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International Journal of Agricultural Sciences ☞ DOI:10.15740/HAS/IJAS/17-AAEBSSD/215-221
Volume 17 | AAEBSSD | 2021 | 215-221 ■ ISSN : 0973-130X Visit us : www.researchjournal.co.in

RESEARCH PAPER

Response of chilli to drip irrigation on sandy clay loam soil under Madukkur soil series (*Typic ustropept*) in cauvery New Delta Zone

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Abstract : In Tamil Nadu, one of the most important agro-climatic zone dictating the total rice production is by Cauvery Delta zone. In Cauvery Delta zone the area under rice cultivation has been reduced drastically and this situation forms the base for a paradigm shift from rice cultivation to alternate crops that requires less amount of irrigation water. Suitable alternate cropping pattern plays an important role in improving the purchasing power of farmer with the help of inclusion of commercial crops in rice based cropping system. Chilli is an important spice cum vegetable crop cultivated extensively in India. This project is indented to study the fertigation system in one of promising alternate crops in chillies in rice ecosystem. By keeping all these points in view, the present investigation was undertaken to study the response of chilli to drip irrigation on sandy clay loam soil under Madukkur soil series (*Typic Ustropept*) in cauvery new delta zone. Field experiment was conducted at Soil and Water Management Research Institute, Kattuthottam, Thanjavur financially supported by Department of Science and Technology under SERB programme with a budget outlay of Rs. 13.0 lakhs for three years during 2012-2015 in strip plot design with four replications. The results revealed that Sub surface drip fertigation at 10 cm depth recorded the maximum plant height, number of branches, number of flowers and number of fruits at B_2 irrigation regime (IW/CPE = 0.75). Total green chillies yield was higher under sub surface drip fertigation @ 10 cm depth at IW/CPE=1 (15.59 t ha^{-1}) followed by surface drip fertigation at IW/CPE = 0.75 (13.50 t ha^{-1}) and sub surface drip fertigation @ 10 cm depth at IW/CPE = 0.75 (11.17 t ha^{-1}).Thus, introduction of chillies as an alternate crop under sub surface drip fertigation @ 10 cm depth technology during January under Broad bed furrow method of cultivation paves the way for improving the social security to the rice farmers.

Key Words : Chilli, Sub surface drip fertigation, Madukkur soil series, Cauvery New Delta Zone

View Point Article : Suganya, S. (2021). Response of chilli to drip irrigation on sandy clay loam soil under Madukkur soil series (*Typic ustropept*) in cauvery New Delta Zone. *Internat. J. agric. Sci.*, **17** (AAEBSSD) : 215-221, **DOI:10.15740/HAS/IJAS/17-AAEBSSD/215-221.** Copyright@2021: Hind Agri-Horticultural Society.

Article History : Received : 27.07.2021; **Revised :** 30.07.2021; **Accepted :** 01.08.2021

INTRODUCTION

In Tamil Nadu Rice is primarily grown under submerged condition in river command areas. One of the most important agro climatic zones dictating the total rice production of the state is by Cauvery Delta zone. In Cauvery Delta zone rice is being cultivated to an extent of 4.5 lakh ha as per the latest statistics available. This

area has been reduced from 6 to 8 lakh ha over a period of 10 to 15 years as a direct consequence of declining water availability in river cauvery in conjunction with water dispute between the states of Tamil Nadu and Karnataka. This situation forms the base for a paradigm shift from rice cultivation to alternate crops that requires less amount of irrigation water. In addition to the yield, Sustainability alternate cropping pattern plays an important role in improving the purchasing power of farmer with the help of inclusion of commercial crops in rice based cropping system. Chilli (*Capsicum annuum L.*) is an important spice cum vegetable crop cultivated extensively in India. India contributes one fourth of world's population of chilli. In India, chilli is mainly grown in Andhra Pradesh, Karnataka, Tamil Nadu and Orissa. In recent years, apart from export of dry chilli, value added products *viz.,* the chilli powder and also the oleoresin are exported. Even for a garden land crop there is no guarantee that irrigation water in conjunction with rainfall is sufficient enough to innovative method of irrigation which improves productivity of crops with limited availability of water, providing the social security forthe resource poor rice farmers.

