PROGRESSIVE HORTICULTURE

Vol. 37(1): 56-62, 2005

# ORCHARD MANAGEMENT PRACTICES FOR LITCHI IN EASTERN INDIA, *IN-SITU* WATER HARVESTING AND MOISTURE CONSERVATION FOR IMPROVING FRUIT YIELD AND QUALITY

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## ABSTRACT

An experiment was conducted at HARP, Ranchi during 2000-2004 to study the individual and combined effect of different methods of *in-situ* water harvesting through inverted 'V' shaped terracing below the tree canopy and mulching with organic and inorganic materials on plant growth, vegetative flushing, flowering, fruit set and initial fruit drop, fruit cracking and yield of litchi cultivar Shahi. Twelve treatment combinations including four mulching materials (paddy straw, local weed, black polythene and no mulch) and three methods of terracing (full moon terracing, half moon terracing and no terracing) were applied in a randomized block design on uniformly growing 16 years old plants. The maximum plant height of litchi was recorded with full moon terracing with or without mulching. Statistically significant and highest values of tree spread and volume were also registered with full moon terracing and local weed mulching. Water harvesting through full moon terracing followed by mulching with paddy straw resulted in early panicle initiation in litchi trees. The average individual fruit weight (21.4 g) and pulp weight (16.7 g) was recorded maximum in trees with full moon terracing and paddy straw mulching. Yield per tree (59.1 kg) was significantly superior in full moon terracing coupled with paddy straw mulching which was at par with half moon terracing + paddy straw mulching (51.1 kg/tree), full moon terracing + local weed mulching (50.4 kg/tree) and no terracing + paddy straw mulching (49.6 kg/tree). Plant with full moon terracing and paddy straw mulching has an additional yield of (32.74 kg) over control leading to an additional income of Rs. 654.80 per tree. Considering the additional expenditure for the treatment, the net income per tree has been found to be the maximum (Rs. 544.30 per tree) in full moon terracing and paddy straw mulching which leads to the net cost: benefit ratio of 1:4.92. Treatment was also effective in reducing the fruit cracking and fruit drop in the litchi cultivar Shahi.

## INTRODUCTION

Moisture requirement at critical stage of growth is obvious with nature of fruit trees for optimum production. For litchi production, optimum moisture level in the root zone of plants must be ensured to stabilize and optimize the fruit production in rainfed areas. Areas having low precipitation and absence of ensured irrigation are compelled to maintain the desired moisture level in the root zone by generating additional runoff around the tree canopy through appropriate water harvesting measures. The areas with high rainfall however, do not require to generate the additional runoff necessarily throughout the monsoon period but needs to collect and conserve the *in-situ* moisture generated out of its canopy area during the season. The term *in-situ* water harvesting refers to measures of storing water in soil profile under the tree canopy during rain spells to augment the seasonal requirement of the plant (Pareek *et al.*, 1996). In fruit trees under rainfed condition critical stage of water requirement of a plant species is of paramount importance and therefore the *in-situ* water harvesting and moisture conservation measures should aim to provide the maximum moisture to the plants at the critical stage of its requirement (Evenari *et al.*, 1968). Litchi is one of the important fruit crops of humid sub tropical region which requires constant soil moisture during fruit growth and maturity. Fluctuation in soil moisture at the time of fruit development and ripening poses the serious

problem of fruit cracking on one hand and hampers vegetative growth of the tree on the other hand. Hence, the constant moisture in root zone of the litchi tree has been adjudged as most crucial for growth and production (Rai *et al.*, 2003). Keeping this in view an experiment was initiated to find the suitable method of *in- situ* water harvesting below the tree canopy and moisture conservation through mulching for growth, yield and quality of litchi under sub humid sub tropical plateau region of eastern India.

