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Pigeonpea evapotranspiration as influenced by sowing time and irrigation

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ABSTRACT

Seasonal evapotranspiration (ET) of pigeonpea was found to be influenced by sowing time and irrigation frequency. Crop coefficient (K_c) values decreased as sowing time was delayed but increased with irrigation frequency. The seed and dry matter yields were found to have a linear association with seasonal ET. Quantum of water used in ET during branch formation to flower initiation, flower initiation to 50 per cent flowering, and 100 per cent podding to maturity was positively correlated with seed yield and dry matter production of pigeonpea.

Key words : Pigeonpea, Evapotranspiration, Sowing time, Irrigation

Increased water application and crop needs should be matched precisely for the efficient utilization of the scanty natural resource. Information on the crop water requirement is important for designing and managing an irrigation system. Crop water requirement varies substantially over the growing season mainly due to variation in crop cover and climatic conditions. Crop coefficient (K_c) value is the empirical ratio of actual evapotranspiration of a given crop under non-stressed conditions to reference crop evapotranspiration (PET). It represents crop specific water use and facilitates estimation of irrigation water requirements. K_c values need to be derived empirically for each crop based on local climatic conditions.

About 90 per cent of the area under pigeonpea in India is rainfed and in Andhra Pradesh it is mainly grown during *kharif* season. However, when sown this time, the crop succumbs to *Heliothis* damage and it's cultivation during *rabi* season was found to be advantageous. This shifting in sowing time, an agronomic measure, is gaining prominence in recent years. Medium duration cultivars of pigeonpea are prone to terminal drought, if they are entirely dependent on stored moisture at the beginning of the season, and thus application of three irrigations were stated to double the yield (Chauhan, 1990). The information on evapotranspiration (ET) and K_c values of pigeonpea may thus aid in scheduling irrigation and that information is scanty. Thus, a field experiment was conducted to study the evapotranspiration and to work out K_c values of pigeonpea during *rabi* season.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural College Farm, Bapatla during *rabi* 1996-97. The soil of the test site was

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clayey having an average field capacity of 47.6 per cent, permanent wilting point of 25.7 per cent on volume basis and a bulk density of 1.32 g cc^{-1} in the 0-30 cm layer. The soil was weakly alkaline in reaction, low in organic carbon (0.4%) and available nitrogen (180 Kg ha^{-1}) medium in available phosphorus (40 Kg ha^{-1}) and available potassium (260 Kg ha^{-1}). The treatments consisted of three dates of sowing (5th November, 20th November and 5th December) and three levels of irrigation based on IW/CPE ratios of 0.25, 0.50 and 0.75. These treatments were laid out in a randomized block design with factorial concept and replicated thrice. A vertical polythene sheet separated each plot from another to a depth of 50 cm to avert seepage. A common irrigation depth of 50 mm was maintained to all the treatments with the help of a water meter fitted to the main pipeline. Pigeonpea Cv. LRG – 30 was sown as per the treatments at a spacing of 90 x 20 cm with a basal dose of 20 Kg N + 50 Kg P_2O_5 ha^{-1}. Need based and timely plant protection measures were taken. Crop evapotranspiration was determined by monitoring changes in soil moisture content thermo-gravimetrically by drawing soil samples from 0-15, 15-30, 30-45 and 45-60 cm depths. Soil samples were taken from each plot at 10-day interval and again before every irrigation. Potential evapo- transpiration was estimated using modified Penman method as suggested by Doorenbos and Pruitt (1979). The crop coefficient (K_c) values during different phenophases were estimated as a ratio between ET and PET. Days taken for the onset of different pheno- phases were recorded visually by tagging 10 plants in each treatment.

