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RESEARCH PAPER

Evaluation of fertigation and drip irirgation on growh, yield and quality parameters of bhendi [*Abelmoschus esculentus* (L.) Moench]

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Abstract : Field experiments were carried out during the *Kharif* season in 2008 and 2009 at Eastern block farm, Tamil Nadu Agricultural University, Coimbatore, to find out Effect of drip irrigation regimes and fertigation levels on plant growth, yield parameters, quality parameters and water use efficiency of bhendi. The treatment includes two irrigation regimes in main plot and eight fertigation levels in sub plot and replicated thrice. Drip irrigation at 100% PE resulted in higher yield parameters of bhendi *viz.*, fruit length, fruit weight and fruit girth and also significantly higher fruit yield of bhendi (13,606 kg/ha) followed by irrigation at 75% PE (12,454 kg/ha). Drip fertigation at 150% RDF with P through water soluble fertilizer registered significantly higher fruit yield (14,434 and 14,711 kg/ha during 2008 and 2009, respectively). The crude protein, crude fibre, ascorbic acid and mucilage of bhendi was significantly higher under irrigation regime of 100 and fertigation at 150% RDF with P as WSF. In both the years, drip irrigation resulted in considerable saving of irrigation water besides enhancing WUE. Highest net return was realized in bhendi with M_2S_8 (Drip irrigation at 100% PE with fertigation level of 150% RDF with P as WSF) recorded a net return of Rs.2, 60,082. However, the B: C ratio was higher with drip irrigation at 100% PE along with fertigation schedule of 75% RDF with P as basal (12.88).

Key Words : Root characters, Yield, Quality parameters, Nutrient uptake, WUE, Economics

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INTRODUCTION

Bhendi or Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop and is commonly grown in India. In India, the area under okra is 0.49 million hectare producing 5.8 million tones of fruits. In Tamil Nadu, it is cultivated in an area of 5,700 ha with an annual production of 46,800 tonnes (Bijay Kumar *et al*., 2011). Adaptability to a wide range of soil and climatic conditions and suitability for year-round cultivation has made bhendi a popular vegetable crop, especially in the semi-arid regions of the State. Non-availability of water during summer season is one of the major constraints that limits the productivity. Drip fertigation permits application of nutrients directly to the site of high

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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 N losses through leaching and volatilization. Drip fertigation also enables accurate adjustment of water and nutrient supplies to meet the crop requirements and thus minimizing the loss of expensive nutrients which ultimately helps in improving productivity and quality of farm produce. Scheduling irrigation and nutrient to optimize the utilization of these limiting resources, therefore, is of utmost importance. Hence, the present experiment was conducted to optimize the irrigational requirement of bhendi.

MATERIAL AND METHODS

Field experiments were carried out during the *Kharif* season 2008 and 2009 at Eastern block farm, Tamil Nadu Agricultural University, Coimbatore. The experimental site is geographically situated in the Western agro-climatic zone of Tamil Nadu at 11° North latitude and 77° East longitude at an altitude of 427 m above MSL. The soil was sandy clay loam in texture with low organic carbon (0.32%) status, available nitrogen (220 kg/ha), medium in available phosphorus (17 kg/ha) and high in available potassium (425 kg/ha). The experiment was laid out in split plot design with three replications. The treatments comprised of two irrigation regimes *viz.,* M_1 - Irrigation through drip at 75% PE once in 3 days, M_2 - Irrigation through drip at 100% PE once in 3 days in main plot and eight fertigation levels *viz.,* S_1 - Drip fertigation with 75% RDF (P as basal), S_2 - Drip fertigation with 100% RDF (P as basal), S_3 - Drip fertigation with 125% RDF (P as basal), S_4 - Drip fertigation with 150% RDF (P as basal), S_5 - Drip fertigation with 75% RDF with P through WSF (17:44:0), S_6 - Drip fertigation with 100% RDF with P through WSF (17:44:0), S_7 - Drip fertigation with 125% RDF with P through WSF (17:44:0) and S_8 - Drip fertigation with 150% RDF with P through WSF (17:44:0) in sub plot. Control plots with surface irrigation at 0.75 IW / CPE ratio with soil application of 100% RDF were maintained separately for comparison. The recommended dose of fertilizer (200: 100: 100 kg NPK/ ha) was applied. For the treatments S_1 to S_4, P was applied as basal in the form of single super phosphate and N and K through drip fertigation as urea and muriate of potash, respectively. For the treatments S_5 to S_8, P was applied through drip fertigation using 17:44:0 WSF grade (urea phosphate). Over and above the N supplied by 17:44:0 grade, the rest of the N was applied using urea as 'N' source. For surface irrigation treatments, irrigation was given after sowing followed by life irrigation at 5 cm depth there after irrigation was given as per the IW/CPE ratio of 0.75 for bhendi. The recommended doses of 50,100 and 50% of NPK fertilizers were applied as basal. Remaining 50% N and K were applied at 30 days after sowing (DAS). The bhendi hybrid (M -10) was sown in February month during both the years with the spacing of 60 x 45 cm. Seeds were sown @ 1 - 2 seeds /hill. Gap filling was done one week after sowing with the reserved seeds of the same variety. Thinning was done 10 DAS. Recommended pre emergence herbicide of Pendimethalin was sprayed on 3 DAS with one hand weeding on 30 DAS. Appropriate prophylactic plant protection measures were taken to keep the crop free from the pest and diseases. Growth and yield parameters were recorded as per standard procedures. Economics was calculated based on the input and output costs. All the observations were statistically analsized for its test of significance in the individual years and pooled over through standard procedure.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads :

Growth parameters :

The data pertaining to growth and development of bhendi recorded in two year pooled data are given in Table 1. Different levels of irrigation regimes and fertigation levels significantly influenced plant height, rooting depth, root volume and root biomass. Higher values of plant growth parameters were recorded by crops irrigated through drip at 100% PE and was followed by drip irrigation at 75% PE. Drip irrigation at 150% with P as WSF resulted in higher values of plant height. Similar findings were also reported by Hebbar *et al.,* (2004).

The root characters like root length, root volume and root biomass were significantly affected by drip irrigation regimes and fertigation levels in bhendi. The highest root depth (51.3 cm), root volume (81.8 cm^3) and root biomass (24.1g/plant) was recorded under drip irrigation at 100% PE which led to with more adventitious roots due to higher availability of moisture. Surface

irrigation at 0.75 IW/CPE resulted in lower root growth and development. Among the fertigation treatments, 150 and 125% RDF with P as WSF level resulted in higher root parameters (Table 1). Adequate quantity of nutrients coupled with adequate moisture might have resulted in higher root proliferation. The frequent application of irrigation through drip at optimum level maintained most of the root zone with well aerated condition and adequate soil moisture content that did not fluctuate between wet and dry extremes. The similar finding was reported by Patil and Janawade, 1999.

Yield parameters and yield :

The yield parameters of bhendi were significantly influenced by both irrigation as well as fertilizer levels. Among the irrigation regimes, drip irrigation at 100% PE produced the lengthier fruit of 18.7 cm followed by drip irrigation at 75% PE. Surface irrigation recorded a fruit length 15.3 cm and fruit girth of 4.38 cm. During both the years, the crop that received drip fertigation at 150% RDF with P as WSF had lengthiest fruit (20.3 cm), followed by drip fertigation at 125% RDF with P as WSF (Table 1).

Drip irrigation at 100% PE recorded significantly higher fruit yield (13606 and 13820 kg/ha) of bhendi as compared to 75% irrigation regime (12454 and 12583 kg/ha) in both year. The yield increase observed under 100% irrigation regime was 9.3 and 9.8% than 75% PE during 2008 and 2009, respectively. The increase in yield might be due to better proportion of air-soil-water which was maintained throughout the life period of crop in drip irrigation as compared to surface irrigation as reported by Kadam and Karthikeyan (2006).The yield increase under drip fertigation at 150% RDF with P as WSF was 17% and 16% in 2008 and 2009, respectively over 100% RDF with P as basal application. Fertigation with higher rates of fertilizer resulted in higher availability of required nutrients in soil solution which obviously led to better photo assimilation and better translocation of assimilates from source to sink which in turn increased the fruit yield as reported by Storie *et al*., 1995. No significant difference was observed between irrigation regimes and fertigation levels.

