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Short Communication

Determination of optimum water for groundnut (*Archies Hypogea*) on the basis of crop coefficient in saline environment

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Crop evapotranspiration(ET_C) is an important parameter for irrigation management. A common procedure for estimating ETc is to first estimate reference evapotranspiration (ETo) from weather data and then to apply empirical crop coefficient (Kc). Different methods have been attempted by many scientists to estimate the ETc for different crops in different climatic conditions (Khandelwal *et al.* 1999; Pandey *et al*. 2008). For estimating ETo, Penman- Monteith method is most preferred method as it suits a wide variety of climatic conditions (Khandelwal & Pandey, 2008; Sahoo *et al*. 2009). The FAO adopted this method as global standard (Allen *et al.* 1998). Doorenbos and Pruitt (1977) have suggested crop-coefficient values for different crop grown under different climatic conditions. The value of Kc are different for different crops and also have different values for different growth stages based on different climatic conditions for the regions.

In coastal parts of India, the over-pumping of groundwater for agricultural use is leading to falling ground water levels, deteriorating ground water quality due to sea water ingress leading to the build-up of salts in the soils of some irrigated pockets. Excessive salinity reduced plant growth primarily because it increases the energy that must be expended to acquire water from the soil of the root zone and to make the biochemical adjustments necessary to survive under stress (Rhoades *et al.* 1992). This energy is diverted from the processes which lead to growth and yield. Plants are more tolerant to salinity in cool climate. Plant water consumption is a reflection of evaporative demand of atmosphere.

Groundnut is an important oilseed crop adopted by farmer in Saurashtra region of Gujarat and is grown during summer (Feb–May) and rainy season (June– October). Groundnut production is also affected by salinity problem especially in summer season. Crop water requirement changes at different growth stages and it's also affected by salinity. Flowering stage of groundnut has optimum water requirement (45%) compared to all other stages. Hence an attempt has been made to determine the rate of ETc and Kc during flowering stage only.

Field experiments were conducted during 2014-15 at the farm of Research Training and Testing Center (RTTC), Junagadh Agricultural University, Junagadh, (lat. 21°30' N, long. 70°27' E and altitude of 77.5 mamsl) to evaluate the impact of varying salinity at flowering stage of groundnut. The climate of area is subtropical and semi-arid with an average annual rainfall of 900 mm and average annual pan evaporation of 2044 mm. Soil type is sandy loam soil. Fresh water was used for pre sowing irrigation and other stages except flowering stage. The different concentrations of saline water selected to irrigate at flowering growth stage of the groundnut are T_1-2 dSm^{-1}, T_2-4 dSm^{-1}, T_3-8 dSm^{-1} and T_4-12 dSm^{-1}. The salinity of fresh water used for control treatment was (Tc) 1.90 dSm^{-1}. The crop period was divided into four distinct growth stages: initial, crop development, mid-season and late season (Dorrenbos and Pruitt, 1975, Allen *et al.,* 1998). The flowering stage were selected for determining the optimum water requirement in saline condition. The irrigation water was given at 50% depletion of moisture at field capacity. So, crop was irrigated at frequency of 7 days interval. During this experiment, traditional method of groundnut cultivation was adopted.

The soil moisture sensors were fitted at a depth of 30 cm from ground surface to all the treatments for measuring daily fluctuation of soil moisture. Different concentration of saline irrigation water was prepared by four major types of salts ($CaCl_2$,$MgSO_4$,$MgCl_2$,NaC_l) added by using the balance ratio of major cations and anions.

The FAO Penman-Monteith method for calculating ET_o can be expressed as (Allen *et al*.,1998):

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{900}{T+273} u2(e_s - e_a)}{\Delta + \gamma\ (1+ 0.34u2)}$$

Where, ET_0 is reference evapotranspiration (mm day^{-1}), R_n is net radiation at the crop surface (MJm^{-2}

