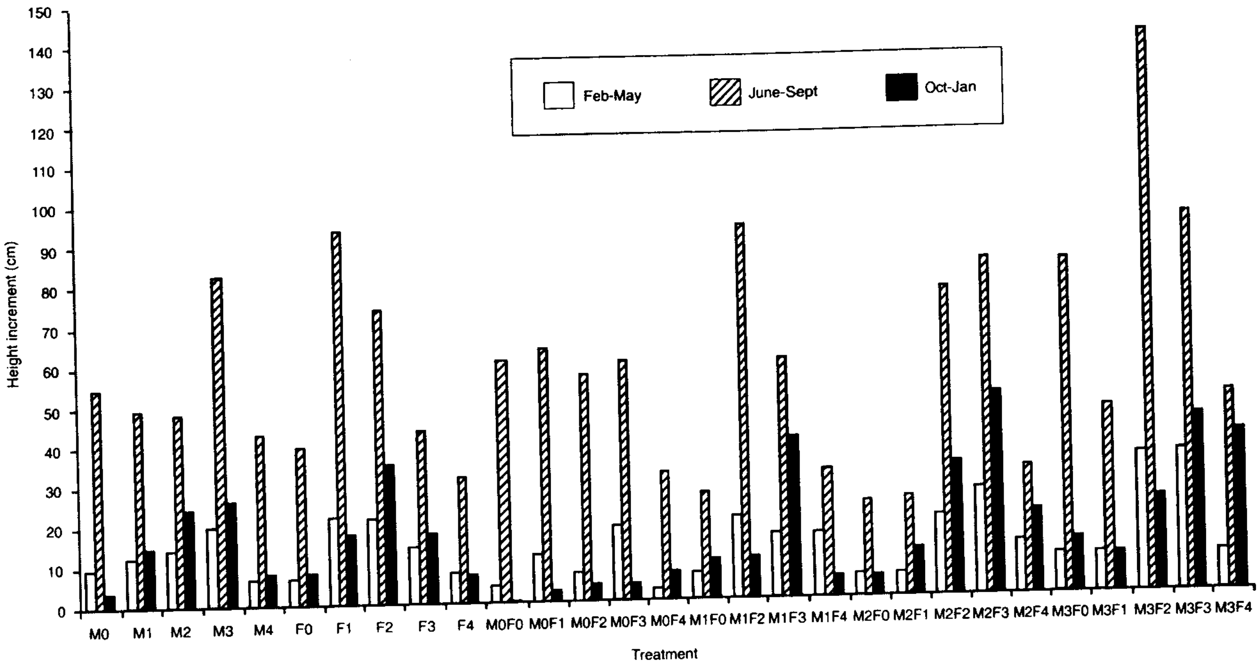
M0 = No moisture conservation F0 = No fertiliser
M1 = Trenching F1 = CF
M2 = Half ring basin F2 = CF + FYM
M3 = Ring basin F3 = CF + VC
F4 = CF + LL

prolonged period of moisture available in the soil, which was indicated by delayed leaf shedding in these treatments. Increased availability of soil moisture and availability of macronutrients have been reported to positively influence height growth and collar diameter growth in teak (Kishore 1987, Kushalappa 1987, Singh 1997, Rajendradu & Naidu 1998).

Height increment was maximum during the rainy season (June to September), followed by the dry seasons, October to January and February to May (Figure 1). Higher increment was observed in plants grown under ring basin method as compared with the other moisture conservation methods. Although CF + FYM resulted in significant increase in plant height during the rainy season, plants grown with CF + VC showed higher increment in the dry season. Interaction M3F2 had significantly higher plant height increment from June to September. M2F3 recorded significantly higher height increment between October and January, whereas M3F2 and M3F3 influenced plant height increment between February and May.

The ring basin method recorded significantly higher collar diameter increment during the rainy season (June to September) as compared with the other moisture conservation methods (Figure 2). Among the fertiliser treatments, CF + FYM application influenced collar diameter greater than the other fertiliser applications during the rainy season. Among the interactions, M2F2 recorded significantly highest collar diameter increment. Trenching, CF + FYM and M1F2 had higher increment in collar diameter from February to May. Similarly, half ring basin, CF + FYM and M1F2 recorded a significant increase in collar diameter from October to January. The plant height and collar diameter increments were attributed to soil moisture and nutrient absorption by plants (Soukar & Kumbhare 1991, Puri *et al.* 1995, Nonhare & Chaubey 1996).

