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Climatological water requirement of groundnut (*Arachis hypogaea L.*) under Nagpur agroclimatic conditions in kharif, rabi and summer seasons

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सार – खरीफ, रबी तथा गर्मी के मौसम में मूंगफली की जल की आवश्यकता को जलवायु पद्धति का अनुसरण करके निश्चित किया गया है। संभावित वाष्पोत्सर्जन का पूर्वानुमान लगाने के लिये संशोधित पेनमन सूत्र का उपयोग किया गया है लगभग 40 वर्षों के लंबे अर्से के (1946-1985) आंकड़ों का संगणन के लिये उपयोग किया गया है। परिणामों से पता चला है कि मूंगफली की जल आवश्यकता तीनों मौसमों में भिन्न-भिन्न है। गर्मी के मौसम में मूंगफली की जल आवश्यकता उच्चत्तम (913.69 मि. मी.) थी और वह संपूर्णतः सिंचाई पर लिये जाने वाली रबी मंगफली की जल आवश्यकता से (431.98 मि. मी.) दुगुनी थी। मूंगफली की खरीफ मौसम में जल आवश्यकता (563.83 मि. मी.) थी और उसकी मानसून वर्षा से ही पूर्ति पायी गयी। रबी मौसम के दरम्यान मूंगफली की जल आवश्यकता सबसे कम थी और उसकी पूर्ति मानसून-पश्चात वर्षा, मानसून के दौरान जमीन में वर्षा के संचयित वर्षा के फलस्वरूप जमी हुई शेष आर्द्रता तथा सहायक सिंचन से हुई थी।

ABSTRACT. Water requirement of kharif, rabi and summer grown groundnut was determined following climatological approach. Modified Penman's model to predict evapotranspiration (ET_0) was employed. Long climatic data of about 40 years (1946-1985) was used in computation. The results showed that water demand of groundnut followed variations in three seasons. Water demand in summer season was highest (913.69 mm) more than double that of rabi groundnut (431.98 mm) requiring totally irrigations. In kharif, crop required 563.83 mm of water and the demand completely met through monsoon rains. Rabi groundnut required lowest water and the demand was met through post monsoon rains, residual soil moisture after monsoon recharge of soil partly and supplementary irrigations.

1. Introduction

Groundnut (*Arachis hypogaea L.*) is one of the most important legume crop among all the oilseed crops. Groundnut responds well to irrigation. As a dayneutral plant, it can be grown in kharif, rabi or in summer season. At Yemmiganur (Karnataka) on red sandy loam soils, 6 to 7 irrigations were required for rabi groundnut (Rao 1966). In Maharashtra, no irrigations were required on heavy soils in kharif season (Yadav 1972). A summer sown crop required 8 irrigations applied at 100 mm pan evaporation at Parbhani on clay loam soils (Khuspe 1975). Water stress retards the growth and also affects the yield of the crop. The exact water need of the groundnut is not yet worked out under Nagpur conditions in detail. Such knowledge is essential for various purposes, *viz.*, for irrigating the crop by drip system wherein the water lost through evapotranspiration is substituted. Therefore, a climatological approach was made to estimate water requirement of the groundnut crop under Nagpur agroclimatic conditions on Vertisols.

2. Materials and methods

Climatic data of 40 years (1946–1985) was used to compute potential evapotranspiration (PET) for Nagpur station. Ghadekar *et al.* (1987), from comparative studies of various climatological methods to predict PET, have found that only modified Penman's model predicted reasonable and adequate PET values under climatic conditions of the region. Therefore, modified Penman's equation (Doorenbos and Pruitt 1979) with adjustment factor to compensate for the effect of day and night weather conditions, *viz.*, wind velocity, temperature, relative humidity and radiation, to predict the effect of climate on reference crops, *viz.*, groundnut evapotranspiration (ET_0) was used as follows :

$$ET_0 = C[W.R_n + (1-W).\ f(u).\ (e_a - e_d)] \qquad (1)$$

where, ET_0 = Reference crop evapotranspiration (in mm/day)

W = Temperature related weighing factor

R_n = Net radiation expressed in mm of evaporable water per day

$f(u)$ = Wind related function

$(e_a - e_d)$ = Saturation deficit (in m bar)

C = adjustment factor to compensate for the effect of day and night conditions.