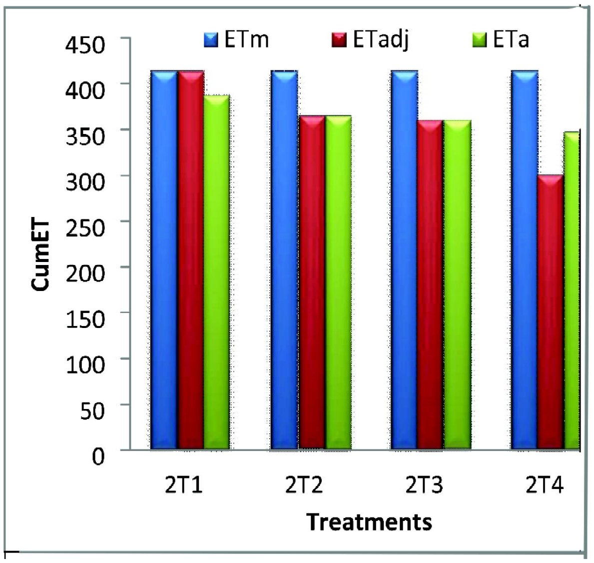

Fig.1: Cumulative ET value for the different treatments

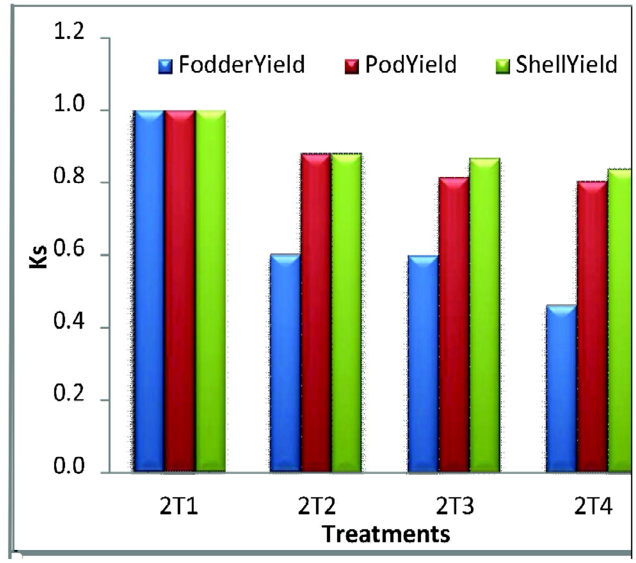

Fig.2: Stress coefficient at flowering stage

day^{-1}), G is soil heat flux density (MJm^{-2} day^{-1}), T is mean daily air temperature at 2 m height (°C), u_2 is wind speed at 2m height (ms^{-1}), e_s is saturation vapour pressure (kPa), e_a is actual vapour pressure (kPa), (es-ea) is saturation vapour pressure deficit (kPa), Δ is slope vapour pressure curve (kPa °C^{-1}) and γ is Psychometric constant (kPa°C-1). The actual evapotranspiration from the field was estimated through the quantity of soil moisture depletion has been depleted from field capacity through the root zone of soilprofile.

Crop coefficient (Kc)

The K_c is determined for three cases in saline and moisture stress condition. The first case is determination of K_c for non-moisture stress and non-saline conditions. The second case is the determination of Kc for non-moisture stress and saline conditions. The last case is the determination of Kc by measuring the daily moisture content (by soil moisture sensors) for each treatment.

In FAO-56, the values listed for Kc represent ET under growing conditions having a high level of management and with no water or other ET reducing stresses and thus represents what are referred to as potential levels for crop ET_m. ET_a can be less than the potential ET_m for a crop under non-ideal growing (actual) conditions including those having water stressor as high soil salinity.The effects of soil water stress on crop ET are described by reducing the value of Kc by multiplying it by the water stress coefficient (Ks). For moisture stress condition the value of water stress coefficient is determined as below;

$$ETa = Kc \times Ks \times ETo$$

Since ET and Kc are interconnected parameters indicating plant growth statues, Kc factor was apparently affected by interactions of soil and plant parameters. The Kc during the mid-season Kc mid (or flowering stage) for standard conditions was 1.15 and Kc value was 1.05 adjusted locally as per the procedure outlined by FAO 56. The cumulative values of crop ET_m for standard conditions, local adjusted conditions ET_{adj} and sensor based ET_a showed that the ET decreased with increase in salt concentration of the irrigation water (Fig.1).

Under non-moisture stress and saline conditions, the value of Ks factor changes with the treatment. The Ks is estimated using the procedure outlined by FAO 56. Ks decreased with increasing salinity and directly affected the groundnut yield (Fig.2). The same trend prevailed for fodder, pod and shell yields.Lower values of Ks indicate restricting the ET and higher values indicate at par with the control.

ETa was also estimated using daily moisture content values obtained from the moisture sensor observations. The Kc with time can be estimated with a third or fourth order polynomial equation expressed as:

$$Kc = e X^4 + f X^3 + g X^2 + h X + i$$

Utilizing the above actual crop coefficients developed, the cumulative actual crop evapotranspiration was plotted with time for different treatments (Fig. 3).

