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Crop coefficients and yield of Lady's finger (*Abelmoschus esculentus* L.Moench) under trickle fertigation in semi arid tropics

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Abstract

A field experiment was conducted on a sandy loam soil at Students' farm, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during summer seasons of 2003 and 2004 to study the influence of trickle fertigation on crop coefficient (kc) and yield of bhendi. The experiment consisted of 12 treatments which comprised three levels of drip irrigation (0, 0.50, 0.75 and 1.00 Epan) with three fertigation levels (60, 90 and 120 kg Nha^{-1}), furrow irrigation with120 kg Nha^{-1}, family drip system with120 kg Nha^{-1} and fertigation control (drip irrigation at 1.00 Epan + 0 kg N ha^{-1}) .The experiment was laid out in a randomized block design and replicated thrice .The results of the study revealed that Crop coefficients (Kc) derived for individual crop growth sub periods indicated that the values were low during initial crop growth period, increased linearly with advancement of crop life and attained peak values at reproductive growth period and decreased towards maturity. Crop coefficients calculated by Modified Penman method were close to values of (FAO-33). Pod yield was maximum with the crop irrigated at 1.00 Epan, fertigated with 120 kg N ha^{-1} which was 54 and 57 percent higher during 2003 and during 2004 respectively over furrow irrigated crop.

Introduction

The pressure for the most efficient use of water for agriculture is escalating with the increased competition for water resources among various sectors with the burgeoning population. The need of the hour is therefore, to maximize the production per unit of water. This calls for adoption of modern irrigation technologies like drip irrigation, which offers efficient and judicious use of irrigation water (Antony and Singadhupe 2004). Fertigation, which combines irrigation with fertilizers, is well recognized as the most effective and convenient means of maintaining optimum fertility level and water supply to crop. Trickle fertigation is an attractive concept as it permits application of nutrients directly at the site of high concentration of active roots as needed by the crop (Bobade *et al.* 2002). Non-availability of water during summer season is one of the major constraints in attaining potential yield of this crop. Scheduling irrigation and nitrogen on the basis of crop requirement is vital for efficient management of these resources. Lady's finger (*Abelmoschus esculentus* L. Moench) okra is an important warm season vegetable cultivated in Andhra Pradesh. In Andhra Pradesh okra is cultivated in an area of 17,890 hectares producing 1,11,130 tonnes with a productivity of 6,212 kg ha^{-1} (CMIE, 2003). Adaptability to wide range of soil and climatic conditions, suitability for year round cultivation has made okra a popular vegetable.

Crop coefficient (Kc) gives the relationship between ETo and ET crop, the effect of crop characteristics and other management practices on crop water requirements and ET of a crop under optimum conditions producing maximum yields.

Material and Methods

The experiment was conducted at the students' farm, college of Agriculture, Rajendranagar, Hyderabad during summer seasons of 2003 and 2004.The experimental site is geographically situated at an altitude of 534 m above mean sea level on 17°19'N latitude and 78°28' E longitude and falls under semi arid tropical zone. The soil was sandy loam in texture, neutral in reaction, low in available nitrogen, medium in phosphorus and higher in available potassium. A total of 207.8 and 49.5 mm rainfall was received in 5 and 6 rainy days during 2003 and 2004 respectively. The class of irrigation water used was C_3S_1.

The experiment consisted of 12 treatments nts viz; I_1- Furrow irrigation at 1.00 IW /CPE ratio+ 120 kg Nha^{-1} (depth of irrigation = 50 mm), I_2 – Drip

irrigation at 0.50 Epan + 60 kg Nha^{-1}, I_3 - Drip irrigation at 0.50 Epan + 90 kg Nha^{-1}, I_4 - Drip irrigation at 0.50 Epan + 120 kg Nha^{-1}, I_5 - Drip irrigation at 0.75 Epan + 60 kg Nha^{-1}, I_6- Drip irrigation at 0.75 Epan + 90 kg Nha^{-1}, I_7- Drip irrigation at 0.75 Epan + 120 kg N ha^{-1}, I_8- Drip irrigation at 1.00 Epan + 60 kg Nha^{-1}, I_9- Drip irrigation at 1.00 Epan + 90 kg Nha^{-1} , I_{10}- Drip irrigation at 1.00 Epan +120 kg Nha^{-1}, I_{11} - Family drip system at 0.75 Epan + 120 kg Nha^{-1} and I_{12}- fertigation control (drip irrigation at 1.00 Epan + 0 kg N ha^{-1}) . In drip system laterals of 16mm diameter were laid at 1.2m apart with a spacing of 40 cm between inline emitters having a discharge of 2 l hr^{-1}. In family drip system water was applied through a tank of 1000 l capacity placed at a height of 1m to facilitate water movement by gravity and laterals of 12 mm diameter were placed at 60 cm interval with a spacing of 20 cm between inline emitters.

