ber apparaently seems to be absent. In a smuch as the Reynold's number also is a function of 'V' for a constant value of μ for water, the only liquid that was experimented with, the Froud number which involved the velocity may be also considered as the substitute. The above equation can be used for estimating the value of 'K' knowing all other variables.

The improved foot valves have the valves of 1.0 to 0.19 for S/A and 2.56 to 0.99 for o/a.

For formulating an empirical equation based on dimensional analysis, the S/A and o/a values were combined to have a systematic permutation and combination.

Finally an equation in the form,

$$K = 3.5 \left(\frac{V}{\sqrt{gd}}\right)^{-1.01} \left(\frac{S}{A}\right)^{-0.7} \left(\frac{O}{a}\right)^{-1.0}$$

has been arrived at. This equation can be advantageously used for computing the pressure loss while designing a pump or while selecting and using a pump.

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CLIMATIC WATER BALANCE AT THE NAGPUR DISTRICT SITUATED IN THE DRY SUBHUMID REGION

S.R. GHADEKAR
Department of Agricultural Engineering and Meteorology,
Punjabrao Krishi Vidyapeeth, College of Agriculture, Nagpur-440 001.

ABSTRACT

Water balance at the Nagpur district was computed from the climatic data. The mean annual precipitation and the potential evapotranspiration values were 124.83 cm and 172.08 cm respectively with the total monthly accumlated water deficit of 97.46 cm being partly met through storage charge and precipitation. Other elements of the water balance viz. water deficit, soil moisture recharge, water surplus etc. were worked out. It was observed that the soil moisture charge (40.45 cm) was useful for the crops during Rabi. Climatic conditions with respect to moisture were favourable during kharif and Rabi seasons but essential during summer irrigations .

KEY WORDS: Water balance, Water deficit, Soil moisture recharge, Dry subhumid region.

An optimum soil moisture is necessary for normal growth of the crop. The knowledge about the gains of water through precipitation and losses of it through run off, percolation and evapotranspiration is essional for determining crop water need, crop-planning, scheduling irrigation and understanding of the ground water movement and is expressed through water balance. Estimation of water balance by actual soil moisture depletion is cumbersome while by lysimeter too costlier and tedius but climatological approach is easy and simple. In the present paper, water budget of the Nagpur district for the first time is investigated.

MATERIALS AND METHODS

Monthly unadjusted values of Potential Evapo Transpiration for Nag-

le 1. Various elements of climatic water balance of Nagpur district (All Figures in cm except T and I).

onth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
p. T°C	21.40	23.85	28.25	32.50	34.90	31.70	27.20	27.05	27.45	26.90	23.00	20.65	
t index I	9.04	10.62	13.75	17.01	18.95	16.38	12.99	13.21	13.14	12.78	10.08	8.55	156.50
Evaporation	16.70	18.40	33.40	40.40	56.30	28.40	12.00	10.70	10.50	16.60	15.40	14.40	273.20
j. PET	4.86	7.28	13.95	23.89	31.34	21.48	12.15	11.89	12.58	11.62	6.42	4.26	161.99
(Adjus)	4.52	6.55	14.33	25.80	37.58	25.32	14.33	13.20	12.83	11.62	5.97	4.06	172.08
recip.)	1.40	1.90	2.80	2.00	1.30	21.00	40.70	28.80	17.30	6.50	1.70	0.30	124.83
age charge)	-3.12	-4.65	-12.13	-23.80	-36.28	-4.32	26.37	15.60	5.53	-5.15	-4.27	-3.76	-49.64
ot.WL ge charge loss)	-16.30	-28.95	-33.08	-56.88	-93.16	-97.48	–	–	–	-5.15	-9.42	-13.18	-97.48
ot.WG(Storage e gain)	–	–	–	–	–	–	26.37	41.97	45.60	–	–		
torage ce	29.30	24.65	12.52	–	–	21.00	26.37	41.97	45.60	40.45	36.18	32.42	
surplus	–	–	–	–	–	–	–	–	1.90	–	–		1.90
deficit	3.12	4.65	12.13	23.80	36.28	4.32	–	–	–	5.15	4.27	3.76	97.46
	←	← Summer →				←		Kharif →		←		Rabi →	

Field capacity (vertisols) at 1 Meter depth = 45.6 cm.
Wilting point = 16.3 cm

Nagpur were worked out by using Thornthwaite's (1948) formula. $e = 1.6 [10 \frac{t}{I})^a$ where e = monthly unadjusted potential evapotranspiration in cm for 12 hours day, t = mean monthly air temp. in °C, I = annual heat index and a = coefficient which varies with heat index.

