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Effect of continuous contour trenches on soil moisture and leaf area index of perennial plantation in small catchment

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Abstract: *The study was undertaken at the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.), India. The area under study was divided into four small catchments. The catchments A and C are treated with continuous contour trenches (CCTs) and B and D are non treated. The catchment A and B are having custard apple (Annona squamosa) plantation and catchment C and D are having atemoya (Annona cherimola) plantation. The soil moisture status at different depths of 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80cm was observed during 2013-14 and the leaf area index was calculated for custard apple and atemoya plantation. It was observed that the CCTs helps in better soil moisture condition and which influences the plant growth and ultimately the leaf area index (LAI) of the plantation in CCT treated catchments was better as compared to non-treated catchments. This indicates the benefits of CCTs for better moisture enhancement in the small catchment. The enhanced moisture will be useful for better growth of the perennial plantation. The LAI relates directly to the canopy interception. Therefore with increase in LAI the canopy interception of custard apple and atemoya (hanuman phal) was observed increasingly more in CCT treated catchment as compared to non treated catchment. LAI was observed maximum in the month of October for custard apple (0.70) and in the month of September for atemoya (1.91).*
Keywords: *Catchment, CCT, LAI, plantation, soil moisture*

I. Introduction

The Leaf is an important plant organ, and is associated with photosynthesis and transpiration; therefore, leaf area measurements are required in most physiological and hydrological studies involving plant growth [1]. Leaf Area Index (LAI) measures the amount of leaf material in an ecosystem, which imposes important controls on, respiration, rain water interception, and other processes that link vegetation to climate. The interest in information on LAI distribution and changes has grown substantially in recent decades, due to its intrinsic importance and the emerging capability for LAI estimation over large areas [2]. The amount of water retained in a particular soil and its subsequent availability to crop plants depends upon the type of soil, soil texture, nature of minerals and other soil properties. Therefore understanding the soil water regime of dryland regions is important for efficient rainwater conservation. Continuous contour trench (CCT) system, developed for plantation in non arable lands in low rainfall areas, has been found to be very effective in soil and water conservation, leading to considerably high groundwater recharge [3]. Whenever rainfall-runoff event occurs, runoff begins and flows down from the slopes causing erosion giving not much chance for water to infiltrate down the soil. In such situations CCTs are adopted for reducing runoff and enabling the water to infiltrate down to the ground. In the top portion of catchment area, contour trenches can be excavated all along a uniform level across the slope of the land. Bunds can be formed downstream along the trenches with material taken out of them to create more favorable moisture conditions and thus accelerate the growth of vegetation which can be indicated with the help of leaf area index. Contour trenches breaks the velocity of runoff and for small catchments the infiltrated water can be helpful for increasing the soil moisture regimes.

Contour trenches

Contour trenches are used both on hill slopes as well as on degraded and barren waste lands for soil and moisture conservation and afforestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e., in both high and low rainfall conditions), varying soil types and depths. Trenches can be continuous or interrupted. The interrupted one can be in series or staggered, continuous one is used for moisture conservation in low rainfall areas and require careful layout [4]. Intermittent trenches are adopted in high rainfall areas. The trench may be of 30 cm base and 30 cm top width and square in cross section or it can be trapezoidal with side slopes 1:1. Based on the quantum of rainfall to be retained, it is possible to calculate the size and number of trenches. For the study the trench size of 60 cm top and 30 cm deep is adopted.

II. Methodology

The study was undertaken at the experimental field of All India Co-ordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.), India. The site is situated at the latitude of 20^0 42' N and Longitude of $77^0$02' E. Soil survey of the catchment was carried out and three types of soils were identified viz. Inceptisol, Entisol and Vertisol. Taxonomically these soils are classified into the family of Vertic Haplustepts, Typic Ustorthents, Typic Haplusterts [5]. The small catchments A and C are treated with continuous contour trenches and B and D are non treated. The catchment A and B are having custard apple (*Annona squamosa*) plantation and catchment C and D are having atemoya (*Annona cherimola*) plantation. The soil moisture status at different depths of 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80cm was observed in all the catchments with Gopher Soil Moisture Profiler.