## Materials and Methods

The experiment was conducted on 16 year old well established litchi orchard at Horticulture and Agro-forestry Research Programme, Ranchi located at 23°25' N latitude, 85°20' E longitude and 620 m above msl altitude. The soil of experimental site was classified as Alfisol which is red latretic soil having sandy loam texture with 6.0 pH, 0.5 % organic carbon, 3.2 kg per hectare available (Bray-I) Phosphorus and 118 kg per hectare available Potassium and poor water holding capacity. The region receives 1100-1300 mm annual rainfall between mid June to mid October with occasional cyclonic rain during winter months (November- December). The experiment was conducted for consecutive four cropping season (2001-2004) on leading litchi cultivar 'Shahi' under Mission Mode NATP, House hold food and nutritional security for tribal, hilly and backward areas programme-2- Horticulture and vegetable gardening for food and nutritional security in tribal, hilly and backward areas. Individual and combined effect of three methods of *in-situ* water harvesting through 30 cm high inverted 'V' shape terracing (full moon, half moon and no moon) on the outer edge of the fertilization trench and four mulch materials (10 cm thick paddy straw, 10 cm thick locally available weeds, 400 gauge black polythene and no mulch) were tested in Randomized Block Design (RBD) with 3 replication and two plants as unit. A total of 12 treatment viz. straw mulching + half moon terracing ($T_1$), straw mulch + full moon terracing ($T_2$), straw mulch + no terracing ($T_3$), black polythene (400 gauge) + half moon terracing ($T_4$), black polythene + full moon terracing ($T_5$), black polythene + no terracing ($T_6$), local weed mulch + half moon terracing ($T_7$), local weed mulch + full moon terracing ($T_8$), local weed mulch + no terracing ($T_9$), half moon terracing and no mulch ($T_{10}$), full moon terracing and no mulch ($T_{11}$), no terracing and no mulch ($T_{12}$) with three replications in randomized block design were applied on adult bearing litchi trees of cultivar Shahi. The uniform trees were selected and pruned by adopting standard methods of pruning during June and fertilized with recommended doses of manures and fertilizers during July through trench method near the feeder roots every year. The treatment of water harvesting was imposed during August where as the mulching was done during October. The organic mulches were incorporated in the basin soil before application of manure and fertilizer in next year. Observation on tree growth, flush characteristics, flowering and fruiting, fruit cracking, physico-chemical characters of fruits and average yield per tree was recorded during the experimentation. Tree growth, flushing and flush characters, flowering, fruiting and fruit characters were recorded by standard procedures whereas the titratable acidity and sugar content was recorded by method described by AOAC (1984). Total soluble solids was estimated by Abee R-8 Refractrometer while per cent cracking was calculated on the basis of total number of fruits versus cracked fruits in each treatment. The per cent fruit drop was computed by initial fruit set versus final fruit retention in a particular panicle/bunch. The average number of days taken for 50% panicle initiation and 50% flowering and fruit set have been computed from 1st August as cutoff date of first flushing in each of the experimental year. The yield increase, additional income and the net benefit due to increased yield/tree was calculated over control (no terracing and no mulching). The cost involved in terracing

and procurement of mulch material was calculated as per the existing rate based on following considerations.

1. One unskilled labor can make 6 half moon terracing and 3 full moon terracing per day in a wage of Rs. 80/- per day.
2. One unskilled labor can spread mulch in 20 plants per day in a wage of Rs. 80/- per day.
3. One tractor-trolley load paddy straw casting Rs. 400/- is sufficient for 5 plants.
4. One tractor-trolley load local weed casting Rs. 500/- (including cost of cutting the grass and transportation up to the site) is sufficient for 5 plants.
5. Cost of black polyethylene (400 gauge) for one full grownup tree is approximately Rs. 256/- (32 kg polyethylene / tree @ Rs. 80/- per kg) which can be used for 3 consecutive years.

The pooled data for all the four seasons were statistically analysed (Panse and Sukhatame, 1985).

## Results and Discussions

Effect of *in-situ* water harvesting and moisture conservation through mulching in litchi trees has been presented and discussed in various sub heads.

