Article

Effect of *in-situ* moisture conservation measures and application of organic manures on soil properties in *Simarouba glauca* plantation

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Abstract

Soil and water conservation measures are one of the most important factors for the improvement of degraded lands. Water conservation technique like *in-situ* soil moisture conservation measures and application of organic manures is to achieve the maximum cultivated soil for the survival and growth of seedlings. In the present study the effect of *in-situ* moisture conservation measures and organic manures application on growth of *Simarouba glauca* in varada watershed area showed significant difference in chemical properties of soil such as available Nitrogen, Phosphorus and Potassium at 12 months after the treatment imposed and the moisture content at the depth of 0 to 30 and 30 to 60. In main plot significantly maximum plant height (1.25 m), collar diameter (2.63 cm) crown diameter (93.98 cm) and number of leaves (45.25) was recorded in ring basin (M_2), whereas, in sub plot maximum plant height (1.71 m), collar diameter (3.49 cm) crown diameter (126.89 cm) and number of leaves (60.66) was recorded in vermicompost (S_2). Among the interaction significantly maximum plant height (1.94 m), collar diameter (3.97 cm), crown diameter (133.83 cm) and number of leaves (63.07) was recorded in ring basin with vermicompost (2.5 t/ha) at 12 months after treatment.

Keywords *Simarouba glauca*; moisture conservation; nutrient management; soil properties.

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1 Introduction

Simarouba glauca belongs to family Simarubaceae, commonly known as “Paradise tree” or “King oil seed tree”, is a versatile multipurpose evergreen tree grows up to a height of 7-15m (Mendonca and Vas, 2013). It is native of El Salvador and was introduced to India in 1960. It can be grown anywhere from the sea coast to elevations of 1000m in tropical climatic conditions. In India it is grown well in the wastelands of Gujarat, Karnataka and Orissa. Besides, Andhra Pradesh, Bihar, Chhattisgarh, Maharastra and Tamil Nadu are potential states where it can be successfully grown. The wood is light and generally preferred by wood eating insects, hence useful in making yoke for oxen, light furniture, toys, packing material, pulp and matches and used as fuel (Joshi and Joshi, 2002). It is considered as a potential source of biodiesel and also known for various medicinal properties. It has ability to check the soil erosion and improves the ground water. It is estimated that 10 million hectares of wasteland or marginal land has to be covered with oil trees to cater the needs of oil shortage in the nation (Joshi and Joshi, 2002). In India, out of 100 biodiesel producing species, *Simarouba glauca* is identified as a promising biodiesel tree having high yielding potential (Neelakantan et al., 2004; Shantha et al., 1996). This eco-friendly tree can be planted even on marginal lands under water stress conditions (Shukla and Padmaja, 2013). For a long-term strategy, cultivation of versatile tree Simarouba is advocated in the abundantly available marginal wastelands in arid and semi-arid regions of tropics and its implementation shall be economically viable and ecologically sustainable. *Simarouba glauca* was found most promising to fast growing nature which is suitable for the dry land areas of the Karnataka for the oil seed purpose (Devaranavadgi et al., 2010).

Soil moisture, nutrients and light are the three important factors which influenced the growth and productivity of trees. Among these resources, soil moisture and nutrients are most essential factors for plant growth. It is well known that conservation of soil moisture along with application of manures and fertilizers has significant impact on the growth of plants. The proper use of soil moisture conservation structures helps to reduce the runoff rate, nutrient losses from soil and improve the soil moisture and nutrient availability for plant growth which in turn, boost the productivity of land and plants.

Growing teak as a perennial component can reduce erosion and conserve soil. However, to make Simarouba as an alternative option, its growth needs to be improved. Soil moisture and nutrients are critical for better growth. There is a need for diverse suitable techniques of soil moisture conservation and also nutrient management. Such information on Simarouba especially in watershed areas is lacking several of the quassinoids found in Simarouba, are considered the plant's main therapeutic constituents and are the ones documented to be antiprotozal, anti-amebic, antimalarial, and even toxic to cancer and leukemia cells (Rajurkar, 2011). Leaf litter is good manure which improves the soil fertility status. The leaf and bark contain simaraubin, a chemical useful in curing amoebiasis, diarrhea and malaria. The wood is generally preferred for oxen, light furniture, toys, packing material, pulp for paper industry, matches and it is also used as fuel (Joshi and Joshi, 2002). This eco-friendly tree with well-developed root system and with evergreen dense canopy efficiently checks soil erosion, supports soil microbial life and improves groundwater position. Large scale planting of this species in the wastelands facilitates wasteland reclamation and converts the accumulated atmospheric carbon dioxide into oxygen and contributes to the reduction of greenhouse effect/global warming (Lele, 2010).

For conservation and management of water there are many water conservation techniques that may be adopted were based on climatological condition of the region and socioeconomic condition of the people. Gupta and Muthana (1985) developed circular catchment of 1.5m radius and 2 per cent slope runoff generating areas. The technique proved effective in improving the moisture content of the plant root zone. Improper nutrition leading to nutrient imbalance in plants is one of the major factors contributing to low yields in many trees. Nutrient plays an important role in formation of proteins. Organic manures supply organic matter to the soil and hence improve the physical condition of the soil like soil structure, aeration and water holding capacity. Organic manures are also a potential source of micronutrients in addition to N, P, K (Gaur and Giand, 1995). It also stimulates the activity of different soil micro-organisms through the supply of energy and food. It improves the buffering and exchange capacities of the soil and also influences the solubility of soil minerals as well as mineral nutrients in soil.