Theory of operation

The Soil Moisture Profiler uses the proven and sensitive technique of measurement of the dielectric constant of the soil plus water to determine the moisture content of the soil. As the water content of the soil increases, the resultant measured dielectric constant increases. The Soil Moisture Profiler is a microprocessor controlled measurement system with an LCD dot matrix display, for display of graphs and information, and a 16-key keypad for operator interface. Power for the microprocessor and sensor head is derived from four super heavy duty batteries [6].

Determination of soil moisture

The access tubes are inserted into the soil in all the four micro catchments. Weekly soil moisture content was determined by inserting the sensitive sensor into the access tubes and the soil moisture content at different depths were recorded at depths of 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80cm.

Leaf Area Index (LAI)

The area of the field under study is 1.0 ha. The area is divided into two small catchments, one catchment is treated with continuous contour trenches and other is non treated. The leaf area index of custard apple and atemoya (Hanuman phal) was calculated for each catchment. For this purpose three plants of large, medium and small category were selected from each catchment. The number of leaves was counted. The area of leaf was determined by leaf area meter. LAI was calculated by dividing the area of total number of leaves by the area occupied by the plant.

Interception component

MIKE SHE applied on a catchment scale implies the assumption that smaller scale equations are valid also at the larger scale. The water movement (WM) is the main MIKE SHE module, which can model, among other water balance (WB) components, the actual evapotranspiration and net rainfall amounts resulting from the processes of (i) interception of rainfall by the canopy (ii) drainage from the canopy; (iii) evaporation from the canopy surface (iv) uptake of water by plant roots and its transpiration and (v) evaporation from the soil surface [7]. The interception process is modelled by introducing canopy interception expressed as a function of leaf area index [8]. The canopy interception (I_{max}) depends on the vegetation type and its stage of development, and is calculated by:

$I_{max} = C_{int} LAI$ where, C_{int} = interception parameter, mm; and LAI = leaf area index.

The parameter C_{int} is independent of vegetation, but depends on time resolution. On the basis of interception storage capacities given in the literature for different vegetation types, a typical value of C_{int} is 0.05 mm.

III. Results and Discussion

The catchment A and B are having custard apple plantation and catchment C and D are having atemoya plantation. The soil moisture status at the depths of 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70 and 70-80cm was observed in different months during 2013-2014 in all the four catchments and is depicted in Fig.1. The soil moisture status was observed to be better in the catchments having continuous contour trenches as compared to untreated catchments. The CCT treated catchments A and C have shown better moisture regime over the untreated catchments B and D in the observed months. The soil moisture content at different depths in CCT treated catchments A and C was more as compared to the untreated catchments B and D in the observed months. The soil moisture content at the depths of 60-70 and 70-80cm in CCT treated catchment A and C had shown higher moisture regime as compared to other depths amongst all catchments. For the catchments having custard apple plantation, it was observed that the soil moisture content in the CCT treated catchment, A was better in all months at almost all depths as compared to untreated catchment, B (Fig. 2). For the catchments having atemoya plantation, it was observed that the soil moisture content in the CCT treated catchment, C was better in all months at almost all depths as compared to untreated catchment, D (Fig. 3). This will clearly indicate the benefit of CCT treated catchment over non treated catchment.

