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Agro-topo climatological studies for crop planning- a case study for the northen hills agrocliamtic zone of Chhattisgarh state

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ABSTRACT

In the Northern Hills agroclimatic zone in Chhattisgarh state (India), the soils are undulating with 15 per cent at the top to 0 per cent slope in the valley areas. Analysis of field hydrological conditions in different soils in the topo-sequence revealed that in the top (sandy) soils agroforestry is a better option while in the valley areas with continuously flowing water from Mid July to November, tall varieties of rice are only suitable. In the clay loam soils rice is the best suited crop while in sandy loam soils maize is an alternative crop for diversifying rice.

Local climate analysis indicated that it varies from near arid type climate at the top of the topo-sequence to near moist sub-humid conditions in the valley areas. Thus, the farmers in the zone need to plan from arid climate crops to moist sub-humid type crops like rice.

Key words: Crop planning, Agro-topo-climatology, CROPWAT

Topoclimates are local climates that occur due to topographical differences in a given area. The topoclimates help in selecting crops and crop varieties based on local field hydrological differences, degree days and thereby phenological changes due to topographical variations. But in India intensive studies on agro-topoclimatic features for agricultural planning were not done. In countries like New Zealand topoclimatic maps were prepared for understanding the degree-day variations for pasture as well as crop growth (Richards, K 1999). Topoclimate and soil information can be used to introduce new crops. Luo Hong *et al* (1988) studied the vertical distribution of agro-topo-climates for agriculture development strategies

In Eastern India especially in Chhattisgarh, Orissa and Jharkhand states, the topography is undulated and the soils vary from very light sandy type to heavy black soils in the valley areas. Rice is the main crop grown during rainy season in all the soils with varying topography at times resulting in very poor productivity. The state governments in these states are taking up intensive crop diversification programme for diversifying rice in unproductive areas. In order to find out a suitable crop for diversification of rice topo-climatic analysis is necessary.

In the northern hill agro-climatic zone of Chhattisgarh the topography varies in every village (Fig. 1). The top most area is of very light soils and the soils vary from very light sandy soils (locally *Tikra*) through sandy loam (*Chawar*), clay loam (*Goda Chawar*) and clayey soils in the valley areas. With a given rainfall distribution during the rainy season, the effective rainfall in different topo-sequences varies significantly resulting in considerable local climate variations. The natural slope in these soils varies from 15 to 0 per cent.

For assessing the suitable crops for diversification, the field hydrological variations within these soils are to be assessed and based on the field hydrological conditions, the duration of crop growth periods could be worked out. In this paper attempts were made to work out the field hydrological variations within the topography in order to find out suitable crops to tailor suit the situations. The agro-topo-climatic analysis is mainly focused on moisture regime point of view as the slight temperature variations within the topo-sequence do not influence the crop phenology especially during rainy (*kharif*) season.

MATERIALS AND METHODS

In order to work out the effective rainfall in soil type, the slope factor was considered and the effective rainfall in each topo-sequence was worked out using the CROPWAT programme developed by Smith (1992). Based on the monthly effective rainfall values in each topo-sequence, the climatic water balance was computed using the book-keeping procedure of Thornthwaite and Mather (1955). For computing climatic water balance in different soil types, the available water holding capacity (AHWC) of the soils was assumed as follows:

1)	Sandy (*Tikra*) soils	100 mm/ m
2)	Sandy loan (*Chawar*) soils	125 mm/m
3)	Clay loam (*Godi Chawar*) soils	150 mm/m
4)	Clayey (*Bahara*) soils	200 mm/m

