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Effect of micro-irrigation systems and fertilizer levels on growth and yield of green chilli (*Capsicum annuum*)

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ABSTRACT : A field experiment was conducted at A.I.C.R.P. on Water Management Dapoli Centre in lateritic soils of Konkan region of Maharashtra during the year 2007 to 2010, to study the effect of micro-irrigation methods and fertilizer levels on growth and yield of green chilli. The experiment was laid out in Factorial Randomized Block Design with nine treatments and three replications. The results revealed that, the growth parameters showed non significant effect with imposed irrigation treatments. In case of yield, the micro sprinkler irrigation at 100 per cent PE with 100 per cent recommended dose of fertilizer (150:50:50 NPK) recorded maximum green chilli yield of 118.23 q-ha^{-1} as compared to all other treatments. The effect of irrigation levels was found to be significant and maximum yield (132.32 q-ha^{-1}) of chilli was reported in I_1 treatment, whereas minimum yield (90.6 q ha^{-1}) was reported in I_3 treatment. The fertilizer levels also showed significant results with maximum yield of 116.7 q ha^{-1} under F_1 treatment and minimum yield of 104.72 q-ha^{-1} in F_3 treatment. The water use efficiency ranged between 62 kg ha-cm^{-1} to 272 kg ha-cm^{-1}. Higher water use efficiency (272 kg ha-cm^{-1}) was found with micro sprinkler at 100 per cent PE with recommended dose of fertilizers. The B:C ratio was 3.06 in micro-sprinkler at 100 per cent PE with 100 per cent recommended dose of fertilizers. This indicates that, micro-sprinkler irrigation is superior for growing chilli in lateritic soils of Konkan region of Maharashtra.

KEY WORDS : Chilli, Micro-irrigation methods, Growth and yield, Water use efficiency, Fertilizer use efficiency

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The total area under irrigation in Maharashtra state is only 18.5 per cent and it is estimated that after full development of water resources the irrigated area in the state may not exceed 30 per cent with the adoption of conventional surface irrigation methods. Bringing more area under irrigation will largely depend on the efficiency of water use. In this context, micro-irrigation has to play a very significant role to achieve not only higher productivity and water use efficiency but also have sustainability. The micro-irrigation system keeps the soil moisture near to field capacity and this system also increases fertilizer use efficiency after avoiding losses through leaching, volatilization and fixing of nutrient in the soil (Nakayama and Bucks, 1986). Micro-irrigation is the major component in adoption of precision agriculture. Maharashtra has largest area under micro-irrigation. The work carried out by Shinde *et al.* (2004) on effect of micro-irrigation system and nitrogen levels on growth and yield of chilli under lateritic soils of Konkan region shows that, the micro jet irrigation supplemented with 100 kg N ha^{-1} could be used for nitrogen saving, higher water use eficiciency and higher green chilli yield. Also the work carried out by Muralikrishnasamy *et al*. (2008) on drip irrigation and fertigation in chillies showed that, drip irrigation at 50 per cent PE along with fertigation of recommended level of N and K resulted in higher yield and water saving compared with surface irrigation. A very meagre work has been carried on micro-irrigation under lateritic soils of Konkan region of Maharashtra.

Chilli is an important vegetable cum condiment. It is called as red pepper/hot pepper. A number of verities are grown for vegetables, spices, condiments, sauce and pickles. Chilli is source of vitamins, especially in vitamins A and C. It has many medicinal properties. India produces about 1.3 million tones of chillies from an area of 0.806 million hectares with an average productivity of 16.11 t ha^{-1}. India contributes one

fourth of the total quantity of chilli exported in the world. Thus, an attempt was made to study the effect of micro irrigation systems and fertilizer levels on growth and yield of chilli (*Capsicum annuum*) in lateritic soil of Konkan region of Maharashtra.