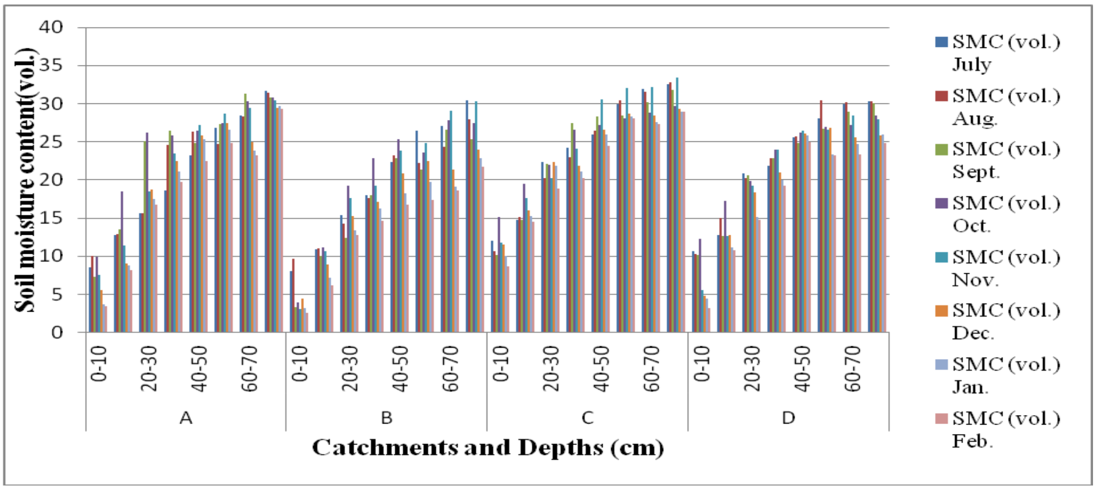

Fig. 1. Soil moisture contents (volumetric) at different depths in different months (2013-14)

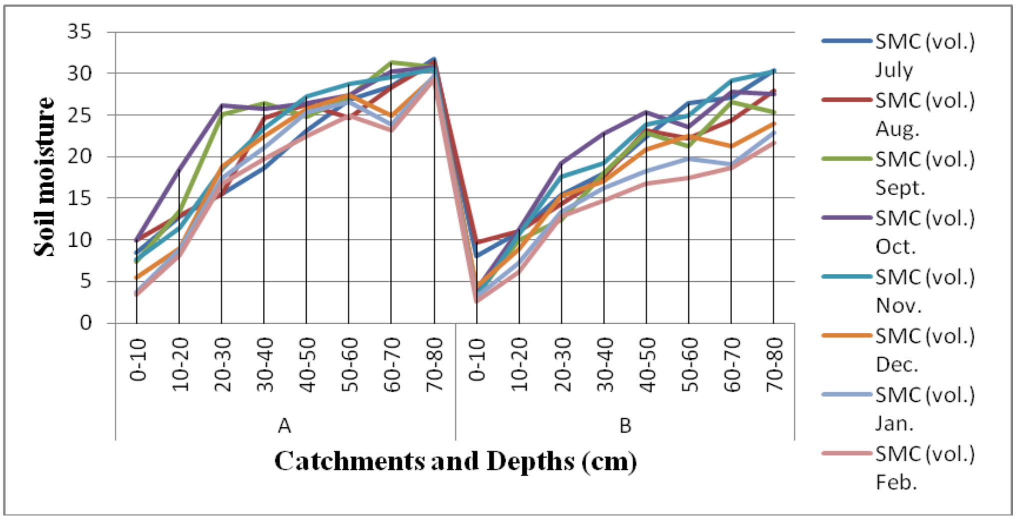

Fig. 2. Soil moisture regime at different depths in different months in the catchments having custard apple plantation

LAI and canopy interception of plantation

The custard apple and atemoya (Hanuman phal) was planted at the spacing of 5mx5m in continuous contour trenches (CCT) treated as well as non treated catchments. The leaf area index (LAI) for plantations is calculated by observing the growth of the plantations in continuous contour trenches treated and non treated catchments. The canopy interception was calculated based on the LAI during the growth stages. The data of LAI and canopy interception is given in Table 1. It is observed that the LAI for custard apple and atemoya (Hanuman Phal) goes on increasing as per the growth of the plantations. LAI was observed maximum in the month of October for custard apple (0.70) and in the month of September for atemoya (1.91). LAI observed to be decreased once the leaves will mature and shreds. The LAI was more in the CCT treated catchment compared to non treated catchment in every month. As the interception component function directly relates the LAI, the canopy interception was observed maximum in the month of October and it was maximum in CCT treated catchment as compared to non treated catchment for custard apple as well as atemoya (Hanuman phal). The monthwise LAI and canopy interception for custard apple and atemoya (Hanuman phal) is presented in Fig. 4 and Fig. 5 respectively.

