Nitrogen and water use efficiency of bhendi (*Abelmoschus esculentus* L. Moench) as influenced by drip fertigation

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Abstract

A field study was conducted on a sandy loam soil at Rajendranagar, Hyderabad to investigate the influence of trickle fertigation on yield and resource use efficiency of bhendi during the summer seasons of 2003 and 2004. The experiment consisted of 12 treatments: three drip irrigation (0.5, 0.75 and 1.0 Epan) + three fertigation rates (60, 90 and 120 N kg ha^{-1}), furrow irrigation +120 kg N ha^{-1}, family drip system + 120 kg N ha^{-1} and a control (drip at 1.0 Epan + 0 kg N ha^{-1}) and was laid out in a randomized block design with three replications. Results show that yield and water use efficiency differed significantly among the treatments. Consistently high yields (4188 and 4153 kg ha^{-1} in 2003 and 2004 respectively) and water use efficiency (8.23 and 8.10 kg ha^{-1} mm^{-1}) were noted when the crop was drip irrigated at 1.0 Epan and fertigated with 120 kg N ha^{-1}. Higher agronomic use efficiency and agronomic use efficiency for the extra nitrogen applied were, however, observed for fertigation at 60 kg N ha^{-1}. Furrow irrigated crop showed 54% and 57% lower yield than drip irrigated at 1.0 Epan and fertigated with 120 kg N ha^{-1} during 2003 and 2004 respectively.

Keywords: Agronomic efficiency, irrigation, nitrogen, pod yield, Telangana

Introduction

Bhendi or okra (*Abelmoschus esculentus* L. Moench) is an important warm season vegetable crop of Andhra Pradesh. It is cultivated over an area of 17,890 ha and produces 1,11,130 tonnes of pods, with a productivity of 6,212 kg ha^{-1} (CMIE, 2003). Adaptability to a wide range of soil and climatic conditions and suitability for year-round cultivation has made bhendi a popular crop, especially in the semi-arid regions of the state. Non-availability of water during summer season, however, is one of the major constraints that limits productivity. Scheduling irrigation and nitrogen to optimize the utilization of these limiting resources, therefore, is of utmost importance. Drip irrigation through the trickle supply of water drops holds promise in this respect (Narda and Lubana, 1999). Trickle fertigation permits application of nutrients directly at the site of high concentration of active roots (Sivanappan et. al., 1987). Since nutrients are applied to a limited soil volume, the fertilizer use efficiency is also high. On the other hand, conventional fertilization especially on light soils may cause huge N losses through leaching and volatilization. Drip fertigation also enables accurate adjustment of water and nutrient supplies to meet the crop requirements. Taking these points into account an investigation was carried out to evaluate the effects of drip fertigation on yield, nitrogen and water use efficiency of bhendi.

Material and methods

The experiment was conducted at the students' farm, Rajendranagar, Hyderabad (17°19' N, 78°28' E and 534 m above mean sea level) during the summer seasons of 2003 and 2004. The site falls under semi-arid tropical zone with sandy loam soils, neutral in reaction, and with

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low available N, medium P and high available K levels. A total of 207.8 and 49.5 mm rainfall was received in 5 and 6 rainy days during 2003 and 2004 respectively.

The experiment consisted of 12 irrigation scheduling and N treatments (Table 1). The drip system used for the study comprised of laterals (16 mm dia) at 1.2 m apart with a spacing of 40 cm between inline emitters and having a discharge rate of 2 L hr^{-1}. In the family drip system, water from a tank (1000 L capacity; 1 m aboveground) flowing under the influence of gravity was used; laterals (12 mm dia) were at 60 cm intervals with a spacing of 20 cm between inline emitters. The class of irrigation water used was C_3S_1.

Bhendi (Mahyco Hybrid No. 10) was sown on 17 February in 2003 and on 1 February in 2004. In drip treatments, the seeds were hand-dibbled along the laterals on either side at 22.5 cm 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 the furrow irrigated plots was 60 × 20 cm. In the family drip system, sowing was done along the laterals (60 cm apart) with an intra row spacing of 20 cm. Immediately after sowing, a uniform surface irrigation equivalent to 50 mm was given to all treatments. The amount of water applied was 485.8 and 508.8 mm during 2003 and 493.2 and 512.3 mm during 2004 in furrow and drip irrigation at 1.0 Epan respectively. A uniform basal dose of 50 kg P_2O_5 and 50 kg K_2O ha^{-1} was given and N was applied in three equal splits through band placement at sowing, 30 days after sowing (DAS) and 60 DAS in furrow and family drip. But in the drip irrigation system, N was applied from 15 DAS upto 71 DAS 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 N ha^{-1} treatments. Agronomic efficiency (*AE*; partial derivative of the function relating economic yield to applied fertilizer nutrient; Yoshida et al., 1971) and agronomic efficiency for extra fertilizer nutrient increment (*AEex*) were calculated for drip irrigation treatment at 1.0 Epan and 0, 60, 90 and 120 kg ha^{-1} as given below:

$$AE = \frac{\text{Pod yield (fertilized) – Pod yield (control)}}{\text{Fertilizer applied}}$$

$$AEex = \frac{\text{Pod yield (fertilized) – Pod yield (next lower fertilizer rate)}}{\text{Extra fertilizer increment rate – Fertilizer next lower rate}}$$

