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Estimation of profile moisture status from surface moisture in hilly slopes of Meghalaya

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ABSTRACT

Water surplus and deficit periods were detected based on climatic water balance for 1993-2002 in upland terrain soil of Meghalaya state, India. Results indicated that June to October were the major part of water surplus periods contributing to 90.5 per cent of annual water surplus. The mean monthly water surplus (1016.6 mm) and deficit periods (311.8 mm) indicated that water surplus in this region is too high as compared to water deficit. The linear relationship between surface (0-15 cm) and profile (0-90 cm) water content has been drawn based on their differential behaviours under water surplus and deficit periods with high correlation coefficients (0.905 and 0.921, respectively).

Key words: Water deficit, Water surplus, Climatic water balance, Meghalaya

Water is most precious for crop production, whether in the form of soil moisture or surface water or as ground water or as precipitation, all part of "hydrological cycle". Any development has to integrate these four forms of water as critical inputs without over exploitation but with sound principles of sustainable use of water. Meghalaya also known as "Abode of Clouds" receives almost 18 per cent of total annual rainfall of the whole country due to its typical topography. Most of the farmers of this region make their livelihood from rainfed agriculture. This region has tremendous potential for crop production being rich in natural resources with rare collection of flora and fauna. A proper knowledge of water deficit, water surplus periods and the transition phase is very useful for estimating agricultural drought and thereby planning for any water conservation techniques for sustainable crop production in this region. Therefore, the present study has been conducted with the objective to detect the water deficit and water surplus periods based on climatic water balance and to predict the profile water content from surface soil moisture status for terrain upland soils of Meghalaya.

MATERIALS AND METHODS

The monthly water deficits or water

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surpluses for ten years were computed from climatic water balance model (Thornthwaite & Mather, 1955; Rao *et al*., 1976). The daily meteorological data needed for the study were collected from ICAR Agro-meteorological Observatory, Umiam, located in the central part of Meghalaya in the East *Khasi* hills near Shillong at 25°41'21" N lat. and 91°55'25" E long. at 1080 m amsl. This place is representative of Meghalaya for meteorological study, categorized under the mild tropical hill zone according to National Agricultural Research Project (NARP) of Indian Council of Agricultural Research (Satapathy *et al*., 1999). Mean monthly potential evapotranspiration (PET) were calculated for whole study period using Thornthwaite formula. Actual evapotranspiration (AET) were calculated with help of Penman Monteinth formula.

The field capacity for profile (0-90 cm) of upland terrain soil of Meghalaya was 396 mm. When precipitation (P) is very high, the soil water status exceeds field capacity value and water surplus occurs. So, when precipitation is greater than PET, water surplus is calculated as:

Water surplus (WS) = (P – PET)- change in soil water storage

But when precipitation is less than PET, soil starts drying out and soil profile water goes below field capacity but not at potential rate. During that period, water deficit is calculated by:

Water deficit (WD) = PET – AET

Based on this, the annual total water deficits and water surpluses were calculated for the study period (1993-2002). Ultimately the monthly percent contributions to annual water deficit or water surplus over different years were calculated and average monthly percent contributions for ten years were computed. The soil moisture observations for profile (0-90 cm) were taken from three altitudinal conditions namely hilltop, foothill and valley of upland terrain soil over different months for two years. Soil samples were collected from 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90 cm using auger method and moisture contents were calculated by gravimetric method. The first depth 0-15 cm was taken to represent surface moisture for correlating with 0–90 cm total profile moisture.

RESULTS AND DISCUSSION

Climatic water balance

The different components of climatic water balance for ten years (1993-2002) in the upland terrain soil profile (0-90 cm) of Meghalaya are presented in Table 1. The mean annual rainfall of Umiam, Meghalaya was 2337 mm. The highest annual rainfall (2739.3 mm) was observed in 2001 and the low (1813.7 mm) in 1998. The mean annual PET for the study period was 2153.6 mm with very marginal variation over the years. The annual AET for the soil profile (0-90 cm) varied from 1691.2 to 2031.8 mm. This region receives more than 86 per cent of annual rainfall during the months of May to October. June is the wettest month with an average of 422.5 mm

Table 1 : Components of climatic water balance (mm) for the study period.

