Conservation pits for *in situ* soil and moisture conservation in rubber plantations

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Abstract

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Effective soil and moisture conservation is a vital part of the quest for sustainable rubber production. The effect of conservation pits on growth and yield of rubber and soil moisture storage were evaluated in two field experiments, one in immature rubber and another in mature rubber in the central region of the traditional rubber growing tract in India. The treatments for immature rubber include conservation pits taken at the rate of 250 per ha and a control without pits. The treatments for mature rubber comprised combinations of conservation pits taken at the rate of 150, and 250 per hectare and two methods of fertilizer application viz., placement in pits and broadcasting. Plots without pits and fertilizer served as control. The experimental fields were well drained. The average slope of immature and mature fields were 12 and 14 per cent respectively. All growth parameters of immature rubber were positively and significantly influenced by taking pits. There was a significant increase in the plant height, diameter and number of whorls of immature rubber in the plots where pits were taken. Higher soil moisture content was retained by the plots with pits. The leaf water potential and the relative leaf water content were also favourably influenced by opening of pits. Dry rubber yield enhanced by 15 per cent by taking pits at the rate of 250 per hectare. Soil moisture storage estimated up to a depth of one meter was substantially higher, when pits were taken at the rate of 250 per ha indicating the contribution of pits towards ground water recharge. The quantity of soil conserved in the pits and thus prevented from being lost through erosion ranged from 5.1 to 9.6 t/ha as the no. of pits increased from 150 to 250. The results of the experiments indicated that excavation of conservation pits is a viable soil conservation and water harvesting technology for the traditional rubber growing regions in India.

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Introduction

Conservation of soil and water. the two basic natural resources plays a major role in sustainable rubber cultivation. Though the traditional rubber growing areas are blessed with two monsoons with an annual average rainfall of 3000 mm. the rainfall is highly seasonal and nearly half the year remains dry or with very scanty rainfall. Around 67 per cent of the annual rainfall is received during the South - West monsoon. The rainfall intensity during this season far exceeds the infiltration rate resulting in runoff. Runoff wherever it occurs, results in washing away of the top fertile soil and nutrients, loss of soil moisture and recharge capacity. The consequence of water runoff and soil erosion not only affects crop production, but results in serious problems of water stress, soil degradation and ecological imbalance (Troeh *et al*.,1991). The impact of climate change, mostly in the form of prolonged hotter, drier climate and unexpected heavy monsoon becomes a reality in the traditional rubber growing regions in India. Drought is one of the most important manifestations of climate change as far as the rubber growing regions in India are concerned. Therefore, water retention and erosion control are major concerns in the traditional rubber growing tracts. This paper collates information on the effect of conservation pits on growth and yield of rubber and discusses their effectiveness in soil moisture conservation and soil erosion control.

Materials and methods

Two field experiment were conducted. one in mature rubber at the Manickal division of TR&T estate. Mundakayam. Kottayam District. Kerala. and the other in immature rubber in a small holding at Kanjirappally, Kottayam District, Kerala both representing the central region of the traditional rubber growing tract in India. The sites are located in tropical humid zone with a

mean annual temperature of 28°C. The mean annual rainfall (2000- 4000mm) has a bimodal distribution pattern with major peaks in June- July and September-October. The period December through February / March constitutes the dry season.

Experiment

The design of the experiment on mature rubber was randomised complete block with six replications. The treatments comprised of combinations of conservation pits taken at the rate of 150, and 250 per hectare in combination with two methods of fertilizer application viz., placement in pits and broadcasting. There were two control treatments viz., plots without pits and with fertilizer and plots without pits and fertilizer. The gross plot size was 24 plants and the net plot size was 8 plants. The treatments were allocated to each plot on area basis. Experiment on immature rubber comprised of two treatments viz., conservation pits taken at the rate of 250 per hectare and a control without pits. The gross plot size was 100 plants and net 30.

Soil management

Pits of size 120cm x 45cm x 75 cm were excavated in each plot in a staggered manner along the contour at regular intervals with sufficient space in between. The soil from the pit was deposited on the lower side of the pit and compacted well.

