Indian J. Soil Cons., 36 (2) : 105-108, 2008

Impact of *in situ* moisture conservation practices on soil moisture and growth of *ber* and *kusum* for sustained lac production in Jharkhand

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Lac, a natural resin of commerce, is produced by specialized tiny scale insects, known as lac insects belonging to the genus *Kerria* (Homoptera: Tachardiidae). These insects are cultured mainly on traditional host species i.e., *palas* (*Butea monospserma*), *ber* (*Zizyphus mauritiana*) and *kusum* (*Schleichera oleosa*) in India, found scattered in the forest and personal holdings of the lac growers. Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra and West Bengal are the main lac producing states in India. Jharkhand is a major lac growing state in the country and it accounts for more than 32% production (7490 ton) of the total production (23000 ton) of the country.

Kusmi and *rangeeni* are the two strains of *Kerria lacca* and each produce two crops in a year (bivoltine). *Kusmi* insect grows well mainly on *kusum* and also on a few other trees but not on palas, whereas rangeeni strain grows well mainly on *palas* and also on a few other trees but not on *kusum*. The *rangeeni* insect matures once in October/November and thereafter in June/July whereas *kusmi* matures in January/ February and then in June/July.

Conventional lac host plants are slow growing and have low to moderate coppicing capacity. The gestation period for lac inoculation varies from 10-15 years for *kusum*, 5 years for *ber* and 7-8 years for *palas*. Although palas is an important host plant accounting for bulk of lac production in India, the lac produced on it ranks below in quality than that produced on *kusum* and *ber*, with lac obtained from *kusum* being considered to be the best. On the other hand, *ber* is a hardy host plant on which both the strains *viz.* *kusmi* and *rangeeni* of lac insect can be grown. Thus, good quality lac (*kusmi*) can also be produced on it with higher productivity.

For conservation and management of water there are many water conservation techniques but the techniques that may be adopted will be based on climatological condition of the region and socio-economic condition of the people. *Lac*, which is generally grown by small and marginal farmers and are not in a position to adopt exogenous technologies for water conservation. Conserving moisture during rainy season for enhancing water availability through *in situ* moisture conservation techniques is a viable option.

From crop production point of view, experience suggests that plant yield is reduced more by shortage or excess of soil moisture than by loss of soil, hence rain water management particularly water conservation, becomes more critical for rainfed farming, (Hudson 1988). Soil moisture conservation practices check or minimize direct evaporation from the soil surface and/or increase the water holding capacity of the root zone. Results of studies on effect of different soil moisture conservation practices on evapotranspiration and growth of young tea plants have indicated significant effect of different soil moisture conservation treatments on height of young tea plants (Hussain *et al.* 2003). Tree growth and fruit production of apricot significantly increased by both pre-plant compost application and mulching of the soil surface (Kotze and Joubert, 1992). Various studies have revealed that in fruit crops like apple, aonla and sapota, mulching led to improved soil moisture status, growth, yield and quantity of these fruits besides reducing weed growth (Jayant Kumar *et al.* 1999; Shukla *et al.* 2000 and Reddy *et al.* 1998). Gupta and Muthana (1985) developed circular catchments of 1.5 m radius and 2 per cent slope as runoff generating areas. This technique proved effective in improving the moisture content of the plant root zone. Low cost water conservation techniques utilizing locally available material can help rural people in efficient water management and utilization.

Since both the strains of lac insects can thrive and complete their life cycle on *ber* with highest sticklac productivity (per day/m shoot length) amongst all the lac host trees in practice (Mishra *et al.* 2000), thus it has an important role to play in boosting *kusmi* lac production in years to come. By adopting water conservation techniques, growth may be enhanced and consequently gestation period may also be reduced.

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However, since only *aghani* (winter season) lac crop of *kusmi* strain is raised on *ber*, to maintain a continuous sustainable production cycle of lac it is desirable that *kusmi* lac production, be taken by raising *kusum* for *jethwi* (summer season) lac. Raising of mixed plantations of *ber* and *kusum* was taken up in this study, so as to have a regular production of lac.

