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Role of Colour Plastic Mulching and Drip Irrigation Levels on Water Saving and Economics of French bean (*Phaseolus vulgaris* L.)

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A B S T R A C T

An experiment was conducted to examine the effect of different plastic colour mulches *viz.*, white on black, silver on black and complete black on water saving and yield of French bean (*Phaseolus vulgaris* L.) variety Arka Komal under different drip irrigation levels at Raichur, is situated in the Northeastern dry zone which comes under Zone II in region-1 of Karnataka.. The treatments were laid in spilt plot design with four replications and sixteen treatments. The irrigation levels used were 60, 80, 100 and 120 per cent of ET. The depth of water applied for 60, 80, 100 and 120 per cent of ET was 110.94 mm, 147.92 mm, 185.10 mm and 222.09 mm, respectively. The per cent of water saving over 100 per cent ET was 40.06, 20.08 and -19.98 for 60, 80 and 120 per cent ET, respectively. The cost benefit ratio of French bean was highest in white on black plastic mulch with 80 per cent ET.

Introduction

Water management efficiency is a key issue for sustainable agriculture development. The relationship between yield and applied water will allow improving the management of water resources under water scarcity. Drip irrigation is one method of on-farm water application optimizing the water use for crop production. Drip irrigation has proved to be a success in terms of water and increased yield in a wide range of crops.

Drip irrigation system was used to maximize yield and quality by taking the advantage of the management control provided by drip irrigation. This technology not only uses each drop of water most efficiently but also results in good crop growth and yield advantage due to stable moisture content maintained always in the root zone of the crop by way of frequent irrigation at shorter intervals. The drip irrigation method is characterized by low rate of water application over a long period of time at frequent intervals into the plant root zone.

Drip irrigation is being used in row crops such as cabbage, potato, cassava, *etc.* in water scarcity areas. There is considerable saving of irrigation water by adopting drip irrigation method, since water can be applied almost precisely and directly in the root zone without

wetting the entire surface area (Bafna *et al.,* 1993). The benefits of drip irrigation may include better crop survival, minimal yield variability and improved crop quality