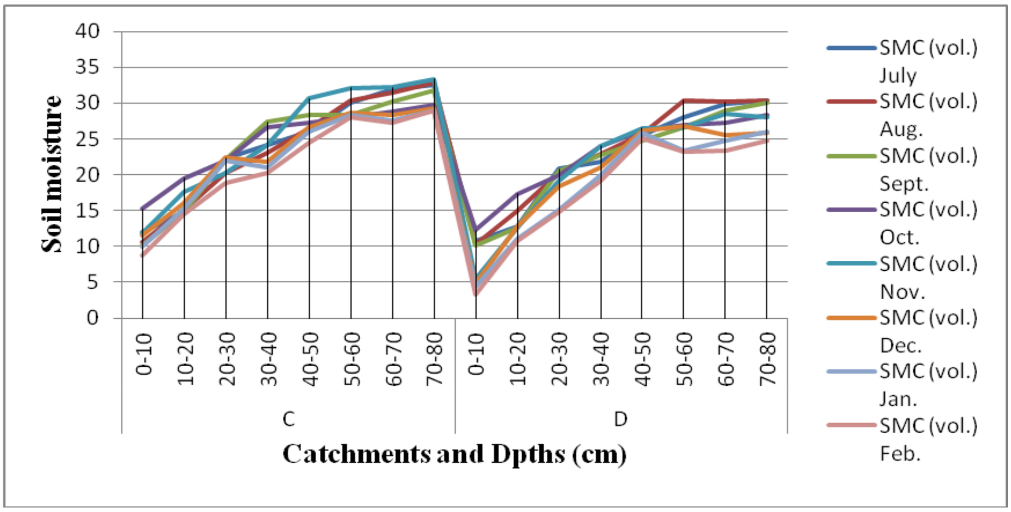

Fig. 3. Soil moisture regime at different depths in different months in the catchments having atemoya plantation