Data collection

Monthly plot wise latex yield was recorded. Annual growth measurement in mature rubber was done by recording the girth of the plants at a height of 150 cm above the bud union. Observations on growth parameters like plant diameter, number of whorls and height were recorded from the experiment on immature rubber.

The soil deposited in the conservation pits in mature rubber was quantified. Computation was made based on a visual rating of the percentage of pit portion filled as 25, 50,75 and 100. After scoring, the fresh weight of the deposited silt was recorded from two pits in each replication. The dry weight was determined based on moisture content of samples pooled over replications for which soil

Table 1. Effect of conservation pits on soil moisture status in immature rubber

Mean soil moisture content (%)						
	Soil Depth (cm)					
	10	20	30	40	60	100
With pits	12.8	16.4	20.8	21.9	26.37	32.12
Without pits	13.1	15.6	18.3	20.1	23.22	27.8

samples were drawn from each replication. Access tubes were installed in the plots and moisture content was measured with Profile probe (Delta-T, UK) attached to a soil moisture meter at depths 10, 20,30,40,60 and 100 cm. The mid day leaf water potential was measured during the summer months using C-52 sample chamber psychrometer (Wescor Inc.,Logan, Utah, USA) connected to HR 33 T Dew Point Microvolt meter. The data were subjected to statistical analysis.

Results and discussion

Effect on soil moisture status

The data on soil moisture content at depths 0cm, 10cm, 20cm, 30cm, 40cm, 60cm and100 cm recorded from immature rubber plantation with and without pits during summer season indicated that the plot with pits retained a higher soil moisture content compared to that without pit (Table 1). The difference in moisture content was more distinct at the lower depths and at one meter depth, the moisture content in the plot with pits was 4.32 per cent higher compared to control (without pits). A similar trend was observed in the case of mature rubber. The soil moisture content increased with increase in the number of pits. A notable difference was observed in the soil

Fig 1. Effect of conservation pits on soil moisture status in immature rubber

Table 2. Effect of conservation pits on leaf water potential and relative leaf water content in immature rubber

	With pits	Without pits
Leaf water potential (-bars)	23.97	29.31
Relative leaf water content (per cent)	95.19	86.94

moisture content among treatments especially at the lower depths (Fig.1). Excavation of pits is an efficient run off management technique wherein a part of the run off is conserved and reused for crop production in a sustainable manner. Haridas *et al.*,1987 reported that silt pits act as a series of storage tanks trapping water from surface runoff and through fall resulting in an increased soil moisture status.

Infiltration pits have demonstrated to improve the soil moisture storage, prolong the period of moisture availability and enhance the growth of agricultural crops (Mugabe,2004). Rubber being grown in the red and lateritic soils, all water inside these pits gets drained down to the lower layers of the soil finally contributing to ground water. Therefore it is possible to mitigate the moisture stress experienced during summer months to a certain extent by taking conservation pits.

Effect on leaf water potential

Indicators of plant water status like leaf water potential and relative leaf water content in immature rubber were relatively higher in the plots with pits (Table 2). Leaf water potential was relatively low in the control plots. A higher leaf water potential was maintained by the plots with

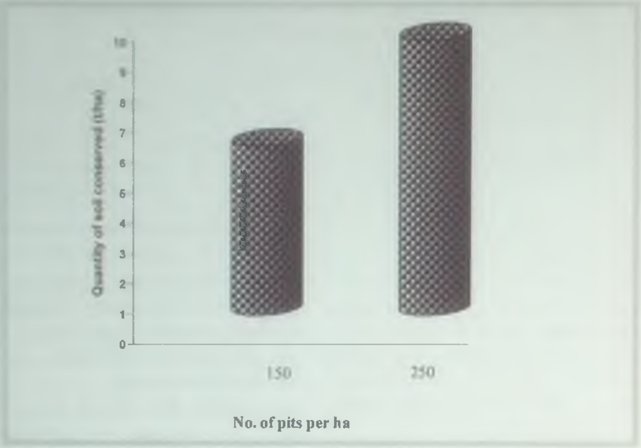

Fig 2. Effect of conservation pits on quantity of soil conserved

pits. The leaf water potential was comparatively low in the control plots. Maintenance of higher plant water status in the plots with pits is associated with the higher moisture availability under this situation as evidenced by the soil moisture status (Table1, Fig.1).