### Effect on plant growth and flushing

Litchi plant put fourth 2-3 vegetative flushes in a year however; it is the first flush which contributes maximum for flowering and fruiting of a tree (Das *et al.*, 2003). Vegetative growth and flushing of litchi tree is influenced by available soil moisture and organic matter content in the root rhizosphere. Data pertaining to different growth and flushing parameter due to *in-situ* moisture harvesting and conservation through mulching have been presented in table 1. It is clear from the table that in general= 6.0 m plant height of litchi was recorded with full moon terracing with or without mulching. The plant height is statistically significant with local weed/ paddy straw mulching. Statistically significant and highest values of tree spread and volume were also registered with full moon terracing and local weed mulching. Chandra and Chauchary (1997) also reported that organic mulches improve the growth of date palm by providing congenial condition near root rhizosphere. Local weeds and black polythene have also been reported to improve the plant growth in mandarin and acid lime (Shirgure *et al.*, 2003 and Shirgure *et al.*, 2004). Treatment of *in-situ* moisture conservation and basin mulching were also effective in improving the length of flush, girth of shoot and number of leaflet per flush in first and second flush however, the differences were statistically non-significant.

### Effect on flowering and fruiting behavior

Effect of various moisture conservation measures on flowering and important moisture related physiological disorder have been presented in Table 2. It is evident from the table that water harvesting through full moon terracing followed by mulching with paddy straw resulted in early panicle initiation

**Table 1:** Effect of *in-situ* water harvesting and moisture conservation on vegetative growth and flushing in litchi

| Treatment | Tree height (m) | Tree spread ($m^3$) | Tree volume ($m^3$) | Trunk girth (cm) | Length of 1st flush (cm) | Girth of 1st flush (cm) | No. of leaflet in 1st flush | Length of 2nd flush (cm) | Girth of 2nd flush (cm) | No. of leaflet in 2nd flush |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 5.7 | 50.1 | 151.1 | 92.8 | 9.2 | 0.4 | 32.2 | 13.3 | 0.40 | 33.1 |
| $T_2$ | 6.0 | 49.8 | 157.7 | 89.2 | 11.0 | 0.4 | 33.7 | 13.7 | 0.38 | 30.7 |
| $T_3$ | 5.7 | 50.5 | 150.6 | 88.9 | 10.7 | 0.5 | 33.0 | 14.9 | 0.38 | 29.9 |
| $T_4$ | 5.7 | 53.3 | 160.4 | 87.5 | 11.5 | 0.5 | 34.0 | 14.4 | 0.42 | 34.1 |
| $T_5$ | 5.9 | 56.3 | 176.4 | 89.9 | 11.5 | 0.5 | 36.0 | 14.2 | 0.41 | 32.3 |
| $T_6$ | 5.6 | 50.1 | 146.7 | 84.5 | 10.3 | 0.4 | 29.9 | 14.7 | 0.36 | 30.9 |
| $T_7$ | 5.6 | 51.1 | 149.3 | 82.2 | 11.8 | 0.5 | 33.8 | 14.5 | 0.38 | 33.8 |
| $T_8$ | 6.3 | 59.8 | 199.4 | 88.8 | 10.5 | 0.4 | 31.9 | 15.4 | 0.38 | 33.9 |
| $T_9$ | 6.0 | 57.0 | 181.0 | 89.6 | 10.5 | 0.4 | 32.6 | 14.3 | 0.37 | 33.4 |
| $T_{10}$ | 5.7 | 44.9 | 134.1 | 87.4 | 10.2 | 0.4 | 33.4 | 14.4 | 0.37 | 31.8 |
| $T_{11}$ | 6.1 | 44.2 | 142.6 | 84.8 | 11.2 | 0.5 | 35.3 | 14.1 | 0.38 | 31.9 |
| $T_{12}$ | 5.6 | 38.4 | 110.0 | 73.8 | 9.8 | 0.5 | 32.0 | 14.3 | 0.37 | 33.1 |
| C.D at 5% | 0.28 | 2.40 | 10.68 | 2.20 | NS | NS | NS | NS | NS | NS |