TABLE 1

Monthly and seasonal water requirement (All figures in mm of water) and water availability periods of groundnut during kharif, rabi and summer seasons

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
				Kharif				
ET_0	117.18	142.52	225.37	243.0	292.64	201.30	174.84	132.99
kc	—	—	—	—	—	0.95	0.95	0.95
ET_{crop}	—	—	—	—	—	95.61	166.09	126.34
R	11.40	23.40	16.80	16.80	20.80	222.0	376.0	286.30
$R \geqslant ET_0$	—	—	—	—	—	—95.61	—166.09	—126.34
$R \geqslant ET_0/2$	—	—	—	—	—	47.80	83.04	63.17
Total irrigation water required =0, Total demand is fulfilled by the rains								
				Rabi				
kc	0.55	—	—	—	—	—	—	—
ET_{crop}	64.44	—	—	—	—	—	—	—
$R \geqslant ET_0$	—	—	—	—	—	—	—	—
$R \geqslant ET_0/2$	32.22	—	—	—	—	—	—	—
Total irrigation water required=431.98								
				Summer				
kc	—	0.95	0.95	0.95	0.95	0.55	—	—
ET_{crop}	—	135.39	214.10	230.85	278.00	55.35	—	—
$R \geqslant ET_0$	—	—	—	—	—	—	—	—
$R \geqslant ET_0/2$	—	67.69	107.05	115.42	139.00	27.67	—	—
Total irrigation water required = 913.69								

TABLE 1 (*contd*)

Crop	Sep	Oct	Nov	Dec	Annual	Total demand	Demand fulfilled by rains	Demand at 1/2 ET_0
				Kharif				
ET_0	138.30	161.51	124.80	100.13	—	—	—	—
kc	0.95	0.55	—	—	—	—	—	—
ET_{crop}	131.38	44.41	—	—	—	563.83	—	—
R	184.70	54.60	19.80	0.90	1233.50	—	—	—
$R \geqslant ET_0$	—131.38	—44.41	—	—	—	—	563.83	—
$R \geqslant ET_0/2$	65.85	22.05	—	—	—	—	—	281.91
Total irrigation water required=0, Total demand is fulfilled by the rains								
				Rabi				
kc	—	0.95	0.95	0.95	—	—	—	—
ET_{crop}	—	153.43	118.96	95.15	—	431.98	—	—
$R \geqslant ET_0$	—	—	—	—	—	—	—	—
$R \geqslant ET_0/2$		76.71	59.28	47.55	—	—	—	215.76
Total irrigation water required = 431.98								
				Summer				
kc	—	—	—	—	—	—	—	—
ET_{crop}	—	—	—	—	913.69	—	—	—
$R \geqslant ET$	—	—	—	—	—	—	—	—
$R \geqslant ET_0/2$	—	—	—	—	—	—	—	456.84
Total irrigation water required = 913.69								

To account for the effect of crop characteristics on the crop water requirements, the crop coefficient (k_c) recommended (Doorenbos and Pruitt 1979) to relate ET_0 to crop evapotranspiration (ET_{crop}) through relationship as follows was used :

$$ET_{crop} = k_c . ET_0 \quad (2)$$

Water requirements of the groundnut crop for kharif, rabi and summer seasons were computed for Nagpur station. Monthly values were portioned according to the duration included in the growing season, considering the normal sowing and harvesting dates of the crop in the region. The monthly values of ET_0 for June and October were portioned to one half in kharif as the crop is sown by mid-June and harvested by mid-October. For the rabi crop (sowing in the beginning of October and harvesting by January end) full monthly values of ET_0 were used. In summer, the crop is sown in the beginning of February and harvested by mid-June, therefore one half value for June and full values of ET_0 for February, March, April and May were used.

3. Results and discussion

The water requirement of the crop is the loss of water through evapotranspiration and is mainly a function of climatic factors such as air temperature, solar radiation, relative humidity, wind velocity, saturation deficit etc. Monthly water requirement of the groundnut crop from modified Penman's equation (ET_0) was computed and then taking into account the crop characteristics and the growth stage of the crop, the net water requirement of the groundnut crop (ET_{crop}) was calculated using adequate values of crop coefficients (k_c) (Table 1). From the table it is observed that the crop required different amounts of water according to its growth stage and season of cultivation. Raman and Murthi (1971) have shown that the crop can utilise soil moisture when $R \geqslant ET_0$ or $R \geqslant \frac{1}{2} ET_0$ but when rainfall $R < ET_0$ /4 or $ET_0/8$ the crop experiences water stress and the growth and yield, both are affected. Therefore, while computing annual water requirement, the ET_{crop} values during the water availability periods (*viz.*, $R \geqslant ET_0$ or $ET_0/2$) were subtracted.

