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Effect of *In-situ* Soil Moisture Conservation Practices on Growth, Moisture Use Efficiency and *Kusmi* Lac Yield of *Ber (Ziziphus mauritiana)* under Rainfed Condition in Jharkhand

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ABSTRACT

Soil moisture conservation practices have favourable effect on surface soil moisture conditions and consequently on the crop growth. For commercial lac host plants, which are generally grown under rainfed condition, the importance of soil moisture conservation remains high especially during its establishment stage. A field experiment was carried out at Indian Institute of Natural Resins and Gums Farm, Ranchi, during 2005-2009 to find out the effect of different *in-situ* soil moisture conservation practices on plant growth and *kusmi* winter season lac yield of *ber (Ziziphus mauritiana)*, which is one of the most important lac hosts alongside *kusum (Schleichera oleosa)* and *palas (Butea monosperma)*. The moisture conservation treatments imposed were: half moon terracing, mulching with locally available grasses, compartmental bunding, cover crop (black gram) and control (without rainwater conservation treatment). All the conservation treatments were effective in increasing soil moisture level over control, but mulching proved to be the best treatment. Mulching at the rate of 10 kg/plant conserved 26.2 % more moisture over control during the post monsoon period. Mulching was also useful in enhancing the *ber* plant height, basal girth and crown spread by 22.8, 24.2 and 28.9%, respectively, over control. Moisture use efficiency increased by 1.51 kg/ha/mm, while the harvested biomass recorded was 86.1% higher over control. Although both the broodlac yield and broodlac yield ratio were statistically non-significant, yet the broodlac yield ratio was 61.9% more under mulching than under control.

Lac is an important subsidiary source of income to the farmers of Jharkhand, which ranks second in production in the country, after Chhattisgarh. According to Pal *et al.* (2009), the average national production of lac during last three years was 20,348 t out of which contribution of Chhattisgarh was 7,744 t (38.1%), followed by Jharkhand accounting for 5,958 t (29.3%). All the three main commercial lac hosts supporting lac insect *Kerria lacca* (Kerr) *i.e.*, *palas (Butea monosperma)*, *ber (Ziziphus mauritiana)* and *kusum (Schleichera oleosa)* are available in abundance in Jharkhand. Two strains of *Kerria lacca i.e.*, *rangeeni* and *kusmi* contribute significantly in lac production. *Ber* trees support both the strains of lac insect, and good quality *kusmi* lac can be produced on it with higher productivity.

Soil moisture conservation practices have favourable effect on surface soil moisture conditions, and consequently on the crop growth. Thus, this practice has been widely used for many fruit trees, bushes and tropical plantations such as coffee and tea (Shaxon and Hall, 1968).

Moisture conservation practices, followed to reduce the loss of moisture through evaporation, have been observed to be effective in improving the yield of rainfed crops (Katiyar, 2001). Organic mulches are poor conductors of heat that effectively reduce soil temperature and conserve soil moisture for longer period (Vaidya *et al.*, 1995). Gupta and Muthana (1985) developed circular catchments of 1.5 m radius and 2 % slope as runoff generating areas. The technique proved effective in improving the moisture content of the plant root zone. Rainwater conservation for various fruit crops such as cashew (Badhe and Magar, 2004), lemon (Ghosh, 1982), sweet orange (Arora and Mohan, 1985) and mandarin (Panigrahi *et al.*, 2006) was observed to be better for tree growth and higher productivity per unit area.

Lac is generally grown by small and marginal tribal farmers. These resource poor farmers 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, thus, a viable option. Low-cost water conservation techniques utilizing locally available material can help rural people in efficient water management of

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plateau eco-system and would prevent degradation of basic resources like soil and water. The present study was undertaken to assess the effect of *in-situ* soil moisture conservation measures on growth and *kusmi* lac yield of *ber* in lateritic soil of Ranchi in Jharkhand.

MATERIALS AND METHODS

Field experiment was conducted during May, 2005 to April, 2009 at Indian Institute of Natural Resins and Gums Farm, Namkum, ($23^0$23' N longitude, $85^0$23' E latitude and 650 m above MSL) in Ranchi district of Jharkhand having sub-humid climate. The soil was sandy loam in texture with 4.4 pH, 1.41 g/cm^3 bulk density, 20.8% field capacity, 10.9% permanent wilting point and 41.7% porosity. The soil had 0.29% organic carbon and 144.2, 10.62 and 157.8kg/ha of available N, P_2O_5 and K_2O, respectively.