**Table 2:** Effect of *in-situ* water harvesting and moisture conservation on flowering and fruiting behavior of litchi trees

| Treatment | Days taken to 50% panicle initiation after first August | Days taken for 50% flowering after first August | Days taken forfruit set set after first August | Number of initial fruit per panicle | Number of final fruit retention | % fruit drop | % fruit cracking |
|---|---|---|---|---|---|---|---|
| $T_1$ | 176.0 | 227.0 | 232.7 | 18.7 | 12.3 | 33.9 | 3.7 |
| $T_2$ | 163.0 | 232.7 | 236.3 | 22.7 | 18.0 | 20.5 | 4.4 |
| $T_3$ | 184.7 | 231.7 | 235.3 | 17.0 | 12.3 | 27.8 | 4.7 |
| $T_4$ | 188.7 | 234.0 | 234.3 | 17.0 | 11.0 | 35.2 | 4.8 |
| $T_5$ | 187.3 | 233.7 | 234.3 | 18.3 | 11.3 | 38.3 | 4.2 |
| $T_6$ | 179.3 | 232.3 | 233.0 | 19.0 | 10.7 | 44.0 | 5.7 |
| $T_7$ | 185.7 | 232.0 | 232.7 | 17.7 | 11.0 | 37.7 | 4.0 |
| $T_8$ | 187.3 | 233.0 | 233.7 | 16.3 | 9.0 | 44.9 | 4.3 |
| $T_9$ | 178.7 | 230.0 | 231.7 | 14.7 | 8.0 | 45.5 | 5.1 |
| $T_{10}$ | 188.3 | 232.7 | 233.7 | 14.0 | 7.0 | 50.5 | 6.4 |
| $T_{11}$ | 186.3 | 232.3 | 233.7 | 14.3 | 8.7 | 39.4 | 6.5 |
| $T_{12}$ | 199.0 | 242.7 | 245.0 | 11.3 | 5.3 | 53.5 | 7.5 |
| C.D at 5% | 14.44 | 1.48 | 4.05 | 1.92 | 2.51 | 11.46 | 1.73 |

in litchi trees where as half moon terracing and mulching with straw was earliest to induce 50% flowering (Table 2). Untreated control took significantly higher days for fruit set. Number of initial fruit set, per cent fruit drop, per cent fruit cracking and final fruit retention are the crucial factors to decide the yield potential of litchi trees. Perusal of data presented in table 2 reveal that initially the maximum and significantly higher number of fruits per panicle were set in trees having full moon terracing and paddy straw mulching. The final fruit retention was also noticed to be the maximum in the same treatment. The maximum fruit drop (53.5%) and fruit cracking (7.5%) was observed under control (no terracing and no mulching ) condition whereas the minimum fruit drop (20.5%) and significantly lower fruit cracking (4.4%) was recorded in full moon terracing and paddy straw mulching. Mulching with local weed coupled with half moon terracing however, recorded the minimum fruit cracking.

**Effect on yield and fruit quality**

Perusal of data presented in Table 3 reveal that the average individual fruit weight (21.4 g) and pulp weight (16.7 g) was maximum in treatment having full moon terracing and paddy straw mulching. Yield per tree (59.1 kg) was significantly superior in full moon terracing coupled with paddy straw mulching which was at par with half moon terracing + paddy straw mulching (51.1 kg/tree), full moon terracing + local weed mulching (50.4 kg/tree) and no terracing – paddy straw mulching (49.6 kg/tree). Values for TSS, acidity and total sugar were non-significant among the treatment.

**Table 3:** Effect of *in-situ* water harvesting and moisture conservation measures on yield and quality of litchi fruits

| Treatment | Fruit weight (g) | Fruit volume (cc) | Peel weight (g) | Pulp weight (g) | Acidity (%) | T.S.S. (0B) | Total sugar (%) | Yield/ plant (kg) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 19.8 | 18.5 | 2.3 | 14.4 | 0.33 | 19.4 | 16.0 | 51.1 |
| $T_2$ | 21.4 | 19.3 | 2.1 | 16.7 | 0.28 | 19.6 | 15.8 | 59.1 |
| $T_3$ | 19.6 | 18.7 | 2.2 | 14.6 | 0.24 | 19.8 | 14.4 | 49.6 |
| $T_4$ | 20.0 | 18.8 | 2.9 | 13.8 | 0.29 | 19.4 | 14.5 | 42.3 |
| $T_5$ | 20.6 | 19.0 | 3.0 | 14.2 | 0.33 | 19.0 | 15.0 | 40.4 |
| $T_6$ | 19.8 | 19.2 | 3.2 | 13.5 | 0.33 | 19.2 | 14.5 | 47.4 |
| $T_7$ | 19.9 | 18.2 | 2.4 | 14.9 | 0.38 | 18.7 | 13.5 | 45.7 |
| $T_8$ | 19.6 | 18.2 | 2.2 | 14.6 | 0.25 | 19.5 | 15.5 | 50.4 |
| $T_9$ | 19.1 | 18.4 | 2.5 | 14.0 | 0.31 | 19.7 | 15.8 | 42.3 |
| $T_{10}$ | 18.8 | 17.7 | 2.8 | 13.0 | 0.27 | 19.4 | 15.3 | 37.8 |
| $T_{11}$ | 18.4 | 16.9 | 2.9 | 12.5 | 0.29 | 19.2 | 13.9 | 38.8 |
| $T_{12}$ | 17.3 | 16.4 | 2.8 | 11.8 | 0.27 | 20.3 | 15.6 | 26.4 |
| C.D at 5% | 1.32 | NS | 0.68 | 1.63 | NS | NS | NS | 10.55 |