METHODOLOGY

A field experiment was carried at All India Co-ordinated Research Project on Water Management, Dapoli centre, in lateritic soils of Konkan region of Maharashtra in *Rabi* seasons during the years 2007 to 2010. The soil was sandy clay loam with pH 5.5, very high in organic carbon content (18.45 g kg^{-1}), low in available nitrogen content (232 kg ha^{-1}), very low in available phosphorous content (6.11 kg ha^{-1}) and very high in available potassium content (369.6 kg ha^{-1}). The experiment was laid in factorial randomized block design with nine treatments and three replications. Three irrigation methods *viz.*, drip (S_1), micro-sprinkler(S_2) and ridges and furrows (S_3) as control and three irrigation levels 1.0 PE, 0.8 PE and 0.6 PE *i.e.* I_1, I_2 and I_3, respectively, were applied to the crop during the entire growing seasons. Three fertilizer levels *viz.*, 100 per cent, 80 per cent, and 60 per cent *i.e.* F_1, F_2, F_3, respectively, of recommended dose (150:50:50, N:P:K) were applied to the crop. The net plot size was 4.8 m x 3.6 m. The chilli seedlings of variety Konkan kirti were transplanted in third week of December every year. The normal plant spacing 60 cm x 60 cm was followed in ridges –furrows and in micro-sprinkler irrigation. For drip irrigation system paired row planting pattern was used with spacing of 45 cm x 90 cm x 45 cm. The discharge of micro-sprinkler was 36 LPH with spacing between two micro-sprinklers was 1.5 m. The discharge of dripper was 4 LPH with spacing between two drippers was 60 cm. The pre-transplantation irrigation of 6 cm depth was applied to all plots irrespective of the treatments during each year. The treatment wise schedule was followed after 15 days of transplanting. Due care was taken while irrigating with micro-sprinkler to avoid the effect on pollination. The recommended plant protection measures were taken during the crop growth. The yield was recorded in six pickings and data were analyzed statistically.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Irrigation requirement:

The experiment on chilli crop was undertaken during *Rabi* seasons of 2006-07 to 2009-10 to determine the irrigation requirement for maximizing the productivity. The irrigation water applied during each growing season their means and percentage of water saving under each treatment of micro-irrigation over furrow irrigation method are presented in Table 1.

The amount of irrigation water applied to chilli crop varied with the evaporation during each season. The average irrigation water applied under furrow irrigation system was 114 ha-cm, while the irrigation mean water applied through micro-irrigation ranged from 36.7 ha-cm to 61.14 ha-cm during crop seasons. Thus, water saving under micro-irrigation system ranging from 46.4 per cent to 67.81 per cent was observed over water applied though furrow irrigation method (Table 1).

Yield of green chilli:

The data pertaining to green chilli yield were recorded in each season under various treatment combinations and the results of pooled analysis are presented in Table 2.

The individual effects of the irrigation methods and levels of irrigation and fertigation were found significant during all the three growing seasons of year 2006-07 to 2009-10 (Table 2). Among the treatments of irrigation methods, irrigation and fertilizer levels, the irrigation levels were found to be most influencing treatment.

Effect of irrigation methods:

The irrigation methods also significantly influenced the green chilli yield. From pooled mean of three years data it is observed that, the treatment S_2 (micro-sprinkler) had produced significantly higher green chilli yield of 118.23 q ha^{-1} as compared to S_1 and S_3. Increased yield indicated that the application of water to chilli crop through micro-sprinkler can be more effective in producing the micro-climate as well as meeting out the water requirement of crop, which might have helped the crop in keeping healthy throughout the crop season.

Effect of fertilizer level on yield:

The fertilizer levels significantly influenced the green chilli yield with the consistant and maximum yield 116.70 q ha^{-1} with 100 per cent recommended doze of fertilizers (F_1) as

Table 1 : Total depth of water applied for different irrigation levels

Sr. No.	Irrigation level	Depth of water applied (ha-cm)				Saving in water (per cent) over control
		2006-07	2007-08	2009-10	Mean	
1.	I_1= 1.0 PE	61	70.1	52.32	61.14	46.37
2.	I_2= 0.8 PE	48.8	56.1	41.85	48.91	57.10
3.	I_3= 0.6 PE	36.6	42.1	31.4	36.7	67.81
4.	Control	126	114	102	114	-

Table 2 : Effect of irrigation methods, irrigation levels and fertilizer levels on yield of green chilli (q/ha) from 2006-07 to 2009-10

Treatments	Green chili yield (q/ha)			
	2006-07	2007-08	2009-10	Mean
Irrigation methods				
S_1= Drip	104.7	104.6	98.3	102.53
S_2=Micro-sprinkler	119.9	120.5	114.3	118.23
Control	80.0	79.6	79.10	9.57
S.E. ±	2.66	2.51	1.83	0.43
C.D. (P=0.05)	7.59	7.17	5.22	2.62
Irrigation levels				
I_1= PE x 1.0	135.1	131.7	130.16	132.32
I_2= PE x 0.8	112.7	109.8	102.81	108.43
I_3= PE x 0.6	90.2	96.03	85.86	90.69
S.E. ±	3.25	3.07	2.24	0.54
C.D. (P=0.05)	9.3	8.79	6.4	3.26
Fertilizer levels				
F_1=100 per cent RDF	118.8	117.0	114.31	116.70
F_2=80 per cent RDF	110.5	115.3	103.14	109.64
F_3=60 per cent RDF	107.5	105.3	101.38	104.72
S.E. ±	3.25	3.07	2.24	0.54
C.D. (P=0.05)	9.3	8.79	6.4	3.29
Interaction effects				
Irrigation levels x Fertilizer levels				
S.E. ±	5.63	5.32	3.88	
C.D. (P=0.05)	16.11	NS	NS	NS
Irrigation levels x Irrigation methods				
S.E. ±	4.60	4.35	3.17	
C.D. (P=0.05)	NS	NS	9.05	NS
Fertilizer levels x Irrigation method				
S.E. ±	4.60	4.35	3.17	
C.D. (P=0.05)	NS	NS	NS	NS

NS=Non-significant

compared to the rest of the treatments and was significantly superior over F_2 and F_3 treatments.