The soil moisture in the ring basin method was significantly higher than that of the other moisture conservation methods from 4 to 24 months (Table 7). Soil moisture in the ring basin recorded in February, June and October from 0–15 cm soil depth was significant (Figure 3). Among the fertiliser treatments, CF + FYM and CF + VC significantly conserved more soil moisture. Some of the interactions, M3F2, M3F3, M1F2, M1F3, M2F2 and M2F3 also influenced the soil moisture content significantly. Soil moisture content recorded from 0–15 cm soil



M0 = No moisture
M1 = Trenching
M2 = Half ring basin
M3 = Ring basin

F0 = No fertiliser
F1 = CF
F2 = CF + FYM
F3 = CF + VC
F4 = CF + LL

Figure 1 Plant height increment as influenced by moisture conservation methods and fertilisers

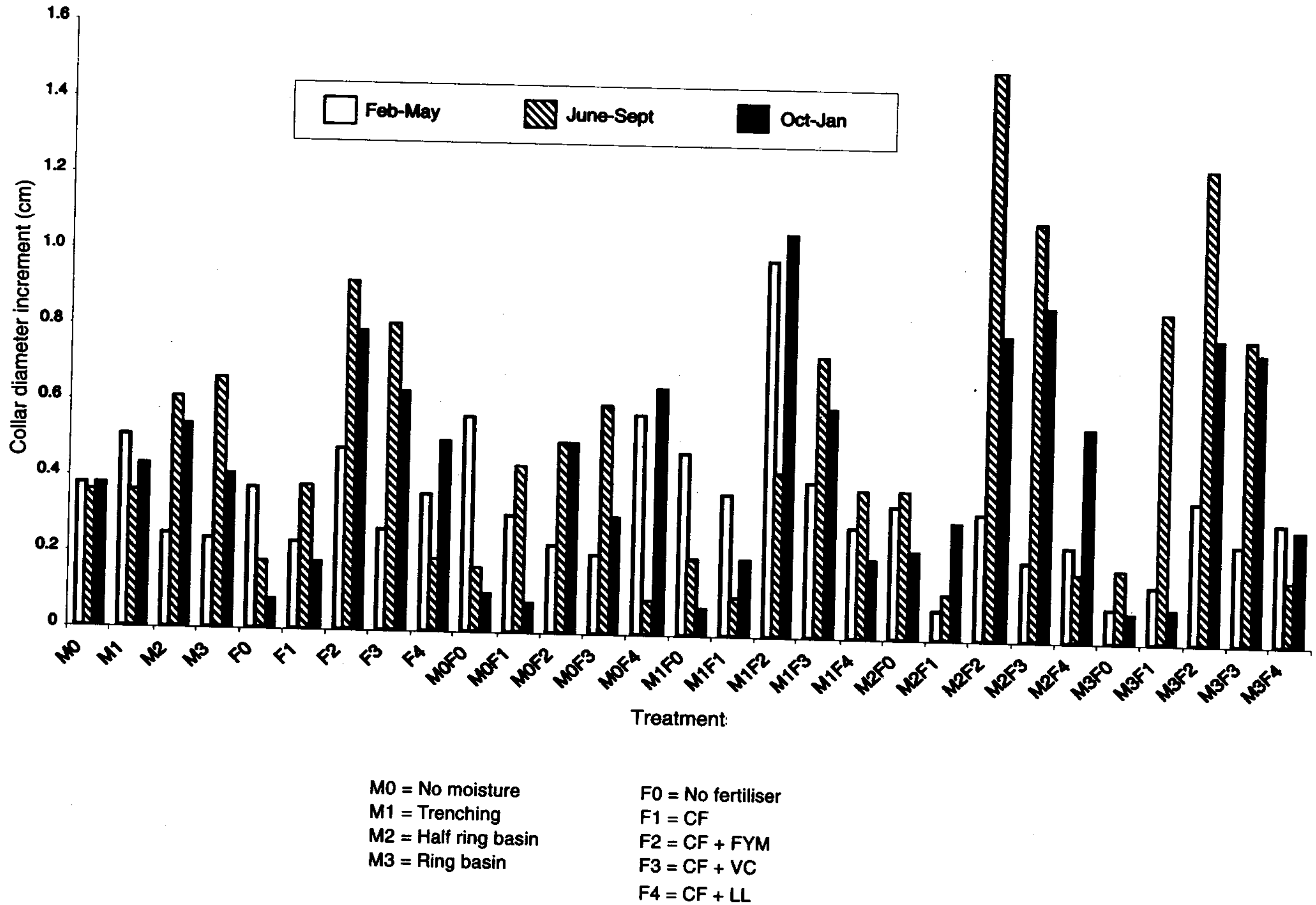


Figure 2 Collar diameter increment as influenced by the moisture conservation methods and fertilisers