Quality parameters :

Drip irrigation regimes and fertilizer levels exerted

Table 1 Effect of irrigation regimes and fertigation levels on growth, yield parameters and yield of bhendi (based on pooled mean of 2 years)

Treatments	Plant height at harvest (cm)	Rooting depth (cm)	Root volume (cm^3)	Root biomass (g/ plant)	Fruit length (cm)	Fresh fruit weight (g)	Fruit girth (cm)	Fruit yield (kg/ha) 2008	2009
Irrigation regimes									
M_1 - Irrigation through drip at 75% PE once in 3 days	102.2	46.8	77.9	19.9	17.5	21.5	5.61	12454	12583
M_2 - Irrigation through drip at 100% PE once in 3 days	110.0	51.3	81.8	24.1	18.7	21.9	5.86	13606	13820
Surface irrigation at 0.75 IW / CPE	89.7	27.5	71.2	27.7	15.3	14.4	4.38	9580	9987
S.E.±	0.3	0.2	0.1	0.1	0.1	0.2	0.1	108	52
C.D. (P=0.05)	1.5	1.3	1.2	0.46	0.9	NS	NS	353	159
Fertigation levels									
S_1 – 75 % RDF + P Basal	98.4	43.3	75.7	17.7	16.4	18.7	4.99	11984	12153
S_2 – 100 % RDF + P Basal	102.3	45.5	77.5	18.8	17.2	20.0	5.32	12325	12576
S_3 – 125 % RDF + P Basal	106.9	48.2	79.5	21.7	17.8	21.3	5.56	12597	12862
S_4 – 150 % RDF + P Basal	110.4	50.4	81.0	23.0	18.8	22.8	5.93	13125	13030
S_5 – 75 % RDF + P WSF	102.6	48.6	78.6	20.8	17.5	20.9	5.60	12825	13103
S_6 – 100 % RDF + P WSF	106.4	50.1	79.8	23.2	18.1	21.6	5.81	13221	13396
S_7 – 125 % RDF + P WSF	108.9	52.4	81.6	24.3	18.9	23.2	6.19	13734	13780
S_8 – 150 % RDF + P WSF	112.9	54.0	85.1	26.7	20.3	25.0	6.52	14434	14711
S.E.±	1.4	0.4	1.3	0.1	0.1	0.4	0.10	165	115
C.D. (P=0.05)	4.0	0.9	3.9	0.4	NS	1.0	NS	477	315

NS= Non-significant

their significant influence on the quality parameters of bhendi *viz*., crude protein, crude fibre, ascorbic acid and mucilage. The crude protein content in bhendi fruit was found to be significantly high in drip irrigation of 100% PE as compared to surface irrigation at 0.75 IW/CPE (Table 2). Application of fertilizer dose of 150% RDF with P as WSF resulted in higher protein content, crude fibre and mucilage per cent and 75% RDF with drip fertigation resulted in lower protein content in bhendi. Among the fertilizer levels, increasing the fertilizer doses increased the content of the quality parameters. Fertigation given at 75% RDF through drip resulted in higher content of ascorbic acid, which was significantly higher in 125% RDF with P as basal followed by 125% fertigation level followed by 150% of RDF with P as basal. These were in conformity with findings of Kavitha *et al*., 2007.

Nutrient upatake :

Significantly maximum uptake of nutrients (NPK) were observed under drip irrigation regime of 100% PE followed by 75% PE (Table 2). Drip irrigation at 100% PE recorded highest N uptake (101.9 kg/ha) followed by drip fertigation at 75% PE. Both irrigation regimes recorded higher NPK uptake in both years as compared to surface method of irrigation. The NPK uptake of bhendi crop showed a marked difference among different levels of fertigation. Drip fertigation at 150% of RDF with P as water soluble fertilizer registered higher NPK uptake of 104.1, 20.5 and 73.7 kg/ ha followed by 125% RDF with P through WSF. Drip fertigation has helped the plants to utilize the nutrients from the rhizosphere more efficiently in comparison to drip or conventional methods which also improves the availability of nutrients, slowly, steadily and in suitable proportions, the crop has taken up all the three macronutrients more efficiently which resulted in progressive growth changes in the crop. The similar results have been reported by Tumbare and Nikam, 2004 and Sundar Raman *et al.* (2000).