Normally most of the plants grow successfully and utilize water from the soil at 50 per cent and above available soil moisture. The maximum demand (daily or seasonal) always equals to the potential evapotranspiration (ET_0) which is utilised through soil moisture. If the soil is charged through rains or irrigation water to the extent, so that all the water evapotranspired is totally substituted, the condition for this amounts to $R \geqslant ET_0$ marking 100 per cent available soil moisture. Based on this, the regimes : (*i*) $R \geqslant ET_0$, (*ii*) $R = ET_0/2$, (*iii*) $R = ET_0/4$ and (*iv*) $R = ET_0/8$ are designated as humid (H), moist (M), moderately dry (MD) and dry (D) respectively and presumably correspond to the soil moisture regimes with 100, 50, 25 and 12.5 per cent available soil moisture approximately under no ground storage charge condition to meet the actual evapotranspiration. During humid and moist periods, there is no moisture stress but when rainfall is between $ET_0/2$ and $ET_0/4$ the plants begin to suffer from drought and when it is below $ET_0/4$, they are severely affected by water stress and their growth is also retarded as the available soil moisture falls below (50 per cent level) the optimum level (Thornthwaite and Mather 1955).

It is observed from Table 1 that the water requirement of the groundnut crop in kharif and summer seasons is 563.83 mm and 913.69 mm respectively. Ghadekar [1987(b), 1987 (c), 1988] considered the climatic adaptation of groundnut during winter and from the extensive climatic data of the region and the meteorological equivalents of the crop has shown that groundnut in rabi reason in Vidarbha can be successfully grown. The water requirement of groundnut in rabi season stood to the value of 431.98 mm only. In summer season the crop required almost the double amount of water (913.69) than in rabi season (431.98). In kharif season, all the required quantity of water is supplied through the rains as $R \geqslant ET_0$ or $ET_0/2$. But in rabi and summer $R \leqslant (1/2)ET_0$ falling available soil moisture below 50 per cent and therefore, irrigations are needed. In winter or rabi season (October-January) due to low temperature, moderate humidity and calm conditions, the ET_0 or monthly consumptive use was much smaller than in summer but as there was no sufficient rainfall, irrigations were needed to meet the crop requirement. Under advective conditions of summer (Feb-Mar) with hot, dry and windy weather the ET_0 values shoot up and, therefore, frequent irrigations are required. In kharif or rainy season irrigations were not needed. For successful growth and effective uilization of water from the soil, the available soil moisture must be at least at 50 per cent level which correspond approximately to $ET_0/2$ level forming optimum limit. Therefore, the water requirement computed at $ET_0/2$ level is optimum; the values for kharif, rabi and summer seasons being 281.91, 215.76 and 456.84 mm respectively.

There is meagre information of water requirement of the groundnut based on climatological approach. Groundnut responded well when irrigated at 75 mm [(PE in summer seanson (Anonymous 1983)]. Yadav (1975) reported that rabi groundnut requires 670 mm of water. Sainy *et al.* (1973) reported from their experiment at Ludhiana that the crop in kharif season requires about 300 mm of water. Lenka and Misra (1973) reported that rabi groundnut required 690 mm of water at Chakuli (Orissa). Rao (1966) reported that the spring groundnut requires 300-350 mm of water. Ali *et al.* (1974) reported that the rabi groundnut required 500 to 700 mm of water at Bhavanisagar. At Hissar (Haryana) Singh *et al.* (1968) reported that a crop sown in kharif season after presowing irrigation required four irrigations.

Our studies clearly showed that the climatological water requirement of the groundnut in Nagpur region for kharif, rabi and summer seasons is 563.83 mm, 431.98 mm and 913.69 mm respectively. The water requirement in rabi season is quite in agreement with the Ali *et al.* (1974) and slightly greater than that of Rao (1966) 350 mm. In kharif, irrigations were not required.

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