Table 7 Soil moisture at different depths of soil as influenced by moisture conservation methods and fertilisers

Treatment	Soil moisture (%) at different depths of soil					
	4 months (Oct 2000)		8 months (Feb 2001)		12 months (June 2001)	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
Main plot treatment						
No moisture conservation	15.4 b	16.3 c	10.0 c	8.4 b	25.5 b	24.5 c
Trenching	17.1 a	17.1 b	10.5 bc	10.4 a	24.2 c	25.2 b
Half ring basin	15.4 b	16.1 c	10.7 b	10.8 a	24.7 c	25.1 b
Ring basin	17.4 a	18.2 a	11.5 a	10.8 a	26.3 a	26.5 a
LSD	0.7	0.7	0.5	0.5	0.7	0.5
Sub-plot treatment						
No fertiliser	13.9 c	14.4 c	9.1 c	8.8 c	24.1 c	23.5 e
CF	14.8 b	15.7 b	10.1 b	8.8 c	23.5 c	24.1 d
CF + FYM	17.7 a	18.5 a	11.6 a	10.3 b	26.5 a	26.5 b
CF + VC	17.7 a	18.6 a	11.3 a	11.0 a	26.5 a	27.3 a
CF + LL	17.5 a	18.1 a	11.4 a	11.4 a	25.1 b	25.0 c
LSD	0.5	0.6	0.4	0.4	0.8	0.5
Interaction (M × F)						
M0F0	11.4 h	12.8 j	8.7 f	6.5 f	24.2 fg	23.8 h-j
M0F1	13.1 g	14.3 hi	10.4 de	7.7 e	24.3 fg	23.7 h-j
M0F2	17.3 c-e	18.2 b-d	10.4 de	8.4 e	27.5 ab	25.1 d-g
M0F3	17.5 cd	18.4 b-d	10.2 e	9.3 d	26.7 a-d	25.8 c-e
M0F4	17.9 b-d	17.9 b-e	10.4 de	9.8 d	24.7 e-g	24.2 g-i
M1F0	16.1 ef	13.6 ij	8.8 f	10.0 d	22.1 hi	23.7 h-j
M1F1	16.9 c-e	15.5 gh	9.0 f	9.5 d	21.2 i	24.4 f-i
M1F2	18.1 a-c	18.3 b-d	12.2 ab	9.6 d	25.8 b-f	25.4 c-f
M1F3	17.4 cd	19.0 a-c	10.5 de	10.3 cd	26.8 a-c	28.1 b
M1F4	17.2 c-e	19.2 ab	12.0 a-c	12.5 a	24.6 e-g	24.6 f-h
M2F0	12.8 g	14.8 hi	9.2 f	9.5 d	25.1 c-f	23.6 h-j
M2F1	13.7 g	14.5 hi	9.3 f	8.4 e	23.2 gh	24.7 f-h
M2F2	16.8 de	17.3 d-f	11.2 cd	11.7 ab	24.4 e-g	26.4 c
M2F3	16.8 de	17.6 c-f	12.2 ab	12.2 a	24.4 fg	25.9 cd
M2F4	16.9 c-e	16.6 e-g	11.6 bc	12.1 ab	26.3 b-e	24.9 d-g
M3F0	15.3 f	16.4 fg	9.3 f	9.4 d	24.9 d-g	22.7 j
M3F1	15.7 f	16.5 fg	11.5 bc	9.5 d	25.3 c-f	23.4 ij
M3F2	18.7 ab	20.1 a	12.5 a	11.7 ab	28.4 a	28.9 ab
M3F3	19.2 a	19.3 ab	12.3 ab	12.0 ab	28.1 a	29.3 a
M3F4	18.1 a-c	18.7 bc	11.8 a-c	11.2 bc	24.8 e-g	26.5 c
LSD	1.1	1.2	0.8	0.9	1.6	1.0