Water use efficiency and economics :

Different drip irrigation regimes and fertilizer levels exerted significant difference on water use efficiency (WUE) of bhendi. For bhendi, irrigation given through drip at the rate of 75% PE recorded significantly the higher WUE followed by irrigation at 100% PE (Table

Table 2 : Effect of irrigation regimes and fertigation levels on quality parameters and nutrient uptake (kg/ha) of bhendi (based on pooled mean of 2 years)

Treatments	Crude protein content (%)	Crude fibre (%)	Ascorbic acid (mg/100g)	Mucilage (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)
Irrigation regimes							
M_1 - Irrigation through drip at 75% PE once in 3 days	2.13	15.50	11.9	1.29	96.4	17.2	64.8
M_2 - Irrigation through drip at 100% PE once in 3 days	2.37	16.10	12.6	1.42	101.9	19.1	71.9
Surface irrigation at 0.75 IW / CPE	1.47	15.29	11.1	1.00	93.1	12.3	58.8
S.E.±	0.01	0.07	0.03	0.002	0.07	0.03	0.05
C.D. (P=0.05)	0.03	0.30	0.18	0.015	0.40	0.20	0.34
Fertigation levels							
S_1 – 75 % RDF + P Basal	1.98	15.3	12.0	1.26	94.8	15.6	67.6
S_2 – 100 % RDF + P Basal	2.08	15.5	12.1	1.30	96.8	17.0	69.0
S_3 – 125 % RDF + P Basal	2.22	15.7	12.2	1.34	99.1	18.4	70.4
S_4 – 150 % RDF + P Basal	2.30	16.0	12.3	1.39	100.8	19.5	71.6
S_5 – 75 % RDF + P WSF	2.23	15.7	12.1	1.33	96.7	16.1	69.4
S_6 – 100 % RDF + P WSF	2.31	15.8	12.2	1.37	99.0	18.3	71.1
S_7 – 125 % RDF + P WSF	2.38	16.2	12.4	1.40	101.9	19.7	72.1
S_8 – 150 % RDF + P WSF	2.51	16.3	12.4	1.44	104.1	20.5	73.7
S.E.±	0.04	0.3	0.2	0.02	0.1	0.1	0.1
C.D. (P=0.05)	0.10	0.8	NS	0.06	0.3	0.3	0.3

NS=Non-significant

Table 3 : Effect of drip irrigation regimes and fertigation levels on WUE and economics of bhendi (based on pooled mean of 2 years)

Treatments	WUE (kg/ha/mm)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio
$M_1 S_1$	33.1	231000	211449	11.82
$M_1 S_2$	34.7	241590	218748	10.58
$M_1 S_3$	35.7	248670	224054	10.11
$M_1 S_4$	37.2	259070	229421	8.74
$M_1 S_5$	34.4	239750	208812	7.75
$M_1 S_6$	35.3	246280	209464	6.69
$M_1 S_7$	37.5	261220	219111	6.21
$M_1 S_8$	39.5	275400	227992	5.81
$M_2 S_1$	30.1	251730	232179	12.88
$M_2 S_2$	30.6	256430	233588	11.23
$M_2 S_3$	31.1	260500	235884	10.58
$M_2 S_4$	31.5	254030	224381	8.57
$M_2 S_5$	33.3	278810	247872	9.01
$M_2 S_6$	34.2	286050	249234	7.77
$M_2 S_7$	34.5	289050	246941	6.87
$M_2 S_8$	36.7	307490	260082	6.49
SI	20.0	195670	172828	8.57

3). Similar findings of water saving and WUE was observed by Bobade *et al.* (2002). The lower WUE under surface irrigation (20.0 kg/ha/mm) might be due to higher consumption of water and lower yield recorded by the treatment. Increase in irrigation amount did not increase the marketable yield of crops but reduced the irrigation production efficiency significantly (Imtiyaz *et al.,* 2000). Soil moisture regime could increase the WUE upto a certain level, but it tends to decline thereafter. The increase in WUE in all drip irrigated treatments over surface irrigation was mainly due to considerable saving of irrigation water, greater increase in yield of crops and higher nutrient use efficiency. Among the fertilizer levels, 150% RDF with P as WSF through drip resulted in significantly higher WUE (39.5 kg/ha/mm), followed by 125% RDF P as basal. Fertigation at the rate of 75% RDF and soil application of 100% RDF with drip irrigation recorded the lowest WUE and both were significantly on par with each other. During both the years of study highest net return was realized in bhendi with drip irrigation at 100% PE and fertigation level of 150% RDF with P as WSF recorded a net return of Rs. 2,60,082/-. However, the B:C ratio of 12.88 was recorded with drip irrigation at 100% PE along with fertigation schedule of 75% RDF with P as basal.

The present study concluded that drip irrigation at 100% PE with fertigation level of 150% RDF with P as water soluble fertilizer could enhance the productivity of bhendi. But, considering the high cost of water soluble fertilizers, drip irrigation at 100% PE with fertigation level of 125% RDF with P as basal could be an alternative option to realize a reasonably good yield in bhendi.

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