The unadjusted values of PET were corrected for actual day light hours and days in a month (Michel *et al.* 1977). The water balance was then computed by following the book keeping method of Thornthwaite and Mather (1957). The various elements of water balance *viz.* temp. heat index (I), precipitation (p), potential evapotranspitation (PET), water deficit (WD), water surplus (WS) and accumulated potential water loss (WL) are tabulated in Table 1. The simplified water budget graph (Lockwood, 1974) for the Nagpur district based on precipitation (P) potential evapovanspiration (PET) is given in the Fig. 1.

The climatological data for the Nagpur district for the period of 12 years (1946-1960) were obtained from the Regional observatory of India Meteorological Department, Nagpur.The values of PET, P, I, WD were first computed yearly and then averaged over 12 years to obtain the normals. The field capacity of the black soil (vertisols) is 456.0 mm and wilting point is 163.2 mm at the depth of 1 meter. For estimating the various elements, the use of water balance equation is made where PET = p−(R +ds), where p is gain by precipitation, R the loss to run off, PET loss by evapotranspiration and ds the gain or loss of water stored in the soil.

RESULTS AND DISCUSSION

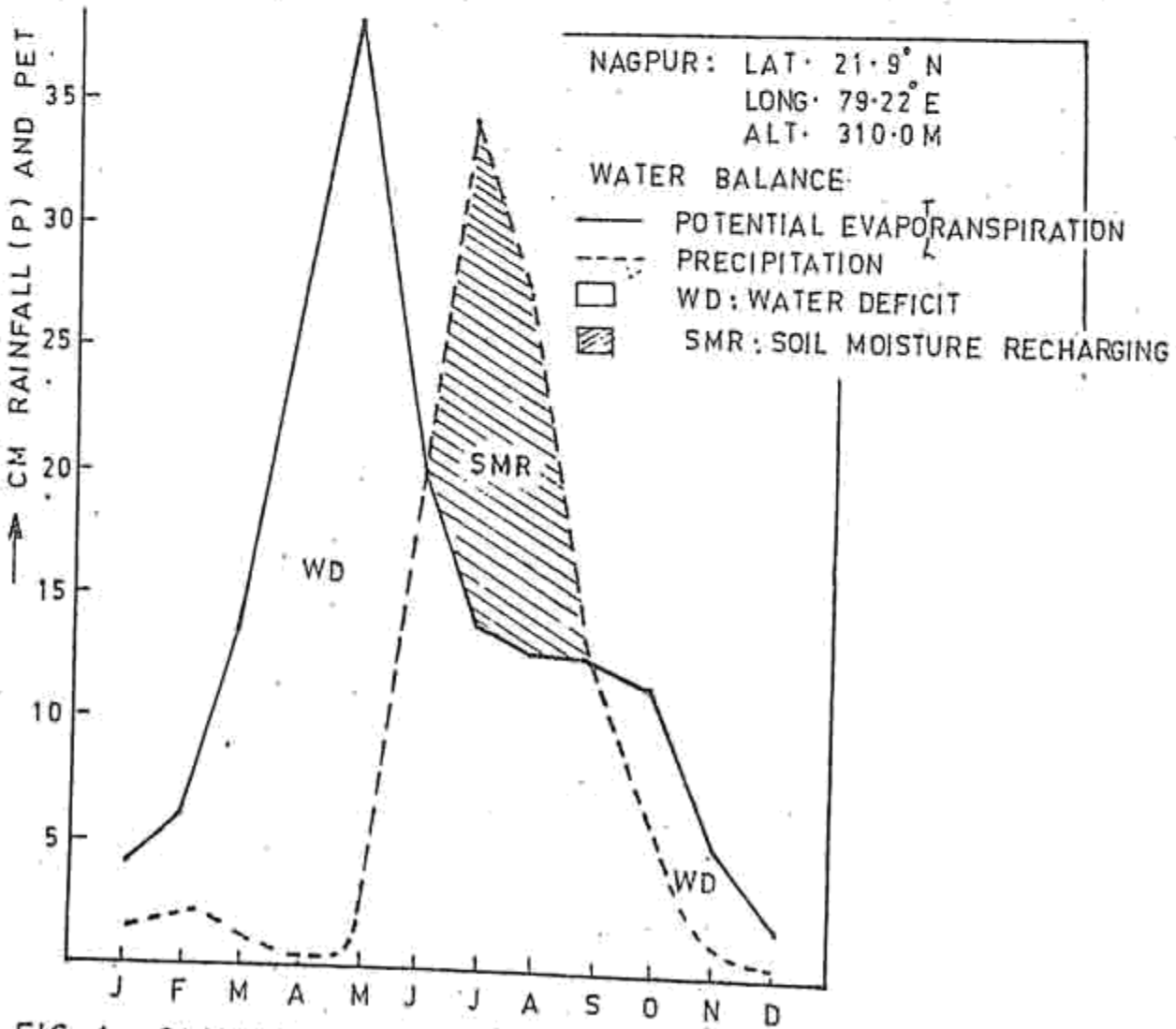
The annual moisture index for the Nagpur district on Thronthwaite's climatic classification is − 28.96 as calculated from the modified equation: $Im = 100 (\frac{P}{PET} - 1)$ and therefore the climatic moisture type of the place is C_1-dry subhumid on Thronthwaite's modified scale. Thermal efficiency which is simply the potential evapotranspiration in centimeters (Critchfield, 1975) of the place is 172.08 cm which can be catagorised as 'A'-megathermal. The mean annual precipitation is 124.83 cm while the need of water for PET is 172.08 cm. Thus it is clear that the precipitation is insufficient to meet the water demand of vegetation for PET. This describes (P < PET) dry conditions in the region. The total monthly accumulated water deficit is 97.46 cm which is partly met through storage charge of 47.6 cm through precipitation during July, August and September. However, the total storage charge is -49.64 cm. The water deficit (W.D.), soil moisture recharge (SMR) in the annual cycle are clearly shown in the Fig. 1.