**Cost: benefit ratio**

It is quite clear from the above results and discussion that and *in-situ* water harvesting near root rhizosphere of litchi plant and organic mulching of the tree basins has significant and positive effect on tree health, yield and yield attributing characters of the litchi tree under plateau region of the eastern India. It is quite imperative to calculate the cost: benefit ratio of the technology before recommending to the farmer for large scale adoption. An attempt has been made to find out the net benefit of the various treatments under the existing price scenario of the goods and services required for the technology during the experimentation period. Perusal of fact presented in Table 4 reveal that plant with full moon terracing and paddy straw mulching has an additional yield of (32.74 kg) over control leading to an additional income of Rs. 654.80 per tree. Computing the additional expenditure for the treatment (considering the cost of material, proportionate man power, etc.) it ranges from Rs. 0.00 in control where no treatment has been applied to Rs. 130.00 in local weed mulching + full moon terracing. The net income per tree has been found maximum (Rs. 544.30 per tree) under treatment of full moon terracing and paddy straw mulching which leads to the net cost: benefit ratio of 1:4.92.

**Table 4:** Cost:benefit ratio of the technology.

| Treatment | Mean yield kg/ tree | Yield difference due to mulching kg/ tree | Additional income @ Rs. 20.0/ kg fruit | Additional & Expenditure due to mulching | | | Net benefit Rupees per tree |
|---|---|---|---|---|---|---|---|
| | | | | Labor cost per tree | Cost of material per tree / year | Total additional cost/ tree | |
| $T_1$ | 51.06 | 24.70 | 494.0 | 17.5 | 80.0 | 97.5 | 396.5 (1:4.06) |
| $T_2$ | 59.10 | 32.74 | 654.8 | 30.5 | 80.0 | 110.5 | 544.3 (1:4.92) |
| $T_3$ | 49.50 | 23.14 | 462.8 | 4.0 | 80.0 | 84.0 | 378.8 (1:4.50) |
| $T_4$ | 42.26 | 15.90 | 318.0 | 17.5 | 85.3 | 102.8 | 215.2 (1:2.09) |
| $T_5$ | 40.40 | 14.04 | 280.8 | 30.5 | 85.3 | 115.8 | 165.0 (1:1.42) |
| $T_6$ | 47.36 | 21.00 | 420.0 | 4.0 | 85.3 | 89.30 | 330.7 (1:3.69) |
| $T_7$ | 45.70 | 19.34 | 386.8 | 17.5 | 100.0 | 117.5 | 269.3 (1:2.29) |
| $T_8$ | 50.40 | 24.04 | 480.8 | 30.5 | 100.0 | 130.5 | 350.3 (1:2.68) |
| $T_9$ | 42.33 | 15.97 | 319.4 | 4.0 | 100.0 | 1.4.0 | 215.4 (1:2.07) |
| $T_{10}$ | 37.80 | 11.44 | 228.8 | 17.5 | 0.0 | 17.5 | 211.3(1:12.07) |
| $T_{11}$ | 38.83 | 12.47 | 249.4 | 30.5 | 0.0 | 30.5 | 218.9 (1:7.17) |
| $T_{12}$ | 26.36 | 00.00 | 00.0 | 0.0 | 0.0 | 0.0 | 0.0 |

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