The evapotranspiration values were generally higher under low salt treatment. A reduced water loss under high saline treatment was found as compared to low saline water. Reduced bioavailability of water and retarded plant growth

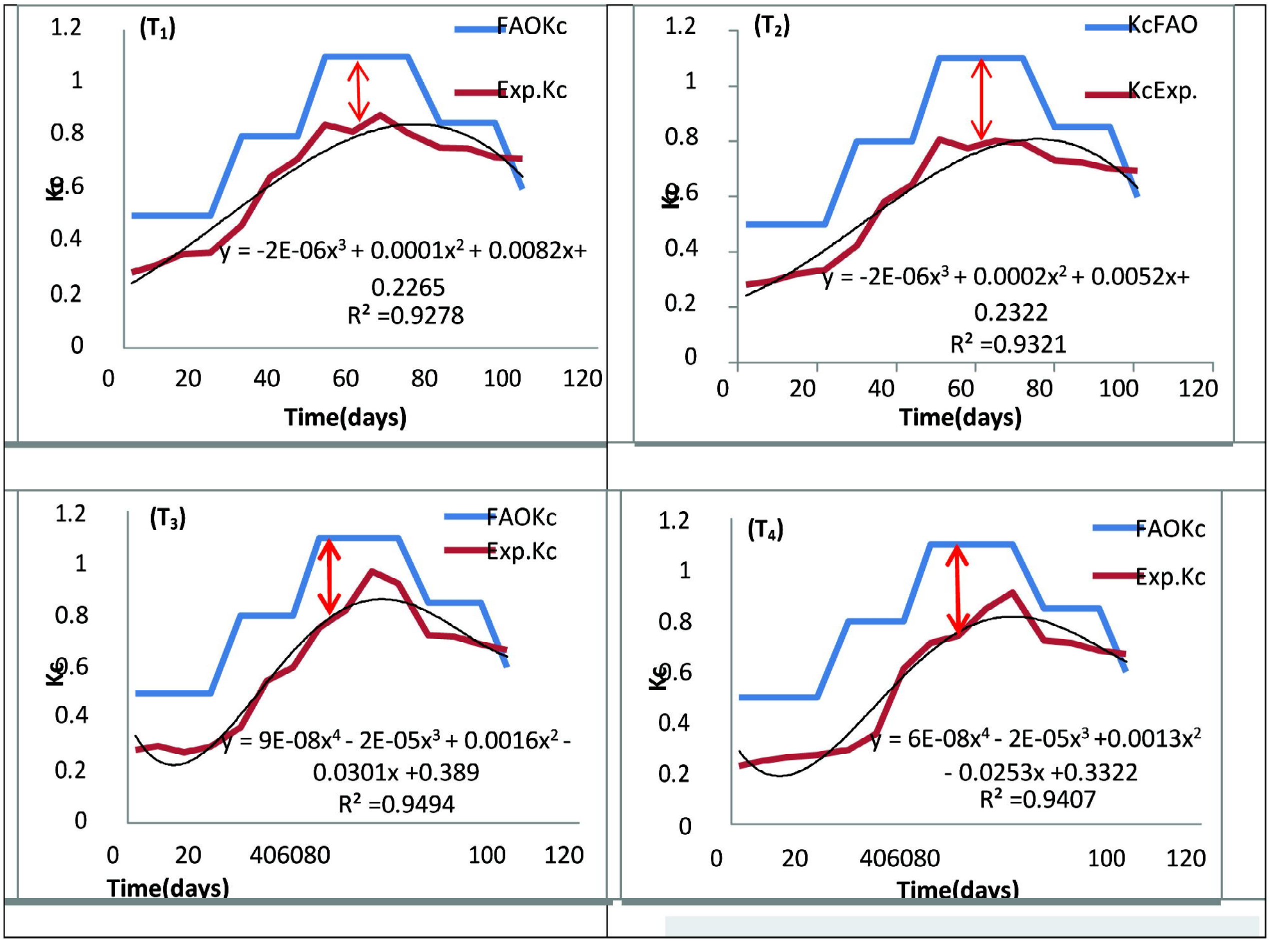

Fig. 3: Sensor based crop coefficient curves for the different treatments

under saline irrigation produced a poor ET in the system. The depressing effects of salinity on plant growth have been reported by various researchers (Heakal *et al*., 1990; Abdul *et al*., 1988;Koszanski and Karczmarczyk, 1985).

The duration of crop growth stages and respective crop coefficient for flowering stage and for different saline condition of groundnut crop determined in the study will be useful to estimate crop water requirement and further developing optimum irrigation schedules for achieving higher water productivity in saline condition. The evapotranspiration of the crop during the whole season using Penman approach with the modified crop coefficient for non- moisture stress (K_s=1) and non-saline conditions was estimated to be 413.8 mm. The K_c developed based on daily fluctuation of soil moisture with moisture probes can be expressed with a polynomial equation of 3rd or 4th order for different treatments.

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