During kharif season (June to September), the rains received begin to charge the soil with moisture after getting depleted in summer and soil reaches its field capacity by september end. Though the temperatures are greater than 27°C, the high relative humidity (RH) and low solar radiations reduce partly PET demand of crop. The total PET during kharif is 65.68 cm while precipitation is 107.8 cm exhibiting (P > PET) wet conditions and favourable conditions for the kharif crops to meet their water demand. The soil reaches field capacity value of 456 mm in September. At that time,

the precipitation (P) being greater than PET it percolates as surplus water below the depth of the plant roots, that is bottom of soil presumably reaching the ground water.

During Rabi season (October to January), precipitation (P) received is only 9.9 cm while the PET is 26.2 cm. The value of PET is greater than the value of precipitation but the soil moisture charge is as much as 40.45 cm and is exhausted progressively till it becomes 29.3 cm during January end. This is a zone of utilization and the plants continue to draw the stored soil moisture freely for the sustenance of their growth and development at the Rabi end. The cold temperature and high RH during this season reduce the actual ET of the crop. Thus the conserved water charge in soil is just sufficient to meet the water needs. Thus even in Rabi favourable conditions exhist.

During the Summer season, the PET reaches highest value of 84.26 cm in the annual cycle while the rainfall is lowest being only 7.4 cm presenting extremely dry conditions (PET > P). The hot temperatures, low RH and more radiation increase the PET of the vegetation to very high value (84.26 cm). The water deficit also progressively increases and the soil moisture falls below the wilting point. During April and May the soil is at permanent wilting point and the plants struggle hard for their existence or may die until either the recharge begins or the artificial irrigation is supplied for the growth sustenance. During May, the PET demand is the highest (37.58 cm).



FIG·1—CLIMATIC WATER BALANCE AT NAGPU

These conditions are unfavourable for crop growth and warrant supplementary irrigations.

Thus it is seen that there exists different conditions in three season; in kharif the climate is wet and humid with Thornthwaites moisture index of + 64.12, in Rabi it is cold and semi arid with thornthwaites Moisture Index of- 62.22, while in summer season the conditions are hot and arid with Thornthwaites Moisture Index of - 91.21. In Rabi eventhough semi arid conditions exist, the conserved soil moisture storage and reduced water demand due to moderate humidity, low temperature and low radiations enabled the growth of the crops. Also, the actual ET is always less than the PET. It can therefore be concluded that the climatic conditions with respect to moisture are favourable during Kharif and Rabi seasons while during summer supplementary irrigations are essential.

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RESEARCH NOTES

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NEW RECORD OF TORTOISE BEETLE, *Oocassida pudibunda* Boh ON BER IN ANDHRA PRADESH

Among the pests of ber (Zizyphus mauritiana), the fruit fly, bark eating caterpillar, hairy caterpillar, leaf chaffer and lac insect were important (Pareek, 1983). Insect pests belonging to as many as 33 families were recorded on ber (Nair, 1986).

During Kharif 1987, a new pest was observed damaging the leaves of ber in the orchards belonging to Krishi Vigyan Kendra, Anantapur and also the villages of Tadipatri taluk. This pest was identified as the tortoise beetle, *Oocassida pudibunda* Boh (Coleoptera : Chrysomelidae). This beetle was previously reported from Nainital, Almora, Pusa and Nagpur (Maulik, 1919). Rawat and Modi (1972) reported this pest causing heavy damage to foliage of ber in Madhya Pradesh. But occurance of this pest on ber in this area has been onserved, recently for the first time.

The pest was active from June to November but was more active and abundant during August. Both larva and adult were found to feed on the leaves, leaving behind some whitish membraneous patches. In severe cases, the leaves were skeletonised, later dried and dropped.