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Deficit Irrigation Effects on Groundnut (*Arachis hypogaea* L.) with Micro Sprinklers

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An experiment was conducted at Agricultural Research Station, Bhavanisagar to study the effects of deficit irrigation on groundnut with micro sprinklers. To identify the impact, water-yield relationship was derived and interpreted. The yield response factor (k_y) ranges from 0.45 and 0.42 (normal irrigation) to 1.72 and 1.70 (full deficit irrigation) for summer and *Rabi* seasons, respectively. From the results, the pod formation and flowering stages were more sensitive to moisture stress and irrigation during these stages is more important to overcome the yield reduction in groundnut.

Key words: deficit irrigation; water-yield relationship; yield response factor

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop as its seed contains 44-56% of oil and 22-30% protein on a dry seed basis. Groundnut is grown on 19.6 million ha of land area in about 82 countries. In India, groundnut yields fluctuated from 550 to 1100 kg ha^{-1} in different years and consequently the total production of the country also varied from 4.3 to 9.6 million tons (Patel, 1988). The rise and fall in the yield and production coincided with the percentage deviation from the mean annual rainfall (DES, 1990). This study was conducted to determine appropriate yield response factor for different growth stages with deficit irrigation.

Materials and Methods

Field experiments were conducted in Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar during summer 2005 and *Rabi* 2005-2006. The experimental area is located at 11°29' N latitude, 77°08' E longitude and at an altitude of 256 m above the mean sea level. The experiment was laid out with groundnut variety TMV 7 in a Randomized Block Design (RBD) and replicated thrice with a gross plot size of 18.0 m^2 and a net plot size of 11.97 m^2. The soil of experimental fields is sandy loam. Crop water consumption in the treatments was calculated using Eq. (1) (Garrity *et al.*, 1982; James, 1988)

$$ET = P + I - R - D_p \pm \Delta S \quad (1)$$

where ET is crop water consumption (mm); P is rainfall (mm); I is irrigation water (mm); R surface runoff (mm); D_p is deep percolation (mm) and “S is soil water content variation in crop root depth (mm). In this study, deep percolation (D_p) and surface runoff (R) in Eq. (1) were assumed to be negligible because

Table 1. Allowed depletion factor for different growth stages of groundnut

Treatment	Irrigation method	Allowed depletion factor*			
		Vegetative stage	*Flowering stage*	*Pod formation stage*	*Maturity stage*
$T_{control}$	Surface irrigation	0.50-0.60	0.50-0.60	0.50-0.60	0.50-0.60
T_{1111}	Micro sprinkler irrigation	0.50-0.60	0.50-0.60	0.50-0.60	0.50-0.60
T_{0111}		**0.75-0.80**	0.50-0.60	0.50-0.60	0.50-0.60
T_{1011}		0.50-0.60	**0.75-0.80**	0.50-0.60	0.50-0.60
T_{1101}		0.50-0.60	0.50-0.60	**0.75-0.80**	0.50-0.60
T_{1110}		0.50-0.60	0.50-0.60	0.50-0.60	**0.75-0.80**
T_{0000}		**0.75-0.80**	**0.75-0.80**	**0.75-0.80**	**0.75-0.80**

*Allowable depletion factor of 0.50 to 0.60 corresponds to full irrigation and that of 0.75 to 0.80 corresponds to deficit irrigation

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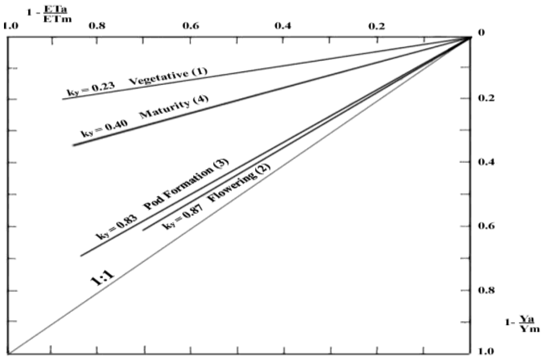
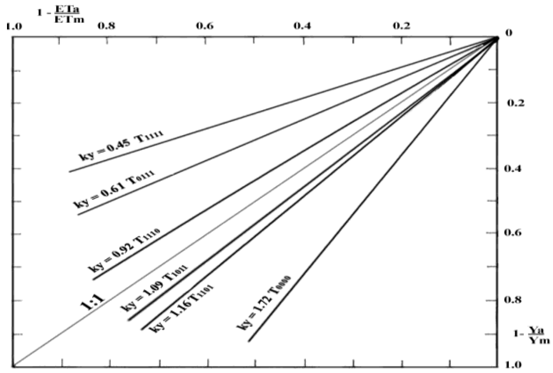
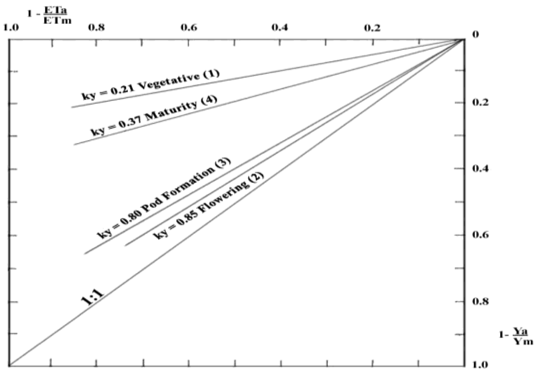