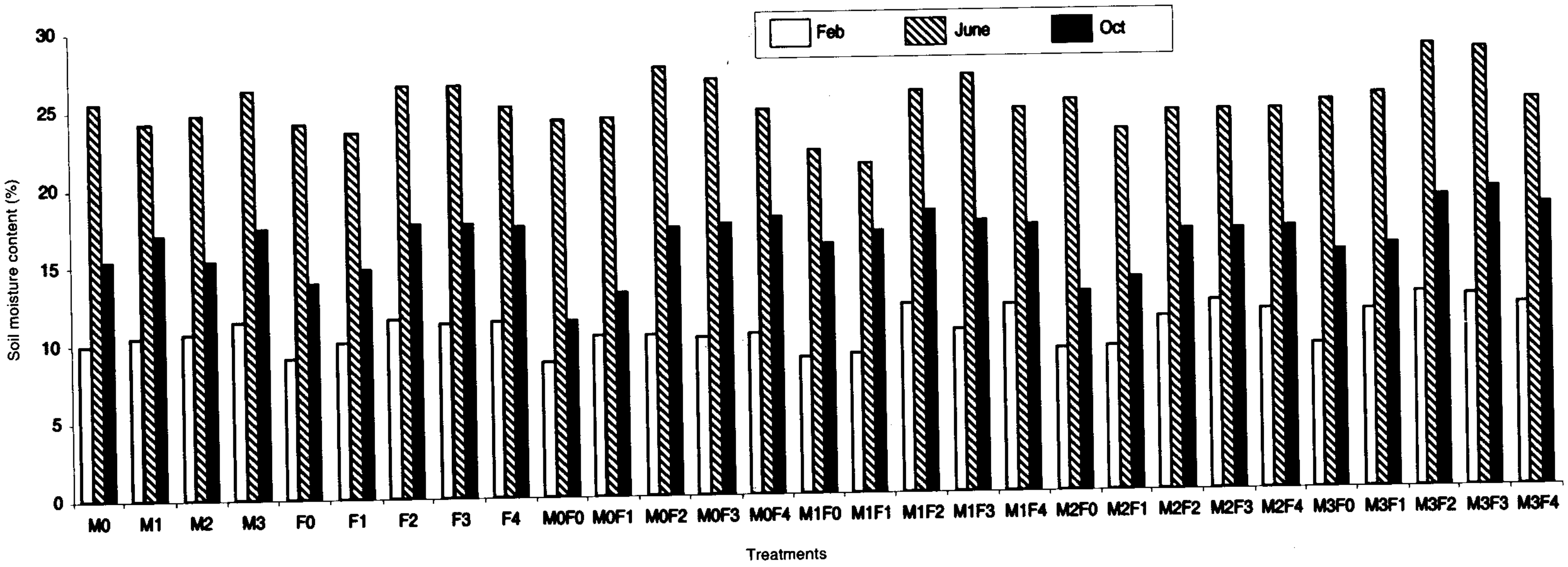
(continued)

CF = Chemical fertiliser, VC = Vermicompost, FYM = Farm yard manure, LL = Leaf litter
Means followed by same letter in the same column are not significantly different at the 0.05 probability level.

Table 7 (continued)