Effect of irrigation levels on yield:

The different levels of irrigation shown significant effect on yield of green chilli. The treatment I_1 (1.0 PE) had produced highest and significant yield of 132.82 q ha^{-1} over the treatment I_2 and I_3.

Interaction effect on yield:

The average yield of chilli showed non-significant effect due to interaction of irrigation and fertilizer levels, methods of irrigation and fertilizer levels, methods of irrigation and irrigation levels.

Water use efficiency:

The water use efficiency is the ratio of yield obtained in a particular treatment to the depth of water applied. From Table 3, it is observed that the maximum water use efficiency was in treatment $S_2I_1F_1$ (272 kg ha-cm^{-1}) followed by $S_2I_3F_1$ (268 kg ha-cm^{-1}). The minimum water use efficiency of 62 kg ha-$cm^{-1}$was found in control (furrow irrigation). This indicates that the irrigation frequency also plays important role in improving the yield. The results also revealed that the water use efficiency in micro-sprinkler was more than 3.5 folds as in the furrow irrigation.

From Table 3, the maximum fertilizer use efficiency (81.13) was observed in treatment $S_2I_1F_3$ followed by treatment $S_1I_1F_3$ (79.60). The fertilizer use efficiency for S_3F_1 treatment was 34.04.

Economics:

The details of economics of chilli crop was worked out. The benefit cost ratio under various treatment combinations is reported in Table 4. The maximum benefit cost ratio of 3.06 was observed under micro-sprinkler irrigation at 1.0 PE with

Table 3 : Water use efficiency for various treatment combinations (Average of 2006-07, 2007-08 and 2009-10)

Treatments	Yield (q ha^{-1})	Depth of water (cm)	Fertilizer used (q ha^{-1})	Water use efficiency (kg ha-cm^{-1})	Fertilizer use efficiency
$S_1I_1F_1$	127.87	61.14	2.5	209.0	51.15
$S_1I_1F_2$	114.03	61.14	2.0	187.0	57.02
$S_1I_1F_3$	119.4	61.14	1.5	195.0	79.60
$S_1I_2F_1$	104.13	48.91	2.5	213.0	41.65
$S_1I_2F_2$	101.0	48.91	2.0	206.0	50.50
$S_1I_2F_3$	96.37	48.91	1.5	197.0	64.25
$S_1I_3F_1$	85.17	36.70	2.5	232.0	34.07
$S_1I_3F_2$	88.9	36.70	2.0	242.0	44.45
$S_1I_3F_3$	85.73	36.70	1.5	234.0	57.15
$S_2I_1F_1$	166.37	61.14	2.5	272.0	66.55
$S_2I_1F_2$	144.73	61.14	2.0	237.0	72.37
$S_2I_1F_3$	121.7	61.14	1.5	199.0	81.13
$S_2I_2F_1$	118.27	48.91	2.5	242.0	47.31
$S_2I_2F_2$	119.07	48.91	2.0	243.0	59.54
$S_2I_2F_3$	108.97	48.91	1.5	223.0	72.65
$S_2I_3F_1$	98.4	36.70	2.5	268.0	39.36
$S_2I_3F_2$	90.33	36.70	2.0	246.0	45.17
$S_2I_3F_3$	96.03	36.70	1.5	262.0	64.02
S_3 F_1	85.1	114	2.5	75.0	34.04
S_3 F_2	82.83	114	2.0	73.0	41.42
S_3 F_3	70.77	114	1.5	62.0	47.18

