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RESEARCH PAPER

Effect of Agrotechniques and Bioengineering Measures for Soil, Water and Nutrient Conservation in Oil Palm Plantations in High Rainfall Areas

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ABSTRACT

An effort was made to quantify the loss of soil and water and nutrients through run off from an oil palm plantation planted in an undulating sloppy area by different bioengineering and agrotechniques. In general, all the treatments tried reduced the soil and water loss from the plantation compared to that of control. Minimum water loss was recorded in plots where half moon circle terracing was done in the basins and soil loss was less, when fodder grass was planted in the interspaces of palms because of binding effect of roots. Nutrient loss through runoff followed the same pattern as water loss. It was estimated that about 6 kg Nitrogen, 4.9 kg Phosphorus and 65 kg potash would be lost every year from a plantation in undulated topography. The study emphasizes the importance of terracing and leveling of basins and recommends growing soil binding crops or mulching with crop residues in sloppy areas.

Key words : Oil palm, agrotechniques, bioengineering measures, nutrient conservation, soil loss

INTRODUCTION

Oil palm, the richest vegetable oil yielding crop is getting attention in recent years in Indian agriculture. Oil palm is a nutrient as well as water demanding crop as evident from the luxurious growth put forth by this crop in a limited span of time. It is estimated that, the crop requires around 150 mm of water per month to meet its evapo transpiration demands under Indian conditions. In high rainfall areas, the rainfall will be mostly confined to 7 to 8 months in a year and experiences a dry spell of about 4 to 5 months. So wherever the crop is grown, especially in undulating topography and hilly terrains, suitable soil and water conservation measures are to be adopted to conserve maximum moisture available through rainfall. Cultivation in slopes causes problems in harvesting and mechanization in addition to water and nutrient loss expected through runoff.

The concept of soil conservation is to limit soil loss to levels that will allow economical maintenance of soil productivity and prevent crop damage by erosion. The limits used in US soil conservation service programme ranges from 1 to 5 tons per acre per year. Maene and Won Suleiman (1980) reported that the canopy cover of rubber is relatively denser than that of oil palm and that the interruption of rain by rubber (25%) is higher than oil palm (17%). The loss of top soil and thus carbon and other soluble nutrients, adversely affects crop productivity in rainfed agriculture, irrespective of the climate. Thus run off losses can be of concern in oil palm plantings. Lal (1985) demonstrated that erosion negatively affects physical and chemical properties of soil. Yost *et al.* (1985) observed that with severe losses of top soil, even addition of high level of nutrients could not enhance the yields, *i.e.*, erosion removes the irreplaceable component of a soil, the top soil. Hence, the top soil should be protected by adequate soil covers and mechanical measures to minimize the chances of runoff and nutrient losses from a plantation in rugged topography. After identifying the problems with slopes, Kee and Soh (2002) concluded that planting should not be done at all above 25^{o} and there were increasingly serious problems from 16^{o} upwards. Hence the present investigation was carried out to find out the different agrotechniques and bioengineering measures for conservation of soil and

water nutrients in oil palm grown under high rainfall areas.

MATERIALS AND METHODS

An effort was made to quantify the loss of soil, water and nutrients through run off from a mature oil palm plantation planted in an undulating sloppy area in Kerala, India. The average rainfall of the area is 2800 mm per year. Different bioengineering and agrotechniques were evaluated in the plantation in the form of different soil and water conservation measures as follows:

T_1: Cutting half moon circled terraces of 3 m radius in the palm basins across the slope + trenches of 3m length, 1m width and 30 cm depth across the slopes in the interspaces

T_2: Piling of fronds + EFB mulching + addition of palm waste compost in the basins

T_3: Trenches across the slope + insitu composting of fronds

T_4: Fronds in trenches + EFB mulching

T_5: Growing cocoa in interspaces + trenches in interspaces

T_6: Growing medicinal plant *Campheria*

T_7: Growing fodder grass in the interspaces

T_8: Oil palm with no conservation measures

T_9: Open catchment area with no conservation measures

Each plot comprised of 24 palms covering an area 1600 sq m after establishing the agronomic conservation measures including ground cover by crop canopy, catchment area around 24 palms was delineated for reading observations. Run off water was collected using run off tanks with multi slot devices with every event of rainfall for a period of one year. Runoff volume was calculated every rainy day depending upon the volume collected and number of slots. Representative samples were collected with every event and monthly samples were pooled and representative samples collected from each plot and dried to get the sediment loss through runoff. The sediment samples were pooled and analysed at quarterly intervals for major nutrients following standard procedures. From these data, average values of runoff water, soil and nutrient loss through runoff expected from a hectare of plantation were estimated. Simultaneously data on rainfall such as total rainfall, duration and number of rainy days were also recorded using a self recording rain gauge. The data were compared with the estimated loss from an open area as well as a plantation without any conservation measures. Nutrients (N, P and K) were analyzed by standard methods.

RESULTS AND DISCUSSION

In general, all the conservation measures reduced the soil and water loss from the plantation compared to that of open control (Table 1).