Table 1. Bhendi yield (pods) and water use efficiency as influenced by different fertigation treatments at Hyderabad during 2003 and 2004

Fertigation treatments[1]	Pod yield (kg ha^{-1})			Water use efficiency (kg ha^{-1} mm^{-1})	
	2003	2004	Mean	2003	2004
Furrow irrigated at 1.0 IW/CPE ratio +120	2724	2650	2691	5.60	5.37
Drip at 0.5 Epan + 60	1118	1117	1117	3.76	4.02
Drip at 0.5 Epan + 90	1498	1428	1463	5.04	5.14
Drip at 0.5 Epan + 120	1676	1584	1630	5.64	5.70
Drip at 0.75 Epan + 60	1881	1739	1811	4.66	4.40
Drip at 0.75 Epan + 90	2418	2573	2496	5.99	6.51
Drip at 0.75 Epan + 120	2931	2935	2985	7.27	7.43
Drip at 1.0 Epan + 60	3107	3160	3134	6.10	6.16
Drip at 1.0 Epan + 90	3562	3642	3603	7.00	7.10
Drip at 1.0 Epan + 120	4188	4153	4171	8.23	8.10
Family drip at 0.75 Epan + 120	1597	1640	1619	3.96	4.15
Drip at 1.0 Epan + no fertilizer	659	698	679	1.29	1.36
SEm (+)	108	131	174	0.40	0.51
CD (0.05)	318	385	345	1.10	1.42

[1]60, 90 and 120 represent N kg ha^{-1}

Results and discussion

Irrigation and N levels exerted a consistent and significant influence on pod yield of bhendi (Table 1). Pooled data indicate that crop irrigated through drip at 1.0 Epan and fertigated with 120 kg N ha^{-1} produced significantly higher yield than other treatments (54 and 57% more than furrow irrigation in 2003 and 2004 respectively). Pod yield also increased with increasing levels of irrigation from 0.5 to 1.0 Epan. Furthermore, at a given level of irrigation, yield increased with successive additional doses of N. Drip at 0.75 Epan and fertigation either with 90 or 120 kg N ha^{-1} produced yields comparable to that of furrow irrigation; and the irrigation only (no N) treatment recorded the lowest pod yield. Application of nutrients in more number of splits in drip fertigation than furrow system may have resulted in minimum or no wastage of nutrients (Kadam et al., 1995), which explains the higher yields obtained in these treatments. Furthermore, the cyclic regulation and continuous wetting of soil associated with drip irrigation maintained optimum moisture in the crop root zone, in turn, facilitating greater water and nutrient absorption (Rajput and Patel, 2002).

Agronomic efficiency and agronomic efficiency for extra fertilizer nitrogen

Agronomic efficiency at 1.0 Epan drip irrigation declined as N levels increased from 60 to 120 kg ha^{-1} (Table 2). Agronomic efficiency was highest (40 kg pod kg N^{-1}) at 60 kg N ha^{-1}. The agronomic efficiency for extra fertilizer N also declined with increasing doses of N from 60 to 120 kg ha^{-1} (Table 2) implying progressively higher N losses with increasing N rates. Patel and Rajput (2003) also recorded higher agronomic efficiency in bhendi crop when drip-fertigated with 60% recommended dose of fertilizer (RDF) than at 80 or 100% RDF.

Water use efficiency

As expected, both irrigation and N exerted a significant influence on crop water use efficiency (WUE; Table 1). Higher water use efficiency in drip fertigation is probable as the volume of water applied through drip system roughly corresponds to the consumptive use of plants. Consistent with this, bhendi irrigated through drip at 1.0 Epan and fertigated with 120 kg N ha^{-1} recorded the highest WUE, followed by drip at 0.75 Epan and fertigated with 120 kg N ha^{-1}. Family drip system was similar to fertigation of 60 kg N ha^{-1} at 0.50 and 0.75 Epan. The lowest WUE was observed when the crop was irrigated without N fertigation. Drip irrigation at 0.75 Epan + 90 kg N ha^{-1} also was comparable to furrow irrigation (IW/CPE = 1.0) +120 kg N ha^{-1} implying a saving of 21.25% water and 25% N. Increase in water use efficiency in drip system over furrow irrigation was mainly due to the controlled water release near the crop root zone (Punamhoro et al., 2003). The favourable effect of water and N on crop growth and pod yield in drip irrigation probably resulted in higher water use efficiency (Table 1). This is consistant with the findings of Gorantiwar et al. (1991).

Overall, our results favour the use of drip irrigation scheduling at 1.0 Epan and fertigation of 120 kg N ha^{-1} for higher yield of bhendi in the semi-arid tropics of India in general and the Telangana region of Andhra Pradesh in particular.

Table 2: Agronomic efficiency and agronomic efficiency for extra fertilizers as influenced by different fertigation levels at 1.0 Epan at Hyderabad during 2003 and 2004

Treatments (N kg ha^{-1})	Agronomic efficiency (pod yield per kg N applied)		Agronomic efficiency for extra fertilizer (pod yield per kg extra N applied)	
	2003	2004	2003	2004
60	40.78	41.05	40.78	41.05
90	32.24	32.71	15.19	16.07
120	28.24	28.80	20.86	17.04

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