The present study was conducted at Indian Lac Research Institute Farm, Namkum, Ranchi, Jharkhand from May 2005 to July 2006. Three month old nursery raised *ber* and *kusum* seedlings were transplanted in the field during July 2005, when plenty of soil moisture was available. The average annual rainfall of Jharkhand is 1326 mm and the rainfall received during the study period (August 05- July 06) was recorded to be 1356.30 mm. The experiment laid out was in an area measuring 120x24 m^2, (approximately 0.3 ha) and in a randomized block design with five treatments and was replicated four times. Each treatment consisted of 8 *ber* plants and 1 *kusum* plant with 4.0 m x 4.0 m row to row and 4.0 m x 4.0 m plant to plant spacing. The inter plant distance for kusum was 12 m. The individual plot size was 12.0 mx12.0 m. Treatments comprised half moon terracing (T_1), mulching (T_2) with locally available grasses in and nearby the experimental plot, compartmental bunding (T_3), use of *urd* (black gram) as cover crop (T_4) and control (T_5). All agronomic practices were kept uniform for FYM and fertilizers application. Soil of the experimental plot was sandy loam in texture with average bulk density of 1.41 g/cm^3. To determine fertility status of the soil, 40 soil samples were collected from two depths 0-30 cm and 30-60 cm in May 2005 and May 2006 (Table 1). Soil was acidic in nature, low in organic carbon, available nitrogen and available phosphorus and medium in available potassium. Uniform application of lime was also added @ 3.5 q/ha. Gravimetric method was used to estimate the soil moisture content at 105^{0}C till constant weight was obtained. Moisture content of soil on weight basis was calculated and then it was converted on volume basis. Growth attributes i.e., plant height, basal girth (5 cm above the ground level), canopy spread and number of branches and soil moisture status were recorded at monthly interval (25-30 days). Recording of growth attributes was started one month after transplantation i.e. in August, while soil moisture data was recorded from October onwards. Mulching was done with locally available grasses around the periphery of the plant @10 kg/plant after cessation of monsoon in October. Incremental vegetative growth of individual characters of the host plants was obtained by deducting the initial values of growth attributes in August 2005 from the values recorded in July 2006. A cover crop in the form of urd (a pulse legume) was sown in early August and harvested by picking of pods in early November and yield was recorded after harvesting. The biomass obtained (stalks+leaves+ roots) was incorporated in the soil in all the replications of treatment T_4.

Table 1. *Basic physico-chemical properties of the experimental plot*

Depth interval	pH	OC (%)	Av. N (Kg ha^{-1})	Av. K_2O (Kg ha^{-1})	Av. P_2O_5 (Kg ha^{-1})	Bulk density (g cm^{-3})
			May 2005			
0-30	4.00-4.67	0.03-0.33	116-428	96-252	4.65-15.39	1.40
30-60	4.10-4.72	0.21-0.60	100-335	90-193	5.26-14.46	1.42
			May 2006			
0-30	4.03-4.81	0.11-1.64	129-429	110-383	4.85-16.0	1.40
30-60	4.20-4.79	0.21-0.75	101-336	114-194	5.37-14.98	1.42

Soil Moisture Status

Perusal of Table 2 reveals that though, there was improvement in soil moisture status on account of adopting different moisture conservation measures over control, significant improvements in soil moisture status was observed only during October 2005 and April- May 2006. During the study period the highest soil moisture content (10.0-26.6 cm m^{-1}) was observed in half moon terracing treatment during all the months, except December 2005. During October, three treatments T_1, T_2 and T_3 were observed to be significantly superior over control while they remained at par amongst themselves. During April and May soil moisture content was observed to be higher in all the four treatments T_1, T_2, T_3 and T_4 over T_5, but they remained at par with each other. The lowest soil moisture content was observed in control (7.1 - 24.8 cm m^{-1}).