Year	Components of climatic water balance*					
	P	PET	AET	P- PET	WD	WS
1993	2559.1	2117.1	1840.6	442.0	243.4	1082.8
1994	2030.5	2272.0	1842.1	-241.5	469.0	602.8
1995	2433.2	2162.4	1691.2	270.8	415.8	1134.5
1996	1992.5	2199.1	2031.8	-206.6	359.8	824.0
1997	2341.7	2190.3	1720.2	151.4	393.6	962.8
1998	1813.7	2125.8	1957.1	-312.1	291.0	550.2
1999	2284.7	2111.8	1986.6	172.9	227.6	1140.9
2000	2658.8	2129.8	1985.0	529.0	233.3	1388.0
2001	2739.3	2121.4	1800.0	617.9	354.7	1352.8
2002	2516.6	2106.3	1911.0	410.3	129.9	1127.6
Mean	2337.0	2153.6	1876.6	183.4	311.8	1016.6

* Field capacity for 90 cm soil profile = 396 mm , P = Precipitation; PET = Potential evapotranspiration; AET = Actual evapotranspiration; WD = Water deficit; WS = Water surplus

rainfall followed by July (401.2 mm), altogether contributing 35 per cent of total annual average rainfall.

Profile water status in relation to surface moisture

The soil of the experimental site is acidic in nature classified under Typic Hapludalf, having water holding capacity of 396 mm. The changes of profile water in relation to changes in surface water showed differential behaviour between water surplus and deficit periods under hilltop, foothill and valley conditions [Fig. 1(a), (b) and (c)]. Soil profile was found to retain higher water content (304.8 to 455.6 mm) during water surplus months as compared to that in water deficit months (162.3 to 335.7mm) in all the conditions. This might be due to higher frequency and intensity of rain spells and long dry spell resulting into drying of profile along with surface soil during water deficit months (Bhattacharya *et al.*; 1997). However, the magnitude of changes varied significantly under different altitudinal conditions. There was almost 10 per cent higher profile moisture content during water surplus months in valley

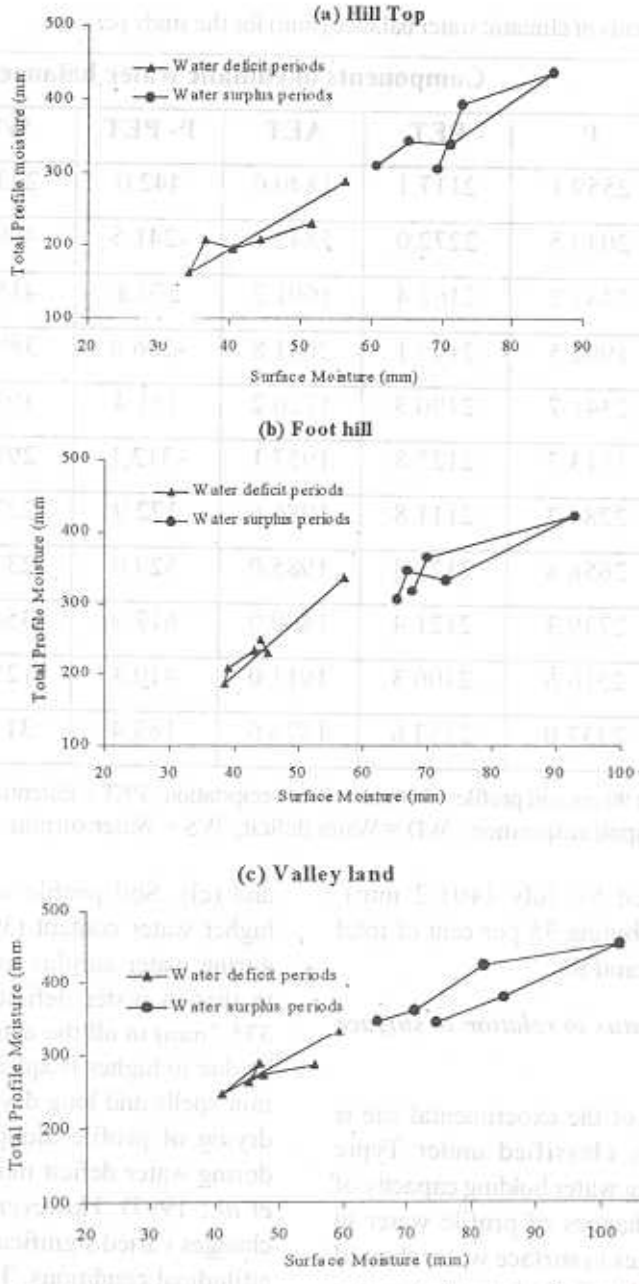

Fig. 1 : Soil profile (0-90 cm) moisture status in relation to surface moisture (0-15 cm) at different slopes