The treatments comprised of half-moon terracing/half basin ring, mulching with locally available grasses *viz.*, *Digiteria sanguinalis*, L. *Setaria verticillata* Beauv, *Cynodon dactylon* (L) Pers, *Brachiaria remosa*, *Eleusine iandica*, *Echinocloa colonum* (L) and *Dactyloctenium aegypticum* (L) at the rate of 10 kg/plant, compartmental bunding with a bund height of 15 cm, use of black gram as cover crop and control (without rainwater conservation treatment). The experiment was laid out in an area of 120 m x 24 m in a Randomized Block Design with four replications. Each treatment consisted of 8 *ber* plants with 4 m x 4 m plant spacing and the individual plot size was 12 m x 12 m.

The amount of rainfall received during preceding rainy season was 412.1 (August-December), 1752.3, 1489.7, 1477.8 and 33.0 mm (January-April) from 2005 to 2009, respectively. Three month old nursery raised *ber* seedlings were transplanted (during July 2005) under moist soil condition in the field. The soil amendment practices were carried out in the form of liming, farm yard manure (FYM) application and mineral fertilizers uniformly for all the treatments. Lime was applied at the rate of 350 kg/ha, FYM at the rate of 15 kg/plant and inorganic fertilizers (urea, single super phosphate and muriate of potash) at the rate of 100, 750 and 120 g/plant, respectively. Single super phosphate and muriate of potash were applied during July every year in single split while urea in double splits, during July and September.

Plant growth attributes *i.e.*, plant height, basal girth (5 cm above the ground level), crown spread and number of primary branches and soil moisture status (gravimetrically) were recorded at monthly (25-30 days) interval from 60 cm depth of soil. Recording of growth attributes were started from August 2005. Incremental vegetative growth of individual characters of the host plants was obtained by deducting the initial values of growth attributes in a month from the values recorded in a particular month. Leaf area index (LAI) of *ber* was measured after nearly two years of its transplantation during August 2007, by Plant Canopy Digital Imager (CI- 110 version 3.0.2.0).

All *ber* plants (160 Nos.) were uniformly pruned head back at 1.25 m from the ground level maintaining single stem during February 2008, and harvested biomass was recorded. Only girth recording was continued till April 2009; while plant height, crown spread and number of branches recording was continued up to January 2008 due to head back pruning of the *ber* plants.

Soil moisture content was estimated by gravimetric method. Moisture content on weight basis was calculated and later converted on volume basis. Soil moisture content was recorded from October 2005 onwards after imposition of all the treatments. Moisture use efficiency (MUE) was determined by dividing the harvested biomass with consumptive use of the water by the plants. The consumptive use was calculated by soil moisture depletion method as described by James (1993). Broodlac inoculation for *kusmi* winter season crop at mean rate of 100 g weight/plant was done during August 2008. Broodlac was harvested during February 2009, and the data were recorded and analyzed statistically.

RESULTS AND DISCUSSION

Soil Moisture Status

Data on soil moisture conserved during the four years indicated that the moisture contents in mulching and half-basin ring was significantly superior over control (Table 1) in all the months, barring the rainy season (June-September). During this period, all the treatments were at par due to monsoon rains. Other two moisture conservation treatments *i.e.*, compartmental bunding and use of cover crop, too, induced better moisture retention over control, but were statistically at par.

Maximum mean moisture conserved (11.6-25.7%) was recorded under mulching, while the lowest (8.2-24.1%) was under control (Table 1). Mulching conserved 26.2% higher moisture over control during the post monsoon period. A slight increase in soil moisture in the month of May is attributed to pre-monsoon showers during the month. Differences between soil water content in conservation measures and control reduced from rainy to

Table 1. Soil moisture content (%, v/v) in various months under different conservation treatments (Mean data during October 2005-April 2009)

Treatment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
*HMT	11.6	11.6	11.1	11.0	11.4	21.2	25.5	21.5	23.4	20.9	14.1	12.4
Mulching	11.9	11.9	11.8	11.6	12.0	21.2	25.7	21.2	23.0	20.5	14.5	12.6
C.B.	10.2	10.1	9.4	9.0	9.9	20.7	25.2	20.1	22.3	19.7	13.1	11.4
Cover crop	9.7	10.1	9.4	9.0	9.5	20.5	24.8	19.8	21.3	17.6	12.1	10.0
Control	8.8	9.3	8.4	8.2	8.9	19.7	24.1	19.2	20.8	13.9	10.9	8.9
#$LSD_{0.05}$	1.24	1.71	1.31	0.89	1.35	NS	NS	NS	NS	2.69	1.72	1.00

HMT- Half moon terracing; C.B. - Compartmental bunding; #$LSD_{0.05}$- Least significant difference at 5% probability level; NS- Not significant; Basal girth data was recorded from August 2005 to April 2009.

post-rainy season, mainly attributed to consumptive use of water by the plants.