Most of the water use in India is for irrigation amounting to 94 per cent of total withdrawal. With increasing population, urbanization and contagious depletion of natural resources, there has to be a paradignm shift in farmers's perception from production to productivity and profitability (Utpal Das *et al*., 2017). However, by 2025 A.D., when industrial and urban demand increases, the proportion of water use for irrigation reduces to 83 per cent of the total withdrawal. According to National Commission on Agriculture, the utilization of water for purposes other than irrigation is expected to raise to 27 per cent of available fresh water and only 73 per cent of fresh water will be available for irrigation. Therefore, sources of water are to be used efficiently. Limited supply of water necessitates a shift in the production objectives from attainment of potential yield per unit of land to potential yield per unit of water. Among different methods of irrigation, drip method results in maximum water and nutrient use efficiency. In recent years, there is declining trend in annual rainfall. Limited sources of irrigation water from wells and tanks can be advantageously used through drip irrigation to enhance water use efficiency in broadly spaced crops like chilli. The yield and quality are the important factors to be considered which can be achieved only through optimum nutrients application. Chilli being a long duration crop, it responds to split application of nutrients.

This project is indented to study the fertigation system in one of promising alternate crops in chillies in rice ecosystem. Chillies are widely grown as vegetable cum commercial crops which requires 650 -750 mm of water under conventional method of irrigation. Research has shown that drip irrigation has the ability to reduce the water requirement to the tune of 40 -50 % without much of yield loss.

It is hypothesized that drip fertigation provides balanced nutrition to crops on daily basis that commensurate with nutrient and moisture demand of the crop. This Fertigation system assists in nourishing the crop sufficiently with moisture and nutrient that facilitates the crop to yield normally with the limited amount of irrigation water. The factors associated with moisture and nutrient dynamics under fertigation and conventional system was extensively studied to gain insight into the mechanism associated with higher water use efficiency and yield of chilli. By keeping all these points in view, the present investigation was undertaken to study the response of chilli to drip irrigation on sandy clay loam soil under Madukkur soil series (*Typic Ustropept*) in cauvery new delta zone.

MATERIAL AND METHODS

The experiment was conducted at Soil and Water Management Research Institute,Kattuthottam, Thanjavur financially supported by Department of Science and Technology under SERB programme with a budget outlay of Rs. 13.0 lakhs for three years during 2012-2015. The treatment details are as follows.

Design		: Strip Plot Design
Horizontal strip plot	(A)	: Drip
	A1	: Surface
	A2	: Sub surface @ 10 cm depth
	A3	: Sub surface @ 20 cm depth
Vertical strip plot	(B)	: Irrigation regimes
	B1	: IW/CPE = 1
	B2	: IW/CPE = 0.75
	B3	: IW/CPE = 0.5
Replication		: Four

– The recommended dose of fertilizer for chilli is 120:80:80 kg N, P_2O_5 and K_2O. Out of which, 75% of the recommended dose of P_2O_5 will be applied basally

Table A : Methods employed for the analysis of soil samples

Sr. No.	Properties	Methods	References
1.	pH	Potentiometry method	Jackson (1973)
2.	Electrical Conductivity (d Sm^{-1})	Conductometry method	Jackson (1973)
3.	Organic carbon (%)	Chromic acid wet digestion	Walkley and Black (1934)
4.	Available nitrogen (kg/ha)	Alkaline permanganate method	Subbaiah and Asija (1956)
5.	Available phosphorus (kg/ha)	0.5 M sodium bicarbonate (pH 8.5) Olsen's method	Olsen *et al*. (1954)
6.	Available potassium (kg/ha)	Flame photometer method	Stanford and English (1949)
7.	Soil moisture (%)	Gravimetric method	Jackson (1973)

and the remaining will be applied through drip with water soluble fertilizers. The entire N and K_2O was applied through drip system with water soluble fertilizers.

– Drip fertigation schedule was given once in three days as per the TNAU Crop Production Guide (TNAU CPG-Horticulture, 2013) recommendation.

Initial soil sample was collected and analysed for their physico-chemical properties. The soil is sandy clay loam in texture. The experimental soil had pH 6.2, EC 0.18dS m^{-1}, organic carbon 0.30 %, available nitrogen, phosphorus and potassium were 160 kg ha^{-1}, 35 kg ha^{-1} and 120 kg ha^{-1}, respectively. The methods employed for the analysis of soil samples are as follows in Table A.