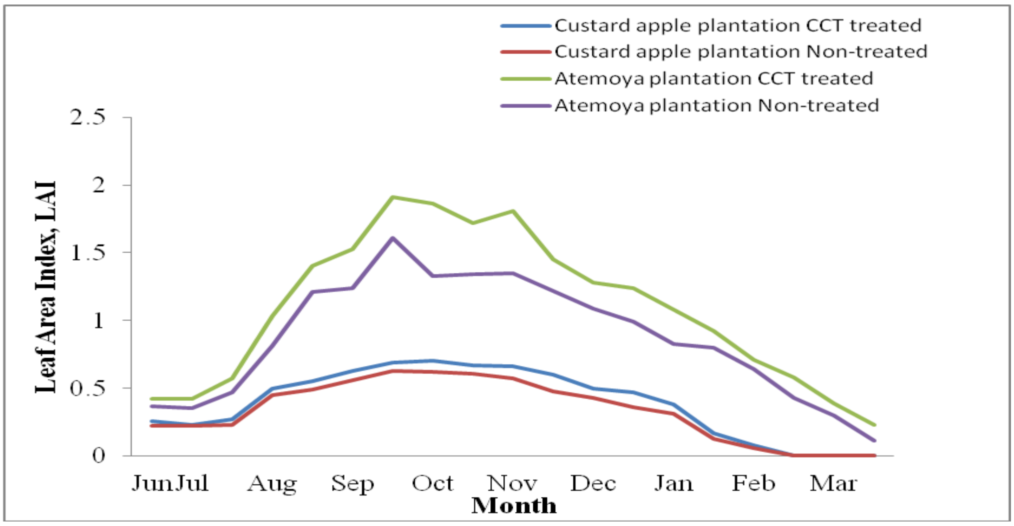

Fig. 4. Month wise LAI for custard apple and atemoya plantation

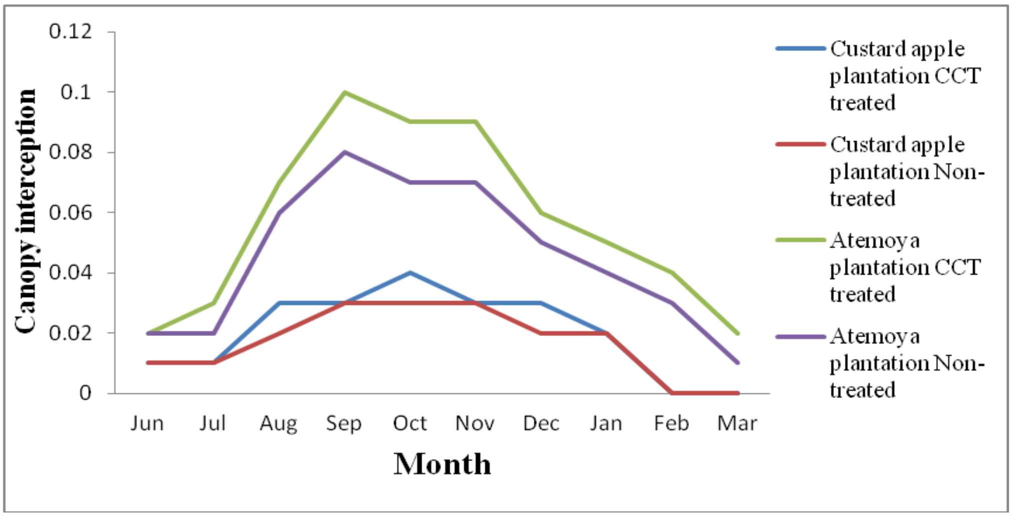

Fig. 5. Month wise canopy interception for custard apple and atemoya plantation

Table 1. Month wise LAI and canopy interception for custard apple and atemoya during 2013-14.

Plantation	Month	Leaf Area Index, LAI		Canopy Interception, (mm)	
		CCT Treated catchment	Non Treated catchment	CCT Treated catchment	Non Treated catchment
Custard apple	June	0.26	0.22	0.01	0.01
	July	0.27	0.23	0.01	0.01
	August	0.55	0.49	0.03	0.02
	September	0.69	0.63	0.03	0.03
	October	0.70	0.62	0.04	0.03
	November	0.66	0.57	0.03	0.03
	December	0.50	0.43	0.03	0.02
	January	0.38	0.31	0.02	0.02
	February	0.08	0.06	0.00	0.00
Atemoya	June	0.42	0.37	0.02	0.02
	July	0.57	0.47	0.03	0.02
	August	1.40	1.21	0.07	0.06
	September	1.91	1.61	0.10	0.08
	October	1.86	1.33	0.09	0.07
	November	1.81	1.35	0.09	0.07
	December	1.28	1.09	0.06	0.05
	January	1.08	0.83	0.05	0.04
	February	0.71	0.64	0.04	0.03
	March	0.39	0.11	0.02	0.01

IV. Conclusion

On the basis of the moisture regimes of different catchments, it can be concluded that the catchments treated with continuous contour trenches have shown better moisture regimes as compared to non treated catchments. This indicates the benefits of continuous contour trenches for better moisture enhancement in the small catchment. The enhanced moisture will be useful for better growth of the perennial plantation and thus the LAI was observed more in the CCT treated catchment compared to non treated catchment in every month. The higher moisture regimes in CCT treated catchments indicates the benefits of continuous contour trenches for rainwater conservation and in rainfed area it is the necessity of the day that every farmer or land holder can treat his own land as a micro-watershed and should adopt the *in-situ* water conservation techniques in order to have sustainable crop / fruit production. The CCTs will be helpful for establishment of perennial plantations in dryland condition and the better moisture regimes will leads to increased groundwater recharge. The better growth of perennial plantation will give more production. The leaf area index is an indicator for plant growth and the continuous contour trenches helps for better plant growth and therefore there is relation of CCTs with LAI. The leaf area index (LAI) relates directly to the canopy interception. Therefore with increase in LAI the canopy interception of custard apple and atemoya (hanuman phal) was observed increasingly more in CCT treated catchment as compared to non treated catchment. Since the area is too small, manual measurement and calculation of LAI is possible and is accurate. For bigger areas the LAI can be computed with other techniques. Overall it can be concluded that CCTs are useful rainwater conservation measures in rainfed conditions for sustainable growth and thereby the production.

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