Table 1: Crop coefficient (K_c) values as influenced by sowing time and irrigation

Treatment	P_1	P_2	P_3	P_4	P_5	P_6	P_7
D_1I_1	0.50	0.70	0.90	0.90	0.85	0.60	0.25
D_1I_2	0.60	0.80	0.95	0.90	0.85	0.65	0.35
D_1I_3	0.65	0.90	1.15	1.25	1.15	0.80	0.30
D_2I_1	0.50	0.60	0.85	0.80	0.85	0.55	0.20
D_2I_2	0.55	0.70	0.85	0.85	0.80	0.60	0.30
D_2I_3	0.60	0.75	0.90	0.95	0.85	0.70	0.53
D_3I_1	0.45	0.55	0.70	0.70	0.55	0.50	0.20
D_3I_2	0.50	0.60	0.75	0.75	0.60	0.55	0.30
D_3I_3	0.60	0.65	0.80	0.85	0.70	0.65	0.30

D_1,D_2 and D_3 – Dates of sowing; I_1,I_2 and I_3 – Irrigation levels

P_1-Branch formation to flower initiation; P_2-Flower initiation to 50% flowering

P_3-50% flowering to 100% flowering; P_4-100% flowering to pod initiation

P_5-Pod initiation to 50% podding; P_6-50% podding to 100% podding

P_7-100% podding to maturity

RESULTS AND DISCUSSION

The reference evapotranspiration (PET) characterizes the evaporative demand imposed by meteorological conditions. Crop coefficient (K_c) normally includes the effects of evaporation from both plant and soil surfaces and is dependent upon available soil water within root zone and wetness of exposed soil surface (Doorenbos and Pruitt, 1979). The variations in K_c values are stated to be site, weather and management specific i.e., a result of planting date, plant population and row spacing. Again these values are dependent on weather because, temperature, radiation and frequency of rainfall effect soil evaporation and plant transpiration directly and temperature influences the rate of crop development (Hanks, 1984). The K_c values, estimated in the present study, at different phenological stages as influenced by different treatments, are presented in Table 1.

They indicate that sowing time and irrigation regimes had considerable influence on crop ET. The K_c values as a mean of irrigation levels for different dates of sowing are presented in Fig. 1. The K_c value as a mean of dates of sowing were found to decrease at all phenological stages as sowing time was delayed. The D_1 date of sowing recorded a mean seasonal K_c value of 0.76 followed by D_2 (0.70) and D_3 (0.59). This could be due to lesser aerial growth in terms of plant height and leaf area index as the sowings were delayed.

The K_c values as a mean of dates of sowing for different irrigation regimes are presented in Fig.2, which reveals highest K_c value in the I_3 irrigation regime (0.76) followed by comparatively dry regimes of I_2 (0.66) and I_1 (0.61). At all the phenological stages, I_3 irrigation regime maintained a higher K_c value which indicates a high evapotranspiration rate in the presence of high soil moisture in the root zone for most part of the crop season compared to other regimes. The results of the present investigation also indicate that pigeonpea though considered as drought tolerant crop, readily transpires to meet the evaporative demand imposed by environment rather than conserving soil moisture. Muchow (1985) found that stomatal conductance in pigeonpea is relatively insensitive to saturation deficit, so that stomata of well-watered plant remained open when the evaporative demand was high.

Evapotranspiration and crop yield

A linear relationship between yield and ET in many field crops was reported by Hanks (1984). However, similar studies in pigeonpea are scanty. The seasonal ET values recorded in different treatments of the present study were related with the corresponding seed (Sy) and above ground dry matter (DM) yields (Fig. 3). These can be expressed mathematically as

$$Sy = -1163.6068 + 8.473\ ET \quad ...(R^2 = 0.61)$$

$$DM = -4267.1067 + 32.212\ ET \quad ...(R^2 = 0.58)$$

The above analysis reveals that pigeonpea utilizes about 260 mm of water to produce 1 t ha^{-1} of seed yield in *rabi* season. Sardar Singh and Russel (1981) reported that under traditional production systems, pigeonpea uses about 200 to 250 mm of water to produce 1 t ha^{-1} of grain. To identify the moisture sensitive stage, the phenophase-wise ET value was correlated with grain and dry matter yields (Table 2). The data show positive correlations between seed and dry matter yields and water used during branch formation, flower initiation and again at 50