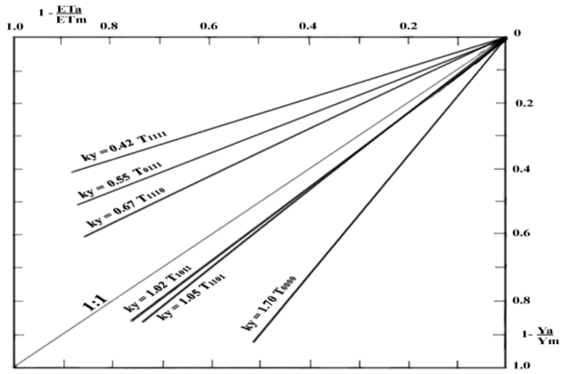
(a) Individual growth periods



(b) Total growth period



(c) Individual growth periods



(d) Total growth period

Fig. 1. Relationship between relative yield decrease and relative ET deficit (Summer 2005 and *Rabi* 2005-2006)

the amount of irrigation water was not increased above the field capacity as a result of micro sprinkler irrigation and deficit irrigation. The amount of irrigation water was calculated using equation (2)

$$I = AE_{pan} K_{cp} CAI \quad (2)$$

where I is irrigation water (mm); A is plot are (m^2); E_{pan} is cumulative water depth from Class A Pan; K_{cp} is crop pan coefficient and CAI is canopy area index which was assumed to be 1. The water use-yield relationship was determined using the

Table 2. Relationship between decrease in relative water use and decrease in relative yield

Treatment	Y_a (kg ha^{-1})	ET_a (mm)	Summer 2005				
			ET_a/ET_m	Y_a/Ym	$1-Y_a/Ym$	$1-ET_a/ET_m$	k_y
$T_{Control}$	2097	480	1.0000	-	0	0	0
T_{1111}	2010	436	0.9083	0.9585	0.0415	0.0917	0.45
T_{0000}	900	321	0.6688	0.4292	0.5708	0.3312	1.72
T_{0111}	1913	410	0.8542	0.9120	0.0880	0.1458	0.61
T_{1011}	1610	378	0.7875	0.7675	0.2325	0.2125	1.09
T_{1101}	1565	375	0.7813	0.7461	0.2539	0.2187	1.16
T_{1110}	1696	380	0.7917	0.8087	0.1913	0.2083	0.92
			Rabi 2005-2006				
$T_{Control}$	2127	516	1.0000	-	0	0	0
T_{1111}	2037	464	0.8992	0.9577	0.0423	0.1008	0.42
T_{0000}	987	353	0.6841	0.4640	0.5360	0.3159	1.70
T_{0111}	1970	432	0.8372	0.9263	0.0737	0.1628	0.55
T_{1011}	1688	411	0.7965	0.7934	0.2066	0.2035	1.02
T_{1101}	1644	407	0.7888	0.7821	0.2179	0.2112	1.05
T_{1110}	1809	401	0.7771	0.8805	0.1495	0.2229	0.67

Stewart model in which dimensionless parameters in relative yield reduction and relative water consumption are used (Doorenbos and Kassam, 1979).

$$\frac{Y_a}{Y_m} = 1 - K_y \left(1 - \frac{ET_a}{ET_m} \right) \quad (3)$$

where, Y_a is actual harvested yield (kg ha^{-1}); Y_m is maximum harvested yield (kg ha^{-1}); K_y is yield response factor; ET_a is actual evapotranspiration (mm) and ET_m is maximum evapotranspiration (mm). Seven irrigation treatments with combinations of method of irrigation and different levels of moisture stress at different stages of crop growth as given in Table 1.

Results and Discussion

When water is a limiting factor, crop yield prediction requires a quantitative analysis of impact of ET deficit on yield. The selected measure to study this impact is the yield response factor (k_y) which is the per cent reduction in yield (below maximum yield) per unit reduction in ET value. The k_y values for individual growth period and for total growing period were calculated and are presented in Figure 1

The treatment wise k_y values were calculated and are presented in Table 2 for summer 2005 and *Rabi* 2005-2006 respectively. The value of k_y implies the response of the crop to moisture stress. Lesser value of k_y indicates that the crop is less sensitive to moisture stress and a value k_y greater than unity implies that more sensitive to moisture stress. The highest k_y value was observed in the treatment imposing stress at all four stages, because the yield was found to be less which further influenced by growth and yield attributes of the crop.

From the above results, it was clear that the pod formation and flowering stages were more sensitive to moisture stress. Hence irrigation must be given to ET requirements during these stages for getting maximum yield.

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