Field experiments were conducted during 2013-15. Nursery was raised with Sierra chilly hybrid at SWMRI and transplanting was done with 35 days old Sierra old seedlings at SWMRI, Thanjavur. Drip irrigation is given based on the potential evaporation as per the technical programme. Fertigation is given as per the fertigation schedule prescribed in CPG-Horticulture 2013. Observations on growth and yield parameters *viz*., plant height, number of branches per plant, number of flowers per plant and number of fruit per plant were recorded on 45, 90 and 135 days after transplanting(DAT). Total green chillies yield was recorded.

RESULTS AND DISCUSSION

The data on plant growth and yield parameters are presented in Table 1 to 5. The results revealed that among the drip systems sub surface drip fertigation @ 10 cm depth (A2) recorded the maximum plant height 47.5, 94.4 and 97.5 cm at 45, 90 and 135 DAT. The plant height was maximum in IW/CPE ratio of 1 (B1) followed by B3 (IW/CPE=0.5). Among the treatment combinations sub surface drip fertigation @ 10 cm depth with IW/CPE=1 (A2B1) recorded the maximum plant height followed by A3B1 at 45, 90 and 135 DAT (Table 1).

More number of branches was recorded under surface drip fertigation at 45 DAT whereas, sub surface drip fertigation @ 10 cm depth (A2) recorded the less number of branches at 90 and 135 DAT. Among the irrigation regimes more number of branches was recorded under IW/CPE ratio of 1 (B1) followed by B3 (IW/CPE=0.5) at 45, 90 and 135 DAT. Among the treatment combinations sub surface drip fertigation @ 10 cm depth with IW/CPE=1 (A2B1) recorded the more number of branches followed by A3B1 at 45, 90 and 135 DAT (Table 2).

It has been found that among the drip systems sub surface drip fertigation @ 10 cm depth (A2) recorded the more number of flowers and fruits at 45, 90 and 135 DAT. More number of flowers were present in IW/CPE

Table 1 : Plant height (cm) as influenced by different treatments under drip fertigation in chillies

	45 DAT				90 DAT				135 DAT			
	B1	B2	B3	Mean	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	47.4	46.2	44.3	46.0	92.4	82.9	88.8	88.0	95.9	86.0	92.4	91.4
A2	49.1	46.2	47.1	47.5	97.0	94.6	91.5	94.4	100.2	96.0	96.2	97.5
A3	48.8	40.3	46.3	45.1	94.8	88.9	91.4	91.7	99.2	90.2	96.7	95.4
Mean	48.4	44.2	45.9		94.7	88.8	90.6		98.4	90.7	95.1	
	A	B	A at B	B at A	A	B	A at B	B at A	A	B	A at B	B at A
SEd	0.02	0.03	0.05	0.05	4.53	2.70	5.93	4.68	3.59	2.81	5.35	4.86
CD P=0.05)	0.05	0.06	0.10	0.11	NS	NS	NS	NS	NS	5.90	NS	NS

ratio of 1 (B2) followed by B3 (IW/CPE=0.5). Among the treatment combinations sub surface drip fertigation @ 10 cm depth with IW/CPE=0.75 (A2B2)recorded more number of flowers followed by A3B1 at 45, 90 and 135 DAT (Table 3). A similar trend was followed in number of fruits (Table 4).

Green chillies were harvested in five times and results revealed that sub surface drip fertigation @ 20 cm depth at IW/CPE=1 recorded the highest yield (3502 kg ha^{-1}) followed by sub surface drip fertigation @ 10 cm depth at IW/CPE=0.75 (3129 kg ha^{-1}). The lowest yield was recorded under surface drip fertigation @ IW/CPE = 0.5 (480 kg ha^{-1} in first picking. The same trend was followed in 2^{nd}, 3^{rd}, 4^{th} and 5^{th} picking (Table 5a).

Total green chillies yield (Table 5b) was higher under sub surface drip fertigation @ 10 cm depth at IW/CPE=1 (15559 kg ha^{-1}) followed by sub surface drip fertigation @ 10 cm depth at IW/CPE=0.75 (11170 kg ha^{-1}).

Plant growth and fruit yields were directly related to the amount of water applied. Average fruit weight, number and size of peppers were markedly increased by irrigation (O'Dell, 1983 and Pratt, 1983). Yield differences due to irrigation were attributed to increase number of fruits per plant, fruit size, wall thickness and reduced number of non – marketable fruits. Haynes and Herring (1981) reported that the percentage of flower retention and fruit set were highest with irrigation at 560 mb.