Table 4 : Cost economics for different treatment combinations for chilli crop

Sr. No.	Particulars	S_2 I_1F_1	$S_2I_1F_2$	$S_2I_1F_3$	$S_2I_2F_1$	$S_2I_2F_2$	$S_2I_2F_3$	$S_2I_3F_1$	$S_2I_3F_2$	$S_2I_3F_3$	Control
1.	Seasonal fixed cost	17465	17465	17465	17465	17465	17465	17465	17465	17465	
2a	Variable cost (Rs ha^{-1})	26800	26800	26800	26800	26800	26800	26800	26800	26800	28800
2b	Fertilizer cost (Rs ha^{-1})	61501	51271	41037	61501	51271	41037	61501	51271	41037	51271
2c	Irrigation water (Rs ha^{-1})	864	864	864	1296	1296	1296	1556	1556	1556	2700
2d	Total variable cost	89165	78935	68701	89597	79367	69133	89857	79627	69393	82771
2e	Interest on working capital	2674.95	2368.05	2061.03	2687.91	2381.01	2073.99	2695.71	2388.81	2081.79	2483.13
2f	Rental value Rs. 1000 ha^{-1}	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
2g.	Total operating cost per season	92839.95	82303.05	71762.03	93284.91	82748.01	72206.99	93552.71	83015.81	72474.79	86254.13
3.	Cost of production (Rs ha^{-1})	110304.95	99768.05	89227.03	110749.9	100213.01	89671.99	111017.71	100480.81	89939.79	86254.13
4.	Yield (q ha^{-1})	168.8	133.6	126.2	114.8	110.3	103.1	94.1	86.8	90.7	79.03
5.	Selling price (Rs ha^{-1})	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
6.	Gross monetary returns	337600	267200	252400	229600	220600	206200	188200	173600	181400	158060
7.	Net income (Rs ha^{-1})	227295.05	167431.95	163173	118850.1	120386.99	116528.01	77182.29	73119.19	91460.21	71805.87
8.	B : C ratio	3.06	2.68	2.83	2.07	2.20	2.30	1.70	1.73	2.02	1.83

Table 4 contd.……

Contd.…Table 4 ……..

Sr. No.	Particulars	$S_1I_1F_1$	$S_1I_1F_2$	$S_1I_1F_3$	$S_1I_2F_1$	$S_1I_2F_2$	$S_1I_2F_3$	$S_1I_3F_1$	$S_1I_3F_2$	$S_1I_3F_3$
1.	Seasonal fixed cost	13615	13615	13615	13615	13615	13615	13615	13615	13615
2a.	Variable cost (Rs ha^{-1})	26800	26800	26800	26800	26800	26800	26800	26800	26800
2b.	Fertilizer cost (Rs ha^{-1})	61501	51271	41037	61501	51271	41037	61501	51271	41037
2c.	Irrigation water (Rs ha^{-1})	864	864	864	1296	1296	1296	1556	1556	1556
2d.	Total variable cost	89165	78935	68701	89597	79367	69133	89857	79627	69393
2e.	Interest on working capital	2674.95	2368.05	2061.03	2687.91	2381.01	2073.99	2695.71	2388.81	2081.79
2f.	Rental value Rs. 1000 ha^{-1}	1000	1000	1000	1000	1000	1000	1000	1000	1000
2g.	Total operating cost per season	92839.95	82303.05	71762.03	93284.91	82748.01	72206.99	93552.71	83015.81	72474.79
3.	Cost of production (Rs ha^{-1})	106454.95	95918.05	85377.03	106899.9	96363.01	85821.99	107167.71	96630.81	86089.79
4.	Yield (q ha^{-1})	125.8	109.2	117.3	97.8	97.4	93.5	84.5	81.6	77.5
5.	Selling price (Rs ha^{-1})	2000	2000	2000	2000	2000	2000	2000	2000	2000
6.	Gross monetary returns	251600	218400	234600	195600	194800	187000	169000	163200	155000
7.	Net income (Rs ha^{-1})	145145.05	122481.95	149223	88700.09	98436.99	101178.01	61832.29	66569.19	68910.21
8.	B: C ratio	2.36	2.28	2.75	1.83	2.02	2.18	1.58	1.69	1.80

100 per cent recommended dose of fertilizer ($S_2I_1F_1$ treatment). The maximum net monetary returns of Rs 2.27 lakhs ha^{-1} was observed in $S_2I_1F_1$ treatment and minimum net monetary returns of Rs. 61832/- was observed in drip irrigation at 0.6 PE under recommended dose of fertilizer ($S_1I_3F_1$ treatment).

Conclusion:

– Total water requirement for growing chilli in Konkan region was found to be 61.14 ha-cm using micro-sprinkler.

– To achieve the average maximum yield of green chilli in Konkan region, the water should be delivered through micro-sprinkler irrigation at 1.0 PE with 100 per cent recommended fertilizer dose.

– If fertilizer is the main constraint, one should go for growing the chilli with the use of drip irrigation, water delivered at 1.0 PE and fertilizer application at 60 per cent RDF. However, the yield may reduce to about 27 per cent of the maximum achievable yield.

– The maximum benefit cost ratio of 3.06 was observed under micro-sprinkler irrigation at 1.0 PE with 100 per cent recommended dose of fertilizer ($S_2I_1F_1$ treatment).

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