In general the main reason for low productivity is high runoff and soil erosion leads to declining of fertility of soils. Keeping this in view, the present study was carried out to assess the effect of *in-situ* moisture conservation measures and application of organic manures on chemical properties of soil in *Simarouba glauca* plantation.

2 Study Area

The present study was carried out in one year old *Simarouba glauca* plantation raised by Karnataka forest department in the year 2011 at Karjagi village of Haveri district during 2012-2013. The area falls under the North Transition Zone (zone-8) of Karnataka state.

3 Material and Methods

3.1 Soils characteristics of the experimental site

The soil of the experimental site was Red Sandy loam. Composite soil samples were collected from 0-45 cm depth of the experimental area before imposition of the treatments. The soil samples were air-dried, powdered, and allowed to pass through 2 mm sieve and were analyzed for chemical properties. Details of methodology adopted for analyzing chemical properties of soil are furnished in the Table 1.

Table 1 Initial chemical properties of soil in the experimental site and methods of analysis.

Sl No.	Chemical Properties	Value	Method used /reference
1	Soil pH (1:2.5)	5.48	Potentiometric method (Jackson,1967)
2	EC (1:2.5) (dsm^{-1})	0.03	Conductometric method (Jackson,1967)
3	Organic carbon (%)	0.39	Wet oxidation method (Jackson,1967)
4	Available Nitrogen(Kg /ha)	195.4 kg/ha	Alkaline permanganate method (Subbaiah and Asija, 1956)
5	Available P_2O_5 (Kg/ha)	19.41 kg/ha	Brays method (Jackson,1967)
6	Available K_2O (Kg/ha)	131.62 kg/ha	Ammonium acetate method (Jackson,1967)

3.2 Experimental design

The experiment was laid out in split plot design with three replications which consisted of four main plots and four sub plots treatments. Main plot treatments include M_1-conservation pit (0.45m x 0.30m x 0.30m), M_2-Ring basin (0.6m Radius), M_3- Half ring basin (0.6m Radius), M_4- Control. Sub plot treatments: S_1-Farm yard manure (FYM)-5 ton/ha, S_2-Vermicompost (VC)-2.5ton/ha, S_3-Poultry manure (PM)-0.75ton/ha**,** S_4-control (C), the nutrient content of organic manures is given in Table 2. For each treatment five plants were randomly selected for observations. The observations on growth parameters such as plant height, collar diameter, crown diameter and number of leaves were recorded at every three month interval for a period extending to twelve months. Simultaneously, soil parameters such as pH, EC, organic content, available nitrogen, phosphorous and potassium were measured to compare the chemical properties of soil and the status of improvement from the initial period (one month after planting) to the final period (10 months after planting) and the moisture content was also measured at 0-30 cm depth and 30-60 cm depth under *S. glauca* plantation at different intervals from the date of planting till 12 months after planting. The data relating to each parameter observed was analyzed statistically using M-STAT-C program. The level of significance used in F test was P = 0.05. Critical difference values were calculated wherever F test was significant (Sumbali et al., 2012).

Table 2 Nutrient content of organic manures used in the experiment.

Organic manure	Nutrient Content (%)		
	Total N	Total P	Total K
Farmyard manure	0.5	0.2	0.5
Vermicompost	3.0	1.0	1.5
Poultry manure	3.03	2.63	1.4

4 Results and Discussion

4.1 Chemical properties of soil

In the present study initial chemical properties of the soil were analysed by the methodology as described by (Subbaiah and Asija, 1956; Jackson, 1967). Before treatment impose the soil pH (5.48), EC (0.03), Organic carbon (0.39%), available nitrogen (195.4 kg/ha), phosphorus (19.41 kg/ha) and potassium (131.62 kg/ha) (Table 1). After the treatment imposed to the *Simarouba glauca* plantation the pH and EC was non-significant. In main plot the maximum organic content was recorded in Ring basin (0.93%), followed by Half ring basin (0.84%), Conservation pit (0.80%) and least was recorded in control (0.76%).

In sub plot maximum organic content was recorded in vermicompost (0.92%), followed by Poultry manure (0.85%), Farm yard manure (0.81%) and least was recorded in control (0.75%). Among the interaction between main plot and subplot the maximum organic content was recorded in ring basin with Vermicompost (1.01%) followed by ring basin with poultry manure (0.94%) respectively. The least was recorded in control (0.63%). Whereas, the application of N, P, K for the plantation showed significant difference among the main plot, sub plot and among the interactions. In main plot maximum nitrogen was recorded in Ring basin (268.90 kg/ha), followed by Half ring basin (262.60 kg/ha), Conservation pit (256.35 kg/ha) and the least was recorded in the Control (245.14 kg/ha). In sub plot maximum Nitrogen was recorded in vermicompost (268.01 kg/ha) followed by Poultry manure (263.82 kg/ha), Farm yard manure (253.14 kg/ha) and the least was recorded in control (248.02 kg/ha). Among the interactions maximum was recorded in Ring basin with vermicompost (277.13 kg/ha) followed by Half ring basin with vermicompost (272.21 kg/ha), Conservation pit with vermicompost (266.74 kg/ha) respectively and the least was recorded in Control (231.86 kg/ha) (Table 4).