Runoff and soil loss

Average values of runoff and sediment loss indicated that minimum runoff occurred in plots when half moon terracing was done in basins along with trenches in the interspaces across the slope followed by plots having cocoa planted in the interspaces and trenches in interspaces. Water loss from bare plantation was almost double compared to those with soil cover. Growing soil covering crops alone in the interspaces could not achieve a satisfactory control

Table1: Mean runoff and soil loss under different conservation treatments in oil palm

No.	Treatments	Runoff		Soil loss
		mm/year	% of total rain	(t/ha/yr)
1.	Half moon terraces and trenching	303.8	10.90	2.9
2.	EFB mulching, piling fronds and compost in basins	309.9	11.12	3.5
3.	Trenching and insitu vermicomposting palm wastes	472.5	16.96	4.7
4.	EFB mulching and frond in trenches	347.9	12.49	3.9
5.	Growing cocoa in interspaces and trenching across slopes	308.4	11.07	3.2
6.	Growing medicinal plants	535.9	19.24	4.1
7.	Growing fodder grass	464.9	16.69	2.4
8.	Bare plantation	639.1	22.94	8.0
9.	Open area	1609.4	57.77	13.7

Total rainfall during the period : 2786 mm

of runoff loss, without adopting any mechanical conservation technique. However the soil loss was minimum when fodder grass was planted in the interspaces of palms. This can be attributed to the thick canopy cover of guinea grass along with binding effects of roots which reduce the velocity of runoff water, though lost more from the plot, thereby minimize the soil being carried away. Pushparajah (2007) also reported that on slopy land, soil vegetative covers are not sufficient and terraces are essential.

Cutting half moon single terraces or growing cocoa as mixed crop along with opening trenches across the slope could control soil loss to a satisfactory limit. Oil palm canopy alone could reduce the runoff and soil loss to almost to 40% compared to open area. Soil loss was estimated to be about 8 tons per hectare per year from an established plantation in sloppy area as against 13.7 tons from open fields.

Leaching loss of nutrients through runoff

Nutrient loss through runoff followed the same pattern as of the amount of runoff loss (Table 2). It was estimated that about 6.0 kg Nitrogen (N), 5.0 kg Phosphorus (P) and 65.0 kg potassium (K) would be lost every year from a plantation with uneven topography. By suitably adopting conservation technologies, the losses would be reduced to 1.4 kg N, 1.0 kg P and 19.3 kg K. As expected, the maximum loss was for K (60.1 kg) even with conservation techniques. Though soil loss was minimum in fodder crop, K being easily soluble in water is getting lost to a great extent, if not checked by suitable terraces or trenches. The open catchment area though not regularly fertilized, led to maximum loss due to inherent fertility as the site is of forest origin.

Ling *et al.* (1979) clearly showed the need for quick establishment of a vegetative cover in an oil palm planting. Runoff, soil erosion and nutrient losses by runoff can be considerably reduced by establishment of legume cover in an immature plantation planted on 10 per cent slope, than when the inter row was kept bare. Soil loss could be reduced from 79 tons/ha/ year by growing creeping legumes.

There is chance of losing approximately 3.5% of applied N, 5.7% of P and 38% of K, if no conservation measures are taken in hill slopes. This could be reduced to almost 1 % for N and P and 11% K with suitable conservation agrotechniques. The arrangement of pruned fronds in the inter row area enhances conservation of soil and nutrients. Empty fruit bunches as mulch together with fronds piled up and soil conservation techniques enhances soil organic matter. Maene *et al.* (1979) showed that losses upto 10% of the nutrients can occur in mature oil palm. Kee and Chew (1996) also confirmed the above losses which indicated losses of 5-8% of N, 10-15% of K, 4-8% of Mg and about 2% of P in mature palms planted on land with 7° slope.

CONCLUSIONS

Water, one of the essential inputs, is to be conserved by all means, along with soil and nutrients for ensuring sustainable oil palm productivity. By incorporating appropriate surface management practices such as taking single half moon terraces across the basin and trenches across the slope in highly slopy areas and in gentle slopes, management of inter spaces by growing soil binding cover crops or mulching helps in minimizing soil and water erosion losses. When oil palm is planted in sloppy areas, suitable conservation practices are to be carried out and should be maintained over a period of time, in order to harvest a better crop on sustainable basis.

Table 2: Estimated loss of nutrients from oil palm plantation due to different soil conservation treatments

No.	Treatments	Nutrient loss (kg/ha/yr)		
		Nitrogen	Phosphorus	Potassium
1.	Half moon terraces and trenching	1.67	1.34	44.1
2.	EFB mulching, piling fronds and compost in basins	3.36	1.52	40.5
3.	Trenching and insitu vermicomposting palm wastes	1.93	1.70	19.3
4.	EFB mulching and frond in trenches	1.44	1.26	20.1
5.	Growing cocoa in interspaces and trenching across slopes	2.56	1.83	32.1
6.	Growing medicinal plants	2.61	0.99	58.3
7.	Growing fodder grass	2.96	1.27	60.1
8.	Bare plantation	6.02	4.91	65.1
9.	Open area	12.92	5.43	209.3

This is important in high rainfall areas where the topography is undulating like Kerala, Andaman and Nicobar Islands and North Eastern states. This is equally important in low rainfall irrigated areas also, to tap the available soil moisture and increase the water and nutrient use efficiency of oil palm.

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Run off tank with multislot devices

Half moon terracing in palm basin

Guinea grass in the interspaces of palms