Table 2 : No. of branches as influenced by different treatments under drip fertigation in chillies

	45 DAT				90 DAT				135 DAT			
	B1	B2	B3	Mean	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	17.7	17.3	17.0	17.3	18.6	20.7	28.6	22.6	22.6	22.9	31.6	25.7
A2	18.3	16.6	14.5	16.5	27.4	27.0	29.3	27.9	29.5	29.8	34.1	31.1
A3	18.2	12.8	16.0	15.7	23.5	22.5	22.7	22.9	27.9	24.6	25.4	26.0
Mean	18.1	15.6	15.8		23.2	23.4	26.9		26.7	25.8	30.4	
	A	B	A at B	B at A	A	B	A at B	B at A	A	B	A at B	B at A
SEd	1.20	2.05	3.13	3.54	1.15	1.09	4.50	3.98	1.85	2.01	3.39	3.48
CD (P=0.05)	NS	NS	NS	NS	2.48	2.30	NS	NS	4.52	4.22	NS	NS

Table 3: No. of flowers as influenced by different treatments under drip fertigation in chillies

	45 DAT				90 DAT				135 DAT			
	B1	B2	B3	Mean	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	18.5	20.9	18.6	19.3	32.8	34.0	36.9	34.6	33.3	39.7	32.9	35.3
A2	16.0	22.2	26.7	21.6	35.9	36.4	36.1	36.1	36.9	34.2	38.0	36.4
A3	15.4	17.9	23.3	18.9	31.9	35.3	34.3	33.8	34.4	35.5	35.8	35.2
Mean	16.6	20.3	22.9		33.5	35.2	35.8		34.9	36.5	35.6	
	A	B	A at B	B at A	A	B	A at B	B at A	A	B	A at B	B at A
SEd	1.57	2.28	3.58	3.94	4.53	1.98	5.93	4.68	1.70	2.27	3.64	3.94
CD (P=0.05)	NS	4.78	NS	NS	NS	3.98	NS	NS	NS	4.75	NS	NS

Table 4 : No. of fruits as influenced by different treatments under drip fertigation in chillies

	45 DAT				90 DAT				135 DAT			
	B1	B2	B3	Mean	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	17.6	17.5	17.4	17.5	38.6	42.5	45.1	42.1	42.1	42.4	40.3	41.6
A2	20.0	19.5	20.9	20.1	45.2	43.1	43.2	43.8	42.0	39.9	46.9	42.9
A3	18.5	14.7	19.3	17.5	40.1	49.9	44.1	44.7	38.9	48.6	43.1	43.5
Mean	18.7	17.2	19.2		41.3	45.2	44.1		41.0	43.6	43.4	
	A	B	A at B	B at A	A	B	A at B	B at A	A	B	A at B	B at A
SEd	1.25	1.13	4.08	2.14	1.20	2.01	3.13	3.54	0.98	1.10	5.84	4.20
CD (P=0.05)	2.84	2.05	NS	NS	2.46	4.05	NS	NS	2.01	2.20	NS	NS

In chilli plant, produce was greatest at the highest irrigation level (Hassan *et al*., 1984). Photosynthetic rate decreased to below 50% of maximum when available soil water capacity was less than 50 per cent (Zira, 1984). Tedeschi and Zerbi (1984) showed that total and marketable yields per plant were linearly related to actual evapo-transpiration and that yield dependent on number of fruits per plant and mean fruit weight rather than on the number of flowers which was less important because abscission of flowers and young fruits was always high.

Klickvenga and Siddiq (1985) opined that chilli was sensitive to both water deficit and surplus, providing too much water results in anaerobic condition within root zone. While insufficient water inhibits leaf expansion and photosynthetic capacity. Pulekar *et al*. (1993) reported that different levels of irrigation had the significant effect on cost benefit ratio of banana. The highest benefit cost ratio (2.28:1) was recorded with irrigation at 25 mm CPE from November to May.