Treatment	Soil moisture (%) at different depths of soil					
	16 months (Oct 2001)		20 months (Feb 2002)		24 months (June 2002)	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
Main plot treatment						
No moisture conservation	16.2 b	17.2 b	13.5 b	11.8 c	25.7 b	24.5 c
Trenching	17.0 b	18.6 a	16.4 a	13.2 b	25.5 b	25.0 bc
Half ring basin	15.3 a	16.5 c	16.2 a	13.8 b	25.8 b	25..8 ab
Ring basin	17.8 a	18.3 a	16.2 a	15.5 a	27.1 a	25.9 a
LSD	1.8	0.4	1.1	0.9	0.3	0.9
Sub-plot treatment						
No fertiliser	15.1 b	16.4 b	13.0 c	11.6 b	25.0 c	23.5 c
CF	15.3 b	16.4 b	14.0 c	12.5 b	24.8 c	24.1 c
CF + FYM	17.5 a	18.5 a	17.2 a	14.1 a	27.1 a	26.5 a
CF + VC	17.5 a	18.8 a	18.1 a	14.8 a	26.9 ab	27.2 a
CF + LL	17.6 a	18.2 a	15.6 b	15.0 a	26.3 b	25.1 b
LSD	1.1	1.2	1.4	1.4	0.8	0.7
Interaction (M × F)						
M_0F_0	13.7 ef	15.3 ef	10.2 i	10.1 g	25.3 c-f	24.5 d-h
M_0F_1	14.2 c-f	15.5 d-f	12.0 hi	11.4 fg	24.6 d-f	23.1 hi
M_0F_2	17.2 ab	18.5 a-c	15.0 d-h	11.5 fg	26.3 b-d	24.4 d-h
M_0F_3	17.6 ab	18.2 a-d	16.1 c-g	11.8 b-g	26.9 a-c	25.9 cd
M_0F_4	18.4 ab	18.6 a-c	14.0 e-h	14.2 b-f	25.3 c-f	24.8 d-g
M_1F_0	16.7 a-c	18.1 a-d	13.0 g-i	12.3 d-g	24.5 d-f	23.7 gh
M_1F_1	16.1 b-e	18.7 a-c	15.0 d-h	12.5 d-g	24.2 f	24.0 e-h
M_1F_2	17.3 ab	17.7 a-f	17.3 b-e	12.5 d-g	27.5 ab	25.9 cd
M_1F_3	17.7 ab	19.6 ab	20.7 a	13.7 c-f	25.3 c-f	26.6 b-c
M_1F_4	17.1 ab	19.0 a-c	16.2 c-g	15.0 b-e	26.1 b-e	24.8 d-g
M_2F_0	13.4 f	15.6 d-f	16.2 c-g	11.8 e-g	25.0 d-f	23.7 f-h
M_2F_1	13.9 d-f	15.0 f	14.0 e-h	12.5 b-g	24.5 ef	24.1 e-h
M_2F_2	16.4 a-c	17.4 b-f	19.9 ab	16.3 a-c	26.1 b-e	27.5 ab
M_2F_3	16.5 a-c	17.9 a-e	16.9 b-f	15.2 a-d	27.2 ab	28.2 a
M_2F_4	16.3 b-d	16.5 c-f	13.9 f-h	13.4 c-g	26.1 b-e	25.3 c-g
M_3F_0	16.6 a-c	16.5 c-f	12.6 hi	12.3 b-g	25.1 c-f	22. 0i
M_3F_1	16.9 ab	16.6 c-f	15.0 d-h	13.5 c-f	26.1 b-e	25.3 c-f
M_3F_2	19.1 a	20.3 a	16.7 b-f	16.2 a-c	28.6 a	28.4 a
M_3F_3	18.1 ab	19.4 ab	18.6 a-c	18.3 a	28.4 a	28.2 a
M_3F_4	18.4 ab	18.7 a-c	18.2 a-d	17.3 ab	27.5 ab	25.5 c-e
LSD	2.3	2.4	2.9	2.9	1.5	1.4
F test	S	S	S	NS	NS	S

CF = Chemical fertiliser, VC = Vermicompost, FYM = Farm yard manure, LL = Leaf litter
Means followed by same letter in the same column are not significantly different at the 0.05 probability level.



M0 = No moisture
M1 = Trenching
M2 = Half ring basin
M3 = Ring basin

F0 = No fertiliser
F1 = CF
F2 = CF + FYM
F3 = CF + VC
F4 = CF + LL

Figure 3 Soil moisture content at 0–15 cm soil depth in different months as influenced by moisture conservation methods and fertilisers depth in all the treatments was more in the month of June followed by October and February (Figure 3). Ring basin, CF + FYM and M3F2 recorded significantly higher soil moisture during the dry season. This may be the reason for maximum plant survival as well as more height growth and collar diameter growth of plant in these treatments.

Conclusions

Moisture conservation methods and fertiliser application significantly influenced plant survival, plant height and collar diameter of teak. Interaction effects were superior to the individual treatments. Among the moisture conservation methods, ring basin resulted in a significantly higher plant survival, height and collar diameter of teak. Among fertiliser treatments, CF + FYM and CF + VC registered significantly higher plant survival, plant height and collar diameter. Among interaction treatments, ring basin method with CF + FYM and ring basin method with CF + VC recorded significantly higher per cent plant survival, plant height and collar diameter. Plant height increment was significant during the rainy season in ring basin, CF + FYM and ring basin with CF + FYM. The higher increment in plant height was attributed to moisture available for the plants. The height increment was less during dry season as compared with the rainy season. During the dry season (Oct–Jan), half ring basin with CF + VC (M2F3) recorded significantly higher height increment, whereas M1F2 recorded higher collar diameter increment. The higher per cent of plant survival and higher plant height and collar diameter were mainly attributed to soil moisture and nutrients available to the plants. The results clearly suggest that during the early stage of plant growth, moisture conservation methods are important to boost the plant growth. Growth increments were appreciable when both organic and inorganic fertilisers were applied.

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