The crop (Mahyco Hybrid No: 10) was sown on 17th February in 2003 and on 1st February in 2004. In drip system seeds were hand dibbled along the laterals on either side at 22.5 cm along with an intra row spacing of 20 cm. Thus, the distance between 2 rows in a pair was 45 cm and between two pairs was 75 cm. The spacing adopted in furrow irrigated plots was 60 cm× 20cm.In family drip system sowing was done along the laterals which were placed at 60 cm apart with an intra row spacing of 20 cm. Immediately after sowing a surface irrigation equivalent to 50 mm was applied uniformly to all treatments .The amount of water applied was 485.8, 508.8 during 2003and 493.2, 512.3mm during 2004 in furrow and drip irrigation at 1.00 Epan, respectively. A uniform dose of 50 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied as basal in all the treatments. Nitrogen was applied in 3 equal splits through band placement in furrow and family drip system at sowing, 30DAS and 60DAS respectively. In drip irrigation system N was applied from 15 DAS upto 71DAS at 4 days interval. The amount of N applied per split was 4,6 and 8 kg ha^{-1} respectively in 60,90 and 120 kg Nha^{-1}treatments. Growth and Plant water parameters were recorded at different stages of crop growth starting from 21DAS to maturity at 21days interval. Pod yield from each net plot including the pod yield of five labeled plants was weighed and expressed in kg ha^{-1}.

Crop Coefficients (Kc)

For estimation of Kc values, the crop life was divided into Establishment (0-15 DAS), vegetative (16-35 DAS), mid season (35-59 DAS) and maturity (60-75 DAS) as per Doorenbos and Kassam (1979). The "Kc" values were calculated by the following expression.

$$Kc = \frac{\text{Water applied at 1.00 Epan through drip}}{\text{Reference crop evapotranspiration}}$$

Estimation of reference crop evapotranspiration (ETo)

Reference crop evapotranspiration (ETo) was determined by Modified Penman method (Doorenbos and Pruitt, 1977) and Hargreaves method (Hargreaves and Samani, 1982).

Results and Discussions

Crop Coefficient (Kc)

The crop coefficient values were lower during seedling stage, gradually increased with the advancement of crop age, attained the maximum value at pod development stage and declined towards maturity in both the years (Table1&2).

The lowest average Kc values of 0.40 and 0.43 were recorded at seedling stage while the maximum values of 0.74 and 0.97 were recorded at pod development stage with Hagreaves and Modified Penman method respectively. The average seasonal Kc value ranged from 0.578 to 0.524 with Hargreaves and 0.694 to 0.671 with Modified Penman method during 2003 and 2004, respectively.

There was variation in the Kc values of two seasons due to difference in the seasonal climatic conditions. The average Kc value was low during seedling stage (0-15 DAS) due to low canopy cover, indicating that major water loss may constitute evaporation from bare soil, attained maximum value at flowering to pod development stage (36-59 DAS) due to maximum water loss by greater transpiring surface as a consequence of rapid leaf development. Over the penultimate crop growth period (60-78 DAS) the value drastically reduced due to leaf senescence and loss of photosynthetic capacity. The mean values during different growth stages were 0.43, 0.97 and 0.40 in modified Penman method and 0.40, 0.74 and 0.29 in Hargreaves method.

During early stage the calculated Kc values were about the same as those given by FAO-33, but the values of mid and later stage of crop growth were slightly lower than FAO values. The differences are

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Table 1. Crop coefficients of Lady's finger at various stages of crop growth (2003)

Days after sowing	Water applied (mm) (1.00 Epan + 120 kg N ha^{-1}) (a)	Reference crop evapotranspiration (mm) (Hargreaves method) (b)	Modified penman method (mm) (c)	Crop coefficient (Kc values)		
				Hargreaves method method (a/b)	Modified Penman method (a/c)	FAO (33)
0-15 DAS	61.0	147.07	135.10	0.414	0.451	0.40
16-35 DAS	137.3	220.55	205.13	0.622	0.669	0.70
36-59 DAS	247.7	316.63	254.00	0.782	0.975	1.02
60-74 DAS	62.8	195.09	139.30	0.322	0.450	0.68
Total	508.8	879.34	733.53	0.578	0.694	2.80

Table 2. Crop coefficients of Lady's finger at various stages of crop growth (2004)