For examining the local climate type, the moisture index

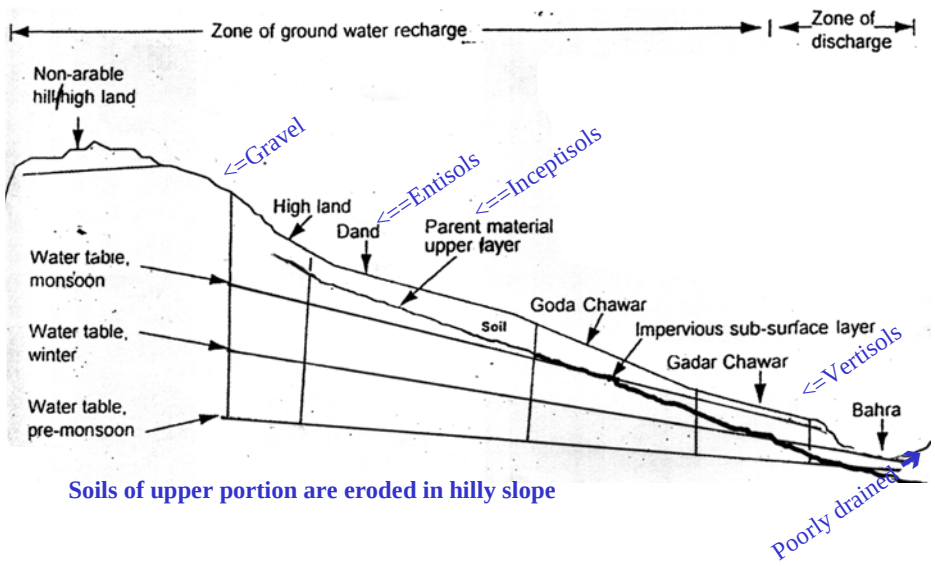

Fig.1: Land topography Northern Hill s Agroclimatic zone of Chhattisgarh state

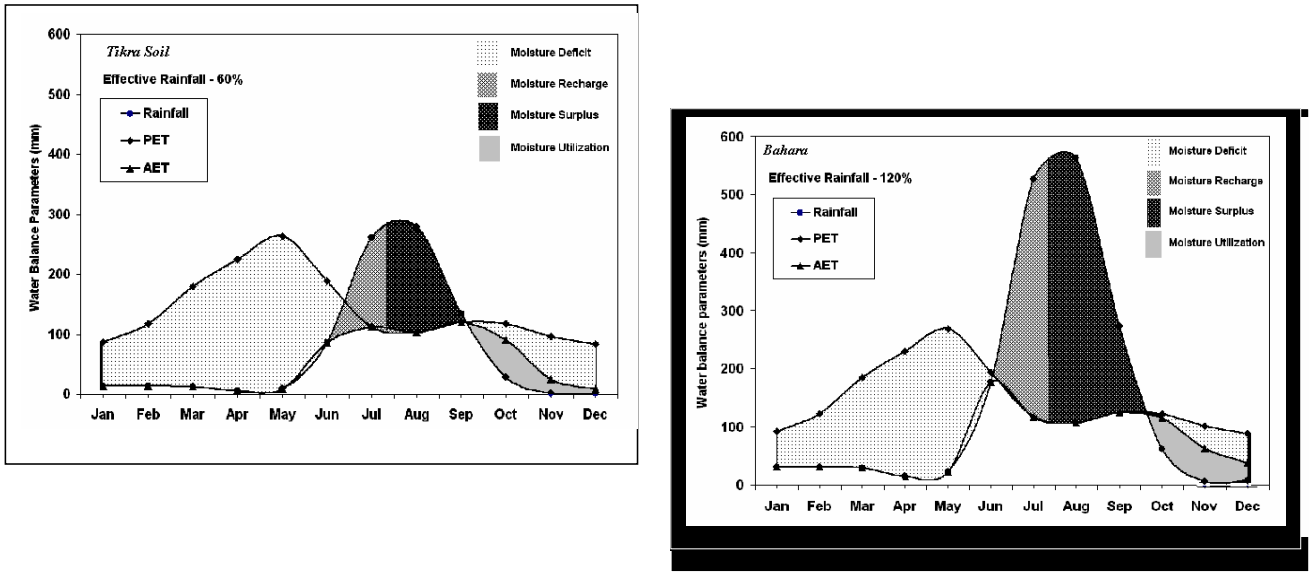

Fig.2: Climatic Water balance diagrams for all the 4 type of soils

Table 1: Monthly climatic water balance parameters in different soils types as per the topo-sequence