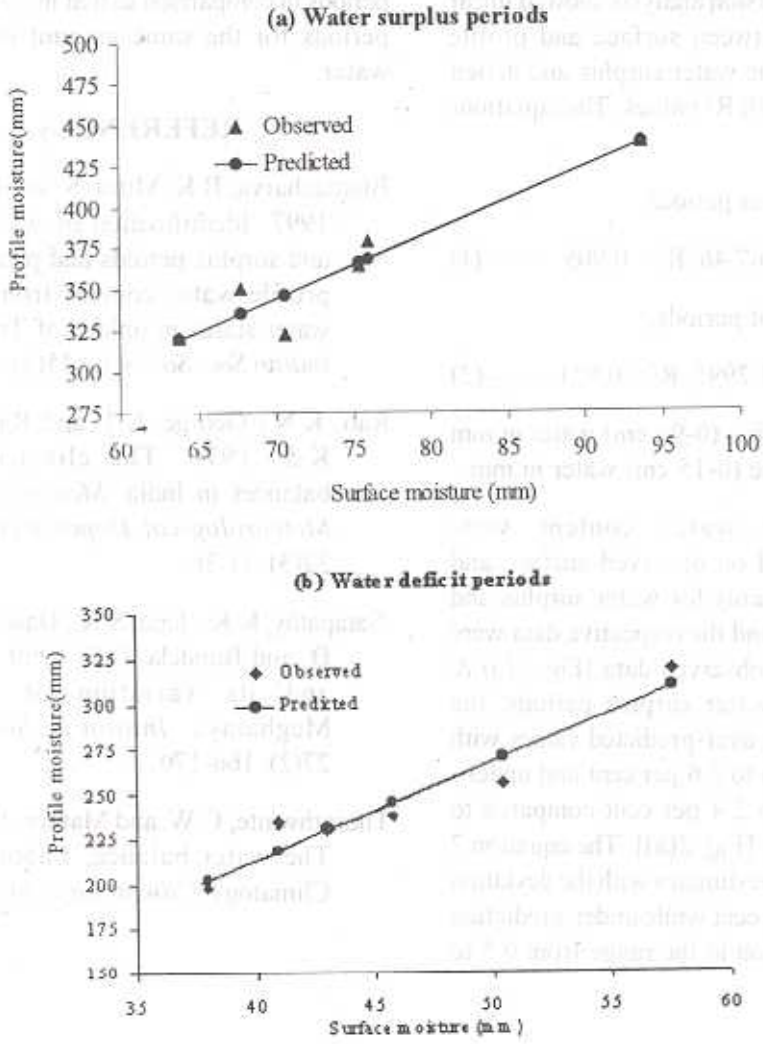

Fig. 2 : Profile water prediction in relation to observed data during water surplus and deficit periods.

condition than others. During water deficit period, it varied from 162.3 mm in hilltop to 332.7 mm in valley (Fig. 1).

Profile water estimation from surface water

The monthly observed data on

surface and profile water for two years were pooled together for regression analysis. Regression analysis showed linear relationship between surface and profile water in both the water surplus and deficit periods with high R^2 values. The equations are:

For water surplus periods,

$$Y = 3.9563X + 67.46, R^2 = 0.905 \quad \text{—— (1)}$$

For water deficit periods,

$$Y = 5.4188X - 3.2995, R^2 = 0.921 \quad \text{—— (2)}$$

Where Y = Profile (0-90 cm) water in mm and X = Surface (0-15 cm) water in mm.

Profile water content were predicted based on observed surface and profile water status for water surplus and deficit periods and the respective data were plotted against observed data [Fig. 2(a) & (b)]. During water surplus periods, the equation 1 gave over-predicted values with the deviation up to 2.6 per cent and under-prediction up to 2.4 per cent compared to observed values [Fig. 2(a)]. The equation 2 gave higher overestimates with the deviation of 2.1 to 5.7 per cent while under-prediction with the deviation in the range from 0.5 to 6.7 per cent [Fig. 2(b)]. Thus, the soil profile can retain higher water during water surplus periods in comparison to that in water deficit periods for the same amount of surface water.

REFERENCES

Bhattacharya, B.K, Mitra, S. and Datta, M. 1997. Identification of water deficit and surplus periods and prediction of profile water content from surface water status in upland of Tripura. *J. Indian Soc. Soil Sci.*, 45(4): 698-701.

Rao, K.N., George, C.J. and Ramasastri, K.S. 1976. The climatic water balances in India. *Memoirs of India Meteorological Department, Pune.* 32(3): 11-36.

Satapathy, K.K., Jena, S.K., Daschaudhuri, D. and Bundela, D.S. 1999. Climate and its variation at Umiam, Meghalaya. *Indian J. Soil Cons.* 27(2): 166-170.

Thornthwaite, C.W. and Mather, J.R. 1955. The water balance, Laboratory of Climatogy. *Climatology*, 8(1): 1-104.