Moisture conservation methods and manure application did not influence significantly with respect to soil pH, but there was slight variation among the treatments with respect to pH. The soil pH ranged from 5.55 to 6.02, these results showed that there was no definite trend in any of the moisture conservation measures, manure application and combination of both treatments, but all the values come under acidic pH range. This might be due to more amount of H^{+}, Fe^{+2} and Al^{+3} ions in the soil that lead to acidic pH range in all the treatments.

The data on soil EC values did not show significant differences due to moisture conservation methods and organic manure treatments or combination of these treatments and also there was no definite trend observed, but Electrical conductivity was ranged from 0.01 to 0.09 dSm^{-1}. This might be due to organic manures does not contain salts and hence there was no influence of organic manure salt accumulation in soil (Bajpai et al., 1980).

Moisture conservation methods had significantly influenced higher organic carbon content of soil. Ring basin (M_2) showed significantly higher organic carbon content (0.93%) compared to other treatments, it might be due to more organic matter accumulation in the soil over the other treatments.

Organic manure had significant effect on organic carbon of soil. Application of vermicompost (2.5 t/ha) had significantly increased higher organic carbon (0.92%) compared to other treatments. It might be due to vermicompost contained higher amount of active humic fraction in turn having high CEC and thus resulted in maximum enhancement of organic carbon. Similar results were reported by Baskaran et al. (1994), Hipparagi (2011) and Navi (2013).

4.2 Soil moisture

At the soil depth from 0 to 30cm soil moisture content was non-significant from the day of planting to six months after planting in main plot, sub plot and among the interactions between main plot and sub plot. Whereas, soil moisture was significant at seven months after planting, the trend of significance continued till the last reading. In main plot maximum soil moisture was recorded in Ring basin (7.62%) followed by Half ring basin (7.15%), Conservation pit (6.3%) and the least was recorded in control (5.31%). In sub plot the maximum soil moisture was recorded in Vermicompost (7.08%), followed by Poultry manure (6.74%), Farm yard manure (6.49%) and the least soil moisture were recorded in control (6.07%). Among the interactions the maximum soil moisture was recorded in Ring basin with vermicompost (7.77%), followed by Ring basin with Poultry manure (7.71%), Half ring basin with vermicompost (7.39%) respectively and least was recorded in control (3.73%).

Table 3 Effect of moisture conservation measures and organic manures on chemical properties of soil in *Simarouba glauca* plantation after one year of treatment imposition.

Treatments	Chemical Properties of Soil		
	pH	EC (dS/m)	OC (%)
Main plots (M)			
Conservation pit(M_1)	5.74	0.03	0.80
Ring basin (M_2)	5.83	0.05	0.93
Half ring basin (M_3)	5.78	0.04	0.84
Control (M_4)	5.69	0.02	0.76
S.Em.±	0.08	0.01	0.01
CD @ 5%	NS	NS	0.03
Sub plots(S)			
Farm yard manure (S_1)	5.75	0.03	0.81
Vermicompost (S_2)	5.85	0.05	0.92
Poultry manure(S_3)	5.77	0.04	0.85
Control (S_4)	5.69	0.02	0.75
S.Em.±	0.07	0.01	0.01
CD @ 5%	NS	NS	0.02
Interactions (M x S)			
M_1S_1	5.67	0.03	0.77
M_1S_2	5.80	0.05	0.90
M_1S_3	5.68	0.03	0.81
M_1S_4	5.83	0.03	0.73
M_2S_1	5.93	0.02	0.90
M_2S_2	5.98	0.09	1.01
M_2S_3	5.79	0.06	0.94
M_2S_4	5.63	0.03	0.86
M_3S_1	5.75	0.04	0.82
M_3S_2	5.81	0.03	0.91
M_3S_3	6.02	0.05	0.85
M_3S_4	5.55	0.02	0.76
M_4S_1	5.63	0.04	0.74
M_4S_2	5.80	0.01	0.87
M_4S_3	5.58	0.03	0.78
M_4S_4	5.74	0.01	0.63
S.Em.±	0.14	0.01	0.01
CD @ 5%	NS	NS	0.04

NS- Non Significant

At 30 to 60cm depth the soil moisture was non-significant from the day of planting to five months after planting of *S. glauca* in main plot, sub plot and interactions between main plot and sub plot. Whereas, soil moisture was significant at six months after planting, the trend of significance continued till the last reading. In main plot maximum soil moisture content was recorded in Ring basin (12.89%) followed by Half ring basin (11.5%), Conservation pit (11.35%) and the least was recorded in control (7.12%). In sub plot maximum soil moisture was recorded in vermicompost (11.59%) followed by Poultry manure (10.69%), Farm yard manure (10.79%) and the least was recorded in control (9.79%). Among the interactions between main plot and sub plot significantly maximum soil moisture content was recorded in ring basin with vermicompost (13.07%) followed by ring basin with poultry manure (13.2%), Ring basin with farm yard manure (13.06%) respectively least was recorded in control (5.77%) (Fig. 1).