Hedge (1989) reported that irrigation at different soil moisture regimes had significant influence on dry matter production in bell pepper during all the three years of study. Pulekar *et al*. (1990) reported that irrigation scheduled at 36 mm CPE increased the chilli yield significantly over 12 and 60 mm CPE. Investigations carried out at Madurai indicated that irrigation at 0.75

Table 5a : Green chillies yield (kg ha^{-1}) as influenced by different treatments under drip fertigation

	I Harvest				II Harvest				III Harvest			
	B1	B2	B3	Mean	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	2151	3129	1031	2104	2409	3333	1316	2353	2756	3716	1769	2747
A2	3502	2258	1573	2444	3813	2622	1956	2797	4320	3022	2356	3233
A3	1547	1324	480	1117	1902	1644	782	1443	2240	2080	1227	1849
Mean	2400	2237	1028		2708	2533	1351		3105	2939	1784	
	A	B	A at B	B at A	A	B	A at B	B at A	A	B	A at B	B at A
SEd	105	78	153	136	106	76	151	132	108	77	152	132
CD (P=0.05)	259	164	347	285	258	159	342	277	263	161	347	278

	IV Harvest				V Harvest			
	B1	B2	B3	Mean	B1	B2	B3	Mean
A1	1953	2589	1098	1880	534	734	455	574
A2	3213	2752	1876	2614	711	516	818	682
A3	1345	1095	762	1067	578	373	613	521
Mean	2170	2145	1245		608	541	629	
	A	B	A at B	B at A	A	B	A at B	B at A
SEd	118	54	141	93	123	128	219	222
CD (P=0.05)	289	112	329	195	300	269	484	466

Table 5b : Total green chillies yield (kg ha^{-1}) as influenced by different treatments under drip fertigation

	B1	B2	B3	Mean
A1	9803	13501	5669	9658
A2	15559	11170	8579	11769
A3	7612	6516	3864	5997
Mean	10991	10396	6037	
	A	B	A at B	B at A
SEd	138	68	154	124
CD (P=0.05)	289	112	331	253

A1 : Surface
A2 : Sub surface @ 10 cm depth
A3 : Sub surface @ 20 cm depth

B1 : IW/CPE = 1
B2 : IW/CPE = 0.75
B3 : IW/CPE = 0.5

Plate 1 : Overall view of the field experiment

IW/CPE ratio resulted in maximum growth and yield attributes (Shibhila Mary and Balakrishnan, 1990). Similar trend of yield increase was noticed by Doyle *et al*. (1994).

Scheduling of irrigation at IW/CPE ratio at frequent intervals resulted in significantly higher yields (Gulati *et al*., 1995; Café Filho and Duniway, 1995). Further, irrigation scheduled at 0.9 IW/CPE ratio registered 37, 30 and 10 per cent increased dry chilli yield over 0.45, 0.60 and 0.75 IW/CPE ratios, respectively (Subramanian *et al*., 1998).

Drip irrigation providing only 250 m3 to 1000 m2 resulted in a high yield (400 kg/1000 m2) of capsicum (Palevitch *et al*., 1979). Sivanappan (1979) indicated that irrigation requirements depend on season, weather factors, soil type, type of irrigation and worked out the irrigation requirement of chilli crop to be 100 cm and 402 cm in Tamil Nadu under furrow and drip irrigation, respectively.

Ramesh (1986) had conducted an experiment during rabi 1985 at Main Research Station, Hebbal, Bangalore to study the drip and furrow methods of irrigation at different levels (0.3 and 0.6 Epan) in green chilli. Higher levels of irrigation recorded more or less same plant height, number of primary branches per plant compared to lower level of irrigation. Higher level of irrigation (0.6 Epan) recorded significantly higher yield of green chilli over lower levels of irrigation.

Summary and Conclusion:

– Sub surface drip fertigation at 10 cm depth recorded the maximum plant height, number of branches, number of flowers and number of fruits at B_2 irrigation regime (IW/CPE = 0.75).

– Total green chillies yield was higher under sub surface drip fertigation @ 10 cm depth at IW/CPE=1 (15.59 t ha^{-1}) followed by surface drip fertigation at IW/CPE = 0.75 (13.50 t ha^{-1}) and sub surface drip fertigation @ 10 cm depth at IW/CPE = 0.75 (11.17 t ha^{-1}).

Thus, introduction of chillies as an alternate crop under sub surface drip fertigation @ 10 cm depth technology during January under Broad bed furrow method of cultivation paves the way for improving the social security to the rice farmers.

Acknowledgement :

The author gratefully acknowledges the financial support received from the Department of Science and Technology, Government of India under Science and Engineering Research Board (DST-SERB) scheme. Technical support and encouragement extended by Dr. T. Senguttuvan and Dr. Ravi for the execution of this project at Soil and Water Management Research Institute is also acknowledged.

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