An experiment on seasonal effects of water relations on yield in *Hevea*, revealed that all the clones maintained a higher leaf water potential during wet season compared to dry season (Devakumar *et al*.,1998). A relatively low leaf water potential associated with the control plots is indicative of the soil water stress which might have occurred in these plots in the absence of pits.

Effect on quantity of soil deposited in the pits

Conservation pits had a significant influence on the quantity of soil deposited in the pits. The quantity of soil conserved in the pits and thus prevented from being lost through erosion was directly proportional to the number of pits and ranged from 5.1t/ha to 9.6 t/ha (Fig 2). In most of the tropical soils, the nutrient reserves are often concentrated in the thin surface horizon.

Erosion is a selective process of preferential removal of the top soil (Lal,1984). Experiments have shown organic matter content of the eroded soil to be five times as high as that in the original top soil. Comparable figures for phosphorous and potassium were three and two respectively (Larson *et al*.,1983).

Opening of pits is an efficient runoff management technique where in the runoff along with the top soil is captured in the pits, the run off infiltrates into the surrounding soils increasing the ground water

Table 3. Effect of conservation pits on diameter, height and no. of whorls of immature rubber

	MEAN	
	With pits	Without pits
Diameter (cm)	1.34**	1.09
Plant height (cm)	133.29*	117.11
No. of whorls	2.49**	2.11

recharge, retaining precious soil and nutrients in the subsurface level which accumulates over years and is recycled inside the plantation.

Effect on growth and yield

All growth parameters of immature rubber were positively and significantly influenced by taking pits. There was a significant increase in the plant height, diameter and number of whorls of immature rubber in the plots where pits were taken (Table 3).

Presence of pits positively influenced the growth and yield of mature rubber. Significant positive response was obtained for yield of rubber (Table 4). Yield showed increasing trend with increase in the number of pits. The mean yield was significantly higher for the treatment with 250 pits per ha compared to control without pits. The cumulative girth increment over a period of five years didn't vary significantly with respect to different treatments (Table 4).

Table 4. Effect of conservation pits on growth and yield of rubber

No. of pits / ha	Girth Increment (cm)	Yield (g/tree/tap)
150 (S)	7.43	50.40
150 (P)	6.74	55.80
250 (S)	7.66	59.34
250 (P)	8.06	61.19
No pit & standard practice	6.68	50.16
No pit & no fertilizer	6.27	52.11
SE CD	0.66 NS	2.28 6.74

However, the girth increment also showed a positive trend and the highest girth increment was recorded in the plots with 250 pits. Control plots without pit and fertilizer recorded the minimum girth increment.

Dry periods with water deficit frequently occur in humid and sub-humid regions where there is a theoretical need to dispose the excess water and positive responses to moisture conservation techniques are frequently obtained.

According to NBSS and LUP (1999) about 60 per cent of the rubber plantations in India experiences more than three months dry period. Haridas *et al.*,1987 reported an enhancement in yield of rubber to the tune of 10- 15 per cent in Malaysia in a field where pits were dug compared to an adjacent field without pits. Studies on seasonal effects on water relations and yield in *Hevea* indicated that the low rubber yield during dry season is associated with low moisture status and drought induced biochemical changes leading to high plugging during this period.

The conservation pits besides conserving soil moisture also trap organic residues, nutrients and eroded top soil and help in sustaining soil fertility and productivity (George *et al.*,2002).

Conclusion

Conservation pits have a significant role in the conservation of soil, water and nutrients in rubber plantation which is reflected in the growth and yield of rubber Therefore, opening of conservation pit is a viable water harvesting and soil conservation technology for the traditional rubber growing regions.

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