Table 2. *Soil moisture status (cm m^{-1}) in 0-60 cm under various conservation measures*

Treatments	Months									
	Oct 05	Nov 05	Dec 05	Jan 06	Feb 06	Mar 06	Apr 06	May 06	Jun 06	Jul 06
T_1	25.2	18.8	14.0	13.9	11.3	10.0	11.3	11.6	26.6	23.7
T_2	22.5	17.2	10.2	10.1	9.9	8.0	10.7	10.9	25.5	23.2
T_3	21.8	18.4	14.1	10.2	10.1	7.9	11.2	11.4	25.9	22.9
T_4	18.4	15.9	10.2	9.9	9.3	9.1	11.0	11.2	26.4	21.4
T_5	14.9	12.8	8.8	8.8	8.5	7.1	7.8	7.9	24.8	20.6
CD (P= 0.05)	5.7	NS	NS	NS	NS	NS	2.0	1.9	NS	NS

Growth Parameters

Vegetative growth parameters such as plant height, basal girth except number of branches of *ber* plants were significantly influenced by *in-situ* moisture conservation practices (Table 3). All the treatments, except plant height under T_4, were effective in inducing better vegetative growth than control, which may be attributed to more moisture conservation under different conservation measures adopted over control. The highest vegetative growth was observed in half moon terracing followed by mulching in all the parameters except number of primary branches/plant. In case of plant height and canopy spread treatments T_1, T_2 and T_3 were at par with each other and superior to T_4 and T_5. Whereas, in case of basal girth only T_1 and T_2 were found to be significantly superior over T_5. The number of primary branches/plant were not influenced by different moisture conservation techniques and showed an erratic trend. The magnitude of increment in plant height, basal girth and canopy spread was 118.65, 6.33 and 94.42 cm in half moon terracing as compared to 102.06, 4.61 and 76.55 cm, respectively in control. It may be due to the fact that half moon terracing method helped to store the moisture for longer period of time when compared to control which in turn resulted in higher absorption of moisture and better growth of plants. Though, the incremental magnitude in plant height, basal girth, canopy spread and number of branches in kusum was found to be 30.25 cm, 2.63 cm, 32.50 cm and 11.75 under T_1 and 15.0 cm, 1.95 cm, 26.50 and 11.0 under T_5, respectively, no significant difference was observed due to different moisture conservation techniques during the period (Table 4).

Table 3. *Incremental vegetative growth of ber under different soil moisture conservation treatments*

Treatments	Plant height (cm)	Basal girth (cm)	Canopy spread (cm)	No. of primary branches/plant
T_1	118.65	6.33	94.42	8.00
T_2	118.56	5.77	91.55	6.00
T_3	118.09	5.34	87.58	6.00
T_4	97.87	4.85	83.76	8.00
T_5	102.06	4.61	76.55	7.00
CD (P=0.05)	14.54	0.94	10.14	NS

Yield of inter-cropped *urd*

Urd (black gram) was sown @ 17.36 kg/ha in the treatment T_4. The average grain yield, stalk and biomass (stalks+roots+leaves) obtained was 169.44 kg/ha, 65.90 kg/ha and 228.25 kg/ha, respectively. Farmers can easily do intercropping under mixed plantation of *ber* and *kusum* for getting some income, particularly in the early stages of plantation since there are no competitive effects. The entire biomass obtained was incorporated in the soil to improve the water retention capacity. The incorporation of organic matter to soil modifies the soil structure and increases water retention (Bhagat *et al.* 1996), thus reducing evaporation losses, deep percolation and seepage loss, which ultimately reduce water use.

Table 4. *Incremental vegetative growth of kusum under different soil moisture conservation treatments*

Treatments	Plant height (cm)	Basal girth (cm)	Canopy spread (cm)	No. of primary branches/plant
T_1	30.25	2.63	32.50	11.75
T_2	35.50	3.10	41.38	13.25
T_3	28.25	2.93	38.75	12.50
T_4	14.25	1.78	24.00	9.25
T_5	15.00	1.95	26.50	11.00
CD (P=0.05)	NS	NS	NS	NS

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the facilities and help provided by the Head, Lac Production Division, IINRG, Ranchi in conducting the study. Support provided by Sri D.W. Runda (T-4) in layout of the plot and collection of data is gratefully acknowledged.

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Received : August 2007; Revised : July 2008; Accepted : August 2008