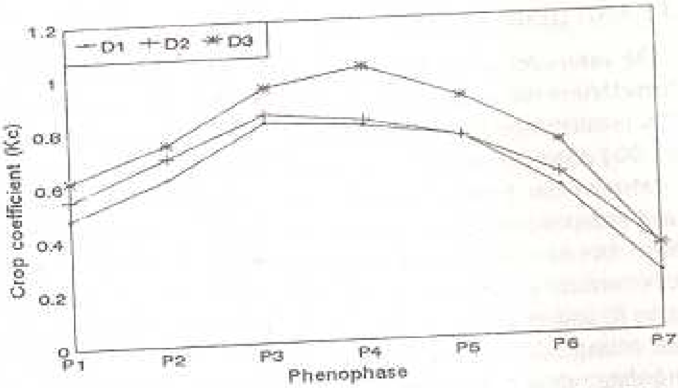

Fig.1:Crop coefficient values as influenced by sowing time

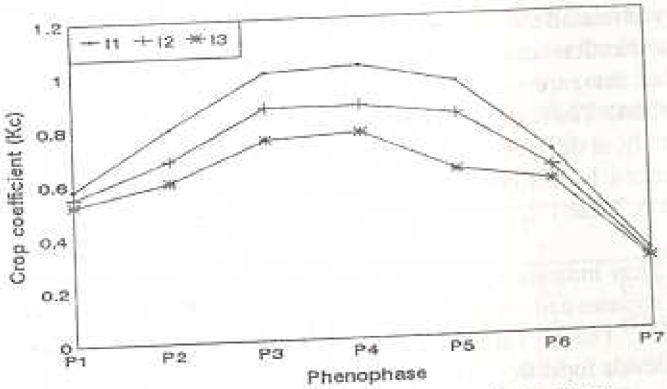

Fig.2: Crop coefficient values as influenced by irrigation levels

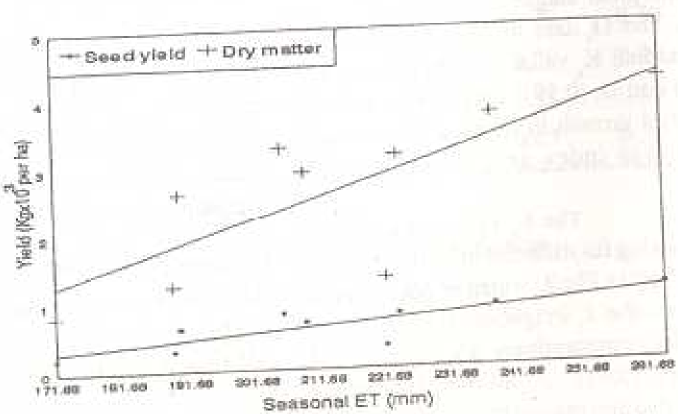

Fig.3:Relation between seasonal ET and seed,dry matter yields

Table 2: Correlation coefficients between yield and phenophase-wise evapotranspiration

Crop phenophase	Seed yield	Dry matter yield
Branch formation-flower initiation	0.76*	0.73*
Flower initiation-50% flowering	0.83*	0.83*
50% flowering – 100% flowering	0.10	0.06
100% flowering – pod initiation	0.16	0.10
Pod initiation – 50% podding	0.55	0.54
50% podding –100% podding	0.34	0.36
100% podding – maturity	0.85*	0.84*

*Significant at 5% level

per cent pod formation to maturity stages. Bhan and Khan (1979); Makhanlal and Gupta (1984) also suggested that highest seed yield was realized by irrigating the crop at branching stage than at early vegetative and /or at flowering stages, which show that consideration of phenophase is important in such studies.

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