Month	Rainfall	PET	Sandy Soil			Sandy Loam			Clay Loam			Clay		
			Effective Rainfall	Water Surplus	Water Deficit	Effective Rainfall	Water Surplus	Water Deficit	Effective Rainfall	Water Surplus	Water Deficit	Effective Rainfall	Water Surplus	Water Deficit
Jan	21.9	86.8	13.1	0.0	73.7	17.5	0.0	69.3	21.9	0.0	64.9	26.3	0.0	60.5
Feb	22.2	117.6	13.3	0.0	104.3	17.8	0.0	99.8	22.2	0.0	95.4	26.6	0.0	91.0
Mar	20.5	179.8	12.3	0.0	167.5	16.4	0.0	163.4	20.5	0.0	159.3	24.6	0.0	155.2
Apr	8.5	225.0	5.1	0.0	219.9	6.8	0.0	218.2	8.5	0.0	216.5	10.2	0.0	214.8
May	14.8	263.5	8.9	0.0	254.6	11.8	0.0	251.7	14.8	0.0	248.7	17.8	0.0	245.7
June	143.0	189.0	85.8	0.0	103.2	114.4	0.0	74.6	143.0	0.0	46.0	171.6	0.0	17.4
July	434.8	111.6	260.9	49.3	0.0	347.8	111.2	0.0	434.8	173.2	0.0	521.8	210.2	0.0
Aug	464.7	102.3	278.8	176.5	0.0	371.8	269.5	0.0	464.7	362.4	0.0	557.6	455.3	0.0
Sep	223.8	120.0	134.3	14.3	0.0	179.0	59.0	0.0	223.8	103.8	0.0	268.6	148.6	0.0
Oct	47.2	117.8	28.3	0.0	27.7	37.8	0.0	19.4	47.2	0.0	13.4	56.6	0.0	8.1
Nov	1.1	96.0	0.7	0.0	70.7	0.9	0.0	59.6	1.1	0.0	50.3	1.3	0.0	38.5
Dec	2.3	83.7	1.4	0.0	74.4	1.8	0.0	67.6	2.3	0.0	60.8	2.8	0.0	50.4
Total	1404.8	1693.1	842.9	240.1	1096	1123.8	439.7	1023.6	1404.8	639.4	955.3	1685.8	814.1	881.6

Im is worked out as follows.

$$Im = \frac{\text{Annual Water Surplus - Annual Water Deficit}}{\text{Annual Potential Evapotranspiration}}$$

The results of the monthly water balance computations are discussed below

RESULTS AND DISCUSSION

The weekly climatic water balance parameters in different soils are as shown in Table 1.

It can be seen from the table that with an average rainfall of 1404.8mm the effective rainfall varied from 842.9mm in sandy soils to as high as 1685.8mm in clayey soils. That is why in the local language the valley area is called '*Bahara'* soils where water continuously flows right from mid July to end of November and in these soils rice crop is inevitable.

Local climate types

When, the moisture index, Im, is examined for different soils in different topo-sequences the results are very interesting.

In a given village or in a given farmers field, due to topographical and soil variations, the effective rainfall varies considerably. In the top portion with sandy soil, the climate is semi-arid and it is bordering arid type. In mid lands, (uplands for rice) the climate is also semi-arid but it is bordering dry sub-humid type. In other words, in the *Tikra* (sandy) and *Chawar* areas the climate is in general, semi-arid but both of them are on border of dry (arid) and wet (sub-humid) climates. The *Goda Chawar* (Clay loam) soils are of dry sub-humid type and these soils are suitable for rice and they are mostly bunded for rice cultivation. The valley (*Bahara* soils) area is also dry sub-humid but it is bordering the wetter (moist sub-humid) type of climate. Thus, some farmers who are having at least 2-3 types of soils in their possession have to plan the crops right from arid climate type to moist sub-humid type.

The climatic water balance diagrams for all the 4 types of soils are shown in Fig. 2. It can clearly be seen that the effective rainfall and thereby the water deficit/surplus conditions increase within the topo-sequence and hence the water deficits decrease.

Field hydrology based crop planning

In the topmost area with sandy type of soils agro forestry is recommended as there is large amount of water deficit. Agroforestry can arrest the erosion of top soil also. In the next topo-sequence, that is sandy loam soils, at present, farmers are taking upland rice under unbunded conditions. In these soils, as there is sufficient drainage provision, maize is a very important crop that is coming up under the rice diversification programme. In the clay loam soils with 100 percent effective rainfall, rice is the main crop that could be grown under bunded conditions. Medium maturity duration varieties like MTU 1010, Mahamaya, etc, are recommended in these soils. This is the potential area for rice cultivation and the potential need to be exploited. In the clay soils (*Bahara*) water flows continuously and the water level goes as high as 60-70 cm. Under such conditions tall varieties of rice are needed. For this special situation, the Indira Gandhi Krishi Vishwavidyalaya, Raipur had recently released a new rice variety called "*Jaldubi*" which is tall genotype that can sustain higher levels of impounded water.

CONCLUSIONS

The agro-topo climatological anlysis in undulating terrain like northern hill agroclimatic zone in Chhattisgarh suggests for detailed analysis of agro-topoclimatology in hilly areas and undulating terrain. Also, for rabi crop planning under irrigation, analysis of temperature variations with altitude helps in computing growing degree days for assessing the crop phenology under different topo-sequences. Topo-climate analysis in hilly areas helps in micro-regional planning for sustainable agriculture.

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