Days after sowing	Water applied (mm) (1.00 Epan + 120 kg N ha^{-1}) (a)	Reference crop evapotranspiration (mm) (Hargreaves method) (b)	Modified penman method (mm) (c)	Crop coefficient (Kc values)		
				Hargreaves method method (a/b)	Modified Penman method (a/c)	FAO (33)
0-15 DAS	50.0	127.56	123.15	0.392	0.406	0.40
16-35 DAS	149.9	259.09	212.88	0.578	0.704	0.70
36-59 DAS	252.1	358.80	260.81	0.703	0.967	1.02
60-78 DAS	60.3	231.23	166.30	0.260	0.363	0.68
Total	512.3	976.68	762.66	0.524	0.671	2.80

attributed to the local climatic conditions, more particularly sunshine hours and wind speed. Since the values reported in FAO-33 have been derived for applicability to any climatic conditions, it may not be possible to directly adopt them for tropical regions, which lie under semiarid to arid climates. Therefore the local calibration of crop coefficients is an essential step before adopting them for the estimation of irrigation water requirements (Mohan and Arumugam, 1994).

Pod yield (kg/ha)

A perusal of data on pod yield per hectare revealed that amount of irrigation and nitrogen levels significantly influenced the pod yield during both the years (Table3). In 2003, pod yield increased with increase in the level of irrigation from 0.50 Epan to 1.00 Epan. At a given level of irrigation, pod yield increased with successive increment of nitrogen and application of 120 kg N ha^{-1} at 1.00 Epan produced the highest pod yield. Drip at 0.75 Epan and fertigation either with 90 or 120 kg N ha^{-1} produced comparable yield as that of furrow irrigation. Fertigation of 60 kg N ha^{-1} at 0.75 Epan was identical to family drip system. Crop grown without fertigation recorded the lowest pod yield among all the treatments. Similar results were recorded during 2004 except that application of 120 kg N ha^{-1} did not increase the yield significantly over 90 kg N ha^{-1} at 0.75 Epan.

Data on pooled yield indicated that crop irrigated through drip at 1.00 Epan and fertigated with 120 kg N ha^{-1} produced significantly higher pod yield than other treatments. With successive increase in the nitrogen level the pod yield increased significantly at

Table 3. Total pod yield (kg ha^{-1}) as influenced by different treatments

	Treatments	Pod yield (kg/ha)		
		2003	2004	Mean yield
I_1	Furrow Irrigation at 1.00 IW/CPE ratio + 120 kg N ha^{-1}	2724	2650	2691
I_2	Drip irrigation at 0.5 Epan + 60 kg N ha^{-1}	1118	1117	1117
I_3	Drip irrigation at 0.5 Epan + 90 kg N ha^{-1}	1498	1428	1463
I_4	Drip irrigation at 0.5 Epan + 120 kg N ha^{-1}	1676	1584	1630
I_5	Drip irrigation at 0.75 Epan + 60 kg N ha^{-1}	1881	1739	1811
I_6	Drip irrigation at 0.75 Epan + 90 kg N ha^{-1}	2418	2573	2496
I_7	Drip irrigation at 0.75 Epan + 120 kg N ha^{-1}	2931	2935	2985
I_8	Drip irrigation at 1.00 Epan + 60 kg N ha^{-1}	3107	3160	3134
I_9	Drip irrigation at 1.00 Epan + 90 kg N ha^{-1}	3562	3642	3603
I_{10}	Drip irrigation at 1.00 Epan + 120 kg N ha^{-1}	4188	4153	4171
I_{11}	Family drip at 0.75 Epan + 120 kg N ha^{-1}	1597	1640	1619
I_{12}	Drip irrigation at 1.00 Epan + without fertigation	659	698	679
	S.Em ±	108	131	174
	CD (P=0.05)	318	385	345

0.75 and 1.00 Epan irrigation schedules. However, at 0.5 Epan the differences in the yield at 60 and 90 kg N ha^{-1} or 90 and 120 kg N ha^{-1} were not significant. Drip irrigation at 0.75 Epan fertigated with 90 kg N ha^{-1} was as good as furrow irrigation applied with 120 kg N ha^{-1}. Yield recorded with family drip irrigation was comparable to drip irrigation at 0.50 Epan fertigated with 120 kg N ha^{-1}. Lowest yield was recoded with crop grown without fertigation.

The increase in pod yield of the crop irrigated through drip irrigated at 1.00 Epan and fertigated with 120 kg Nha^{-1}over furrow irrigation was 54 per cent in

2003 and 57 per cent in 2004. The cyclic regulation and continuous wetting of soil through drip irrigation maintained optimum moisture in the crop root zone. Due to this the force exerted by the plant to extract water and nutrients would be less. Further, application of nutrients in more number of splits in drip fertigation resulted in minimum or no wastage of nutrients either through deep percolation or evaporation as reported by Punam horo *et al.* (2003), leading to higher uptake of nutrients. This enabled the crop to put forth better growth, yield attributes and reap bountiful yield.

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