Plant Growth

Although numerically different, the plant growth parameters were statistically at par in mulching, half-moon terracing and compartmental bunding. Numerically, the highest vegetative growth was observed in mulching followed by half moon terracing in all the parameters except number of primary branches/plant (Table 2). Mulching significantly increased the plant height, basal girth and crown spread by 22.8, 24.2 and 28.9% over control during the entire period. Higher growth in mulching was due to prevention of contact between the soil and dry air, which reduced water loss through evaporation and resulted in higher moisture conservation and better growth of plants. LAI of *ber* revealed that although the maximum value was under mulching (2.12) and the minimum in control (1.94), but there was no significant difference amongst the treatments (Table 2).

The maximum harvested biomass was recorded under mulching (2290 kg/ha), while the lowest was in control (1230 kg/ha), indicating an increase of 86.1 per cent. The harvested biomass in other treatments was 1890, 1690 and 1590 kg/ha for half-moon terracing, compartmental bunding and cover crop, respectively (Table 3).

Table 3. Moisture use efficiency under different soil moisture conservation treatments

Treatment	Harvested biomass production (kg/ha)	MUE (kg/ha/mm)
HMT	1890	3.08
Mulching	2290	3.64
C.B.	1690	2.78
Cover crop	1590	2.65
Control	1230	2.13
SEm (±)	-	0.82
$LSD_{0.05}$	-	NS

Moisture-use Efficiency

The increase in the stored soil moisture resulted in corresponding increase in harvested biomass yield. Moisture-use efficiency for half-moon terracing, mulching, compartmental bunding, cover crop and control were 3.08,

Table 2. Incremental vegetative growth of *ber* under different moisture conservation treatments (August 2005- January 2008)

Treatment	Height (cm)	Basal girth (cm)	Crown spread (cm)	No. of primary branches	Leaf area index
HMT	233.6	20.4	232.8	18.6	1.97
Mulching	243.4	22.6	256.1	18.4	2.12
C.B.	222.3	18.6	219.7	20.1	2.03
Cover crop	211.6	19.1	209.5	16.1	1.96
Control	198.1	18.2	198.6	19.9	1.94
SEm (±)	11.17	1.24	17.13	1.16	0.19
$LSD_{0.05}$	24.35	2.70	37.34	NS	NS

3.64, 2.78, 2.65 and 2.13 kg/ha/mm, respectively. The moisture-use efficiencies did not exhibit statistically significant differences between the moisture conservation treatments (Table 3).

Lac Yield

Broodlac yield ratio (broodlac harvested: broodlac used) was higher by 61.9 % under mulching (3.53) as against under control (2.18), Table 4. However, broodlac yield as well as broodlac yield ratio were statistically non-significant.

Table 4. Mean broodlac yield ratio (broodlac harvested: broodlac used) under different soil moisture conservation treatments

Treatment	Mean weight of inoculated/ used broodlac (g)	Mean weight of harvested broodlac (g)	Broodlac yield ratio
*HMT	362.5	1500.0	3.49
Mulching	500.0	1762.5	3.53
CB	375.0	1312.5	3.48
Cover crop	325.0	862.5	2.46
Control	350.0	762.5	2.18
SEm (±)	-	374.5	0.97
#LSD $_{0.05}$	-	NS	NS

CONCLUSIONS

All *in-situ* soil moisture conservation practices, in general, had favourable effect on growth of *ber* plants. Mulching with locally available grasses was found to be the best practice in terms of enhanced soil moisture for longer duration, leading to enhanced *ber* plant height, basal girth and crown spread by 45.3 cm (22.8%), 4.4 cm (24.2%) and 57.5 cm (28.9%) over control. While the harvested biomass under mulching was 86.1% higher over control, broodlac yield ratio was 61.9% more over control. It conserved 26.2% more moisture over control during the post-monsoon period (October – May). The treatment can be easily adopted by lac growers using locally available materials.

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