Increased soil moisture content might be due to the application of vermicompost manure might have improved soil physical properties. Further, the higher organic matter addition could increase organic carbon content of the soil which resulted in increased water holding capacity of the soil. The humus can absorb water two to six times of its own weight. Soil organic matter is responsible to a great extent, directly or indirectly for making the good physical environment of the soil suitable for the growth of increased organic matter content, which in turn reduced bulk density (Jeyamala and Soman, 1999) that might have helped for significantly higher moisture conservation in soil. The conservation structure might have improved the soil moisture content by permitting water to infiltrate in to the deeper horizons and it directly increased the water level in the soil.

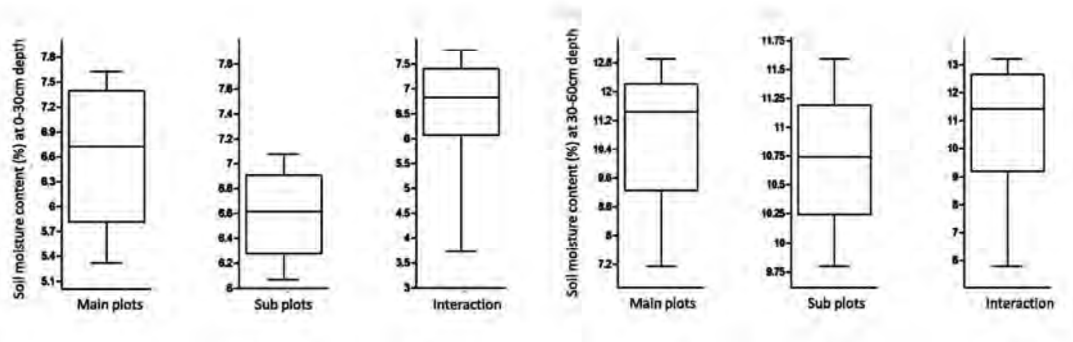

Fig. 1 Effect of moisture conservation measures and application of organic manures on soil moisture content at 0-30cm and 30-60cm depth under *Simarouba glauca* plantation at 10 months after planting.

4.3 Nutrient status of soil

In main plot maximum phosphorus was recorded in Ring basin (25.04 kg/ha) followed by Half ring basin (23.49 kg/ha), Conservation pit (22.60 kg/ha) and least was recorded in control (19.66 kg/ha). Whereas, in sub plot maximum was recorded in vermicompost (24.71 kg/ha) followed by Poultry manure (23.65 kg/ha), Farm yard manure (22.15 kg/ha) and the least was recorded in control (20.29 kg/ha). Among the interactions maximum Phosphorus was recorded in Ring basin with vermicompost (27.81 kg/ha) followed by Ring basin with Poultry manure (26.52 kg/ha), Half ring basin with vermicompost (25.14 kg/ha) respectively and the least was recorded in control (17.16 kg/ha). In main plot Potassium was maximum in Ring basin (166.57 kg/ha) followed by Half ring basin (163.80 kg/ha), Conservation pit (161.48 kg/ha) and least was recorded in control (152.94 kg/ha). Whereas, in sub plot maximum potassium was recorded in vermicompost (166.11 kg/ha) followed by Poultry manure (163.26 kg/ha), Farm yard manure (160.86 kg/ha) and the least was recorded in control (154.55 kg/ha). Whereas among the interactions maximum potassium was recorded in ring basin with vermicompost (170.54 kg/ha) followed by Ring basin with Poultry manure (169.04 kg/ha), Conservation pit with vermicompost (166.43 kg/ha) respectively and the least was recorded in control (138.56 kg/ha) (Table 4).

Nitrogen is the basic nutrient and makes up 1- 4% of dry weight of plants as it forms chlorophyll, amino acids, proteins, alkaloids and protoplasm, thus it is the most important macronutrient needed for plant growth and development. Availability of nitrogen enhances the plant growth and helps in formation of proteins. It also an integral part of chlorophyll, which is primary absorber of light energy needed for photosynthesis (Mahantappa and Shivanna, 2010).

Different moisture conservation measures significantly differed with control but there is a little variation in the nutrient status of the soil. This may be because although increase moisture content of soil might lead to loss of water soluble nutrients but simultaneously the increased moisture also supplies greater amount of dissolved nutrients for plant growth from the underlying soil layers. The loss of soil nutrient was minimal due to soil moisture conservation measures (Verma et al., 2003).

The soil available nutrients *viz.*, nitrogen, phosphorus and potash availability in soil was significantly influenced by moisture conservation methods. However, available nitrogen and potassium was higher in soil compared to available phosphorus. This might be due to moisture stress occurred even during rainy season and also because of longer intervals between the rains. This has led to low growth rate in turn very less amount of nitrogen in the soil.

The available Nitrogen was significantly high in Ring basin with vermicompost as compared to control it might be due to application of vermicompost can be attributed to more release of nitrogen from Vermicompost to the available Nitrogen pool and also due to faster rate of nitrogen mineralization. Similar results were recorded by Korwar et al. (2009) in *Lucaena leucocephala*, Verma et al. (2009) in apple.

The lower phosphorus availability in soil was attributed to very low soil pH, in such soils major part of the phosphorus was bound to $Fe^{+2}$and $Al^{+3}$and it becomes unavailable to the plants (Jeyamal and Soman, 1999).

Similarly, maximum available phosphorus (24.71kg/ha) was also noticed due to vermicompost (2.5tons/ha) application as compared to poultry manure (0.75t/ha) showing steady build up of phosphorus in soil. It might be due to the high microbial activity and enhanced mineralization of soil phosphorous coupled with high phosphatase activity are the reasons for high extract of available phosphorous (Baskaran et al., 1994).

Available Phosphorus status varied significantly among the treatments. Among the interaction effects ring basin with vermicompost @ 2.5tons/ha recorded highest available P in the soil due to organic substances that solubilized and reduced the quantity of insoluble phosphate of $Fe^{+2}$and Al^{+3} through release of organic acids (Welp et al., 1983).

Application of vermicompost @ 2.5 t/ha (S_2) recorded higher available potassium in the soil (166.11kg/ha) as compared to control (154.55 kg/ha) which might be due to K^+ ions from edge, wedge, or inter layer sites within clay minerals, could possibly be replaced by NH^{4+} ions of similar ionic radius, so the concentration of which was increased in the presence of vermicompost (Baskaran et al., 1994). .

The available potassium in soil was varied significantly due to different treatments receiving FYM, vermicompost and poultry manure. The increase in K^+ content can be attributed to the release of K^+ due to organic manures application. Similar results were observed by Muthuvel et al. (1979); Pandey et al. (1985); Parvathappa et al. (1988).

Table 4 Available Nutrients status of soil as influenced by moisture conservation measures and application of organic manures in *Simarouba glauca* plantation.

Treatments	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O(kg/ha)
Main plots (M)			
Conservation pit(M_1)	256.35	22.60	161.48
Ring basin (M_2)	268.90	25.04	166.57
Half ring basin (M_3)	262.60	23.49	163.80
Control (M_4)	245.14	19.66	152.94
S.Em.±	2.50	0.23	0.13
CD @ 5%	8.62	0.79	0.43
Sub plots(S)			
Farm yard manure (S_1)	253.14	22.15	160.86
Vermicompost (S_2)	268.01	24.71	166.11
Poultry manure(S_3)	263.82	23.65	163.26
Control (S_4)	248.02	20.29	154.55
S.Em.±	0.23	0.11	0.17
CD @ 5%	0.68	0.33	0.51
Interactions (M x S)			
M_1S_1	250.02	22.35	160.33
M_1S_2	266.74	24.94	166.43
M_1S_3	263.16	22.82	162.07
M_1S_4	245.48	20.29	157.08
M_2S_1	264.52	23.56	165.15
M_2S_2	277.13	27.81	170.54
M_2S_3	273.53	26.52	169.04
M_2S_4	260.44	22.28	161.55
M_3S_1	257.41	23.01	163.23
M_3S_2	272.21	25.14	166.03
M_3S_3	266.46	24.40	164.91
M_3S_4	254.31	21.41	161.03
M_4S_1	240.61	19.69	154.72
M_4S_2	255.95	20.93	161.45
M_4S_3	252.13	20.84	157.03
M_4S_4	231.86	17.16	138.56
S.Em.±	0.47	0.22	0.35
CD @ 5%	1.37	0.65	1.01

4.4 Growth parameter of *Simarouba glauca*

Influence of moisture conservation measures and application of organic manure on plant growth parameters was non-significant at initial measurements and was significantly different among main plot, sub plot and among interactions at 12 months after planting. In main plot maximum plant height (1.25m), collar diameter (2.63cm), crown diameter (93.98cm), number of leaves (45.25) was recorded in ring basin followed by half ring basin, conservation pit and the least was recorded in control. Similar results were revealed by Negi et al. (2013) in *Emblica officinalis*.

In sub plot maximum plant height (1.71m), collar diameter (3.05cm), crown diameter (111.38cm) and number of leaves (48.11) was recorded in vermicompost followed by poultry manure, farm yard manure and the least was recorded in control. Among the interaction between main plot and sub plot significantly growth parameter recorded maximum in ring basin with vermicompost- plant height (1.94m) collar diameter (3.97cm), crown diameter (133.83cm), number of leaves (63.07) followed by ring basin with poultry manure, half ring basin with vermicompost respectively and the least was recorded in control (Table 5).

Table 5 Effect of moisture conservation measures and application of organic manures on plant growth of *Simarouba glauca* at 12 months after treatment.

Treatments	Plant height (m)	Collar diameter (cm)	Crown diameter (cm)	Number of leaves
Main plots (M)				
Conservation pit(M_1)	1.11	2.22	86.11	42.77
Ring basin (M_2)	1.25	2.63	93.98	45.25
Half ring basin (M_3)	1.18	2.35	89.92	43.29
Control (M_4)	0.98	2.10	81.94	41.44
S.Em.±	0.01	0.03	0.08	0.13
CD @ 5%	0.05	0.10	0.29	0.46
Sub plots(S)				
Farm yard manure (S_1)	1.42	3.00	112.92	56.95
Vermicompost (S_2)	1.71	3.49	126.89	60.66
Poultry manure(S_3)	1.58	3.23	121.41	58.63
Control (S_4)	1.32	2.68	108.05	54.07
S.Em.±	0.02	0.03	0.07	0.08
CD @ 5%	0.06	0.09	0.21	0.24
Interactions (M x S)				
M_1S_1	1.34	2.98	110.07	56.53
M_1S_2	1.74	3.26	124.54	59.52
M_1S_3	1.52	3.10	119.27	57.18
M_1S_4	1.32	2.51	105.38	54.85
M_2S_1	1.55	3.16	121.36	59.58
M_2S_2	1.94	3.97	133.83	63.07
M_2S_3	1.80	3.76	129.71	62.17
M_2S_4	1.41	3.11	116.32	56.51
M_3S_1	1.54	3.13	116.51	56.75
M_3S_2	1.77	3.47	129.51	61.43
M_3S_3	1.60	3.21	123.40	58.22
M_3S_4	1.38	2.72	110.14	54.47
M_4S_1	1.26	2.72	103.73	54.93
M_4S_2	1.42	3.24	119.68	58.64
M_4S_3	1.40	2.83	113.27	56.96
M_4S_4	1.17	2.39	100.35	50.46
S.Em.±	0.04	0.06	0.14	0.16
CD @ 5%	0.12	0.19	0.42	0.48

Among the organic manures treatments, application of vermicompost @ 2.5t/ha significantly increased plant height, collar diameter, crown diameter and number of leaves. It might be due to the vermicompost which had the highest levels of total nitrogen, total phosphorous, C/N and C/P ratio, suggesting superior mineralization of organic forms of nitrogen and phosphorous, improved organic matter and available nutrient content in the soil. Similar observation was reported by Navi (2013) in *Casuarina equisetifolia*. The studies conducted by Krishnan et al. (2004), showed that use of organic manures increased the collar diameter over the control in *Simarouba glauca.* In Ring basin there was more opportunity for the rainwater to infiltrate around the plant when compared to other moisture conservation methods. Because of higher moisture available in this treatment for longer duration plant would have continued to grow even in dry season that was the reason for maximum plant height, collar diameter, crown diameter and number of leaves were recorded in ring basin method. The technique of soil moisture conservation helps in conserving the runoff water and in turn increased the productivity of lands. In ring basin there was more opportunity for the rainwater to infiltrate around the plant when compared to other moisture conservation methods (Sharanbasappa et al., 2009; Sumbali et al., 2012; Anju and Koppad, 2013).

An increased plant height, collar diameter, crown diameter and number of leaves could be due to higher soil moisture available in ring basin. Higher per cent of available soil moisture during dry season might have favoured the nutrient absorption by plants, which in turn resulted in higher plant height, collar and crown diameter and number of leaves. Interaction between the treatments has influenced growth parameters substantially when compared to individual treatments (Venkatesh et al., 2010). Similar results on growth parameters were recorded by Gupta and Muthana (1985) in *Acacia tortilis*; Choudhary, et al. (1998) in *Azadirachta indica*. The maximum plant height (1.25 m), Collar diameter (2.63 cm) and Crown diameter (93.98 cm) was recorded in ring basin at 12 MAT as compared with other moisture conservation methods. Similarly results in ring basin recorded maximum plant height and main stem volume compared to the control in teak plants (Sharanbasappa et al., 2009). Lower plant height, collar and crown diameter was recorded in control might be due to less availability of nutrients to the plants.

Soil moisture conservation measures and nutrient management influence plant height and DBH growth (Rajendradu and Naidu, 1998; Singh, 1999). The interaction effect influenced the plant height than that of individual treatment effect. The main factor might be the combination of moisture and nutrient availability (Venkatesh et al., 2010).

Secondly more number of branches might have helped for more photosynthetic activity which in turn increased the absorption of nutrients which resulted in higher plant height and also might be due to the moisture balance in the plant, which regulated the leaf shedding duration by regulating moisture stress condition (Priya and Bhat 1999). The higher plant height, collar and crown diameter increment in rainy and dry season were mainly due to higher moisture and nutrient availability to the plants. The lower plant height, collar and crown diameter increment in control might be due to moisture stress experienced by the trees during growing period (Kumar and Kulkarni, 1995). The plant continued to grow even during dry season because the meristem was active and layers of cells varying in width are added both to the inner wood and outer bark resulted in more collar diameter Tewari (1999).

Among *in-situ* moisture conservation measures, the ring basin significantly increased the number of leaves. The difference in the response of growth parameters to various *in-situ* moisture conservation treatments was purely due to differences in the moisture holding and retaining efficiency of treatments (Negi et al., 2012). Similar results in ring trench increased the number of leaves and branches as compared to the control in *Acacia mangium* (Vasanthkumar and Koppad, 2013).

The increase in number of leaves might be due to application of vermicompost which might have improved the soil properties, which favoured the growth of Simarouba. Vermicomposts are rich in microbial populations and diversity, particularly fungi, bacteria and actinomycetes. Many studies have demonstrated the effectiveness of vermicompost in providing protection against various plant diseases and improve the plant growth (Moradi et al., 2014). Vermicompost is an excellent soil amendment and a biocontrol agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. Vermicompost is ideal organic manure for better growth and yield of many plants. Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant, chlorophyll content, soil pH, TSS, micro and macro nutrients, carbohydrate and protein content and improved the quality of the fruits and seeds (Joshi et al., 2014). Higher quantity of nitrogen in applied manure might have increased the chlorophyll content of leaves, which led to increased photosynthetic activity resulting in vigorous vegetative growth and development of plant (Banerjee, 1973). Increase in number of branches can be attributed the availability of nutrients might have resulted in increased production of photosynthetic and their translocation into branches and leaves. Similarly the number of branches per plant of *Acacia nilotica* increased linearly with increasing level of nitrogen as well as phosphorus (Deswal et al., 2001; Hulikatti and Madiwalar, 2011). The increase in all growth parameter is mainly due to exogenous application of manures (Prasad et al., 1984) in *Eucalyptus grandis,* (Turvey, 1996) in *Acacia mangium* (Lamani et al.,

2003) in *Acacia auriculiformis*. Janet et al. (2016) revealed that poultry manure, NPK and cow dung gave comparable growth factors *Solanum nigrum*.

References

Anju SV, Koppad AG. 2013. Influence of *in situ* soil moisture conservation measures on growth and productivity of *Acacia auriculiformis*. Karnataka Journal of Agricultural Sciences, 26: 170-171

Bajpai PD, Rajana KM, Arya, et al. 1980. Comparative studies on decomposition pattern of some plant material in two different soil conditions during winter season. Indian Journal of Agricultural Research, 14: 91-102

Banerjee AK. 1973. Plantations of *Acacia auriculiformis* (Benn.) A. Cunn. In West Bengal. Indian Forester, 99: 533-540

Baskaran A, Kirkmon JH, Macqrger AN. 1994. Changes in potassium availability and other soil properties due to soil ingestion by earthworms. Biology and Fertility of Soils, 17: 154-158

Choudhary KR, Gupta GN, Mishra AK. 1998. Effect of rain water harvesting on growth of *Azadirachta indica*. The Indian Forester, 16: 193-205

Deswal AK, Dahiya DJ, Bargarwa KS. 2001. Response of nitrogen and phosphorus to Kikar (*Acacia nilotica*) in FYM treated sandy soil. Indian Journal of Forestry, 24: 220-222

Devaranavadgi SB, Patil SB, Jambagi MB, et al. 2010. Effect of various planting methods on silvicultural parameters of different tree species under dry land condition. MyForest, 46: 139-149

Gaur AC, Giand S. 1995. Microbial and solubalization of Phosphates with particular reference of iron and aluminium phosphate. Science Cultivation, 49: 110-112

Gupta JP, Muthana KD. 1985. Effect of integrated moisture conservation technology on the early growth and establishment of *Acacia tortilis* in the Indian desert. Indian Forester, 111: 477-485

Hipparagi HC. 2011. Influence of in-situ moisture conservation measures and organic manures on growth of *Eucalyptus pellita*. MSc (Agriculture) thesis, University of Agricultural Sciences, Dharwad, India

Hulikatti MB, Madiwalar SL. 2011. Management strategies to enhance growth and productivity of *Acacia auriculiformis.* Karnataka Journal of Agricultural Sciences, 24: 2004-2006

Jackson ML. 1967. Soil Chemical Analysis, Prentice Hall of India Private Limited, New Delhi, India

Janet AM, Oluwafemi AB, Abiodun SR. 2016. Effects of Organic and Inorganic Fertilizers on the Growth Performance of *Solanum nigrum* L. Journal of Agriculture and Ecology Research International, 5: 1-6

Jeyamala M, Soman P. 1999. Short term changes in soil fertility status in intensively managed Teak plantation. Indian Journal of Forestry, 22: 106-111

Joshi R, Singh J, Vig AP. 2014. Vermicompost as an effective organic fertilizer and biocontrol agent: effect on growth, yield and quality of plants. Reviews in Environmental Science and Bio/Technology, 14: 137-159

Joshi S, Joshi S. 2002. Oil tree-*Simarouba glauca* DC. University of Agricultural Sciences, Bangalore and Indian Council of Agricultural Research (ICAR), New Delhi, India

Korwar GR, Pratiba G, Ravi V. 2009. Influence of organic and inorganic sources of nutrients on growth of Leucaena (*Lucaena leucocephala*) and soil quality in semi-arid tropics, Indian Journal of Forestry, 32: 513-516

Krishnan PR, Surender S RJ, Kalai ST. 2004. Influence of inoculation of biofertilizers on growth and biomass productivity of *Simarouba glauca* seedlings. MyForest, 40: 197-202

Kumar AM, Kulkarni PK. 1995. Improved technique of Teak. Indian Forester, 4: 18

Lamani VK, Patil SK, Manjunath GO, et al. 2003. Influence of fertilizers on initial growth of *Acacia auriculiformis.* MyForest, 39: 93-97

Lele U. 2010, Food security for a billion poor. Science, 326: 1554

Mahantappa SS, Shivanna H. 2010. Effect of integrated nutrient management on growth and development of the *Pterocarpus santalinus* (Linn. F) seedlings. Karnataka Journal of Agricultural Sciences, 23: 726-728

Mendonca S, Vas JP. 2013. Influence of Injection Timing on Performance and Emission Characteristics of Simarouba Biodiesel Engine. International Journal of Scientific Research Publications, 3:1-6

Mishra SR, Mohanty MK, Das SP, et al. 2012. Production of Bio-diesel (Methyl Ester) from *Simarouba Glauca* Oil. Research Journal of Chemical Science, 2: 66-71

Moradi H, Fahramand M, Sobhkhizi A, et al. 2014. Effect of vermicompost on plant growth and its relationship with soil properties. International Journal of Farming and Allied Sciences, 3: 333-338

Muthuvel P, Kandaswamy P, Krishnamurthy KK. 1979. Organic carbon and total N content of soil under long term fertilization. Journal of the Indian Society of Soil Science, 27: 186 -188

Navi P. 2013. Studies on effect of integrated nutrient management on early establishment of *Casuarina equisetifolia* plantation in Sharawati watershed area. MSc (Agriculture) thesis, University of Agricultural Sciences, Dharwad, India

Neelakantan KS, Paramathama M, Parthiban KT. 2004. Tree Borne Oilseeds an overview Strategies for Improvement and Utilization of tree Borne Oilseeds. CAR-Winter School Forest College and Research Institute, Tamil Nadu

Negi RS, Baghel BS, Gupta AK, et al. 2012. Standardization of *in-situ* moisture conservation method for establishment of aonla orchards on sloppy degraded wastelands, HortFlora Research Spectrum, 1: 289-294

Negi RS, Baghel BS, Gupta AK, et al. 2013. Effect of *in-situ* moisture conservation method on plant growth and nutrient uptake in aonla (*Emblica officinalis*) in sloppy degraded lands, HortFlora Research Spectrum, 2: 1-7

Pandey N, Upadhyaya SK, Joshi BS, et al. 1985. Integrated use of organic manure and inorganic N fertilizer for the cultivation of low land rice in vertisol. Indian Journal of Agricultural Research, 35: 112 -114

Parvathappa HC, Kantharaj ML, Hegde BR. 1988. Fertilization requirement of crops under dryland condition in the semiarid tropics. Proceedings of International Conference on Dry land Farming, Amarillo, Texas, USA

Prasad KG, Kumardinesh TJ, Chandrashekharan N, et al. 1984. Fertilization in *Eucalyptus grandis* on severely truncated soil. 1: Growth studies. Indian Forester, 108: 113-149

Priya PB, Bhat KM. 1999. Influence of rainfall, irrigation and age on the growth periodicity and wood structure in teak (*Tectona grandis*). International Association of Wood Anatomists, 20: 181-192

Rajendradu G, Naidu CV. 1998. Effect of water stress on leaf growth photosynthetic and transpiration rates of *Tectona grandis*. Biologia Plantarum, 40: 229-234

Rajurkar BM. 2011. A comparative study on antimicrobial activity of *Clerodendrum infortunatum*, *Simarouba glauca* and *Psoralea corylifolia*. International Journal of Research and Review in Phamacy and Applied Sciences, 1: 278-282.

Shantha RH, Joshi S, Shambhulingappa KG, et al. 1996. Floral biology of *Simarouba glauca* DC An oilseed tree. Journal of Oilseeds Research, 13: 93-96

Sharanbasappa BN, Channabasappa KS Naik GV. 2009. Effect of moisture and integrated nutrient management on two year old Teak plantation. MyForest, 45: 191-197

Shukla SP, Padmaja G. 2013. *In Vitro* regeneration from shoot tip and nodal explants of *Simarouba glauca* DC, A promising biodiesel tree. International Journal of Applied Biology Pharmaceutical Technology, 4: 206-213

Singh RP. 1999. Sustainable crop production strategies for management of arid and semi-arid ecosystems India: Management of Arid ecosystem. Research Association of India and Scientific Publisher, Jodhpur, India

Subbaiah BV, Asija GL. 1956. A rapid procedure for the estimation of available nitrogen in soil. Current Science, 25: 259-260

Sumbali S, Koppad AG, Gurav M. 2012. Effect of soil moisture conservation structures and application of manures and fertilizers on growth of *Acacia auriculiformis.* International Journal of Environmental Sciences, 1: 178-185

Tewari DN. 1999. A Monograph on Teak (*Tectona grandis* Linn. F.). International Book Distributors, Dehra Dun, India

Turvey ND. 1996. Growth at 30 months of Acacia and Eucalyptus species planted in imperata grass lands in Kalimantan, Seletan Indonesia. Forest Ecology and Management, 82: 185-195

Vasanthkumar R, Koppad AG. 2013. Influence of *in-situ* moisture conservation methods and application of manures and biofertilizers on growth of *Acacia mangium*. Karnataka Journal of Agricultural Sciences, 26: 97-102

Venkatesh L, Lakshmipathaiah OR, Panduranga, 2010. Effect of moisture and integrated nutrient management on volume teak. Mysore Journal of Agricultural Sciences, 44: 59-63

Verma ML, Charan S, Bhardwaj SP. 2009. Effects of bio fertilizers on soil moisture, Nutrient status and fruit productivity under organic cultivation of apple in Himachal Pradesh. Indian Journal Soil Science, 37: 201 -205

Verma ML, Sharma RK, Bhandari AR, et al. 2003. Runoff soil and nutrient losses and productivity under pea-tomato sequences influenced by soil management practices. Indian Journal of Soil Conservation, 31: 148-151

Welp G, Hermus U, Bruner, 1983. Influence of soil reaction redox condition and organic matter on P content of soil solution. Z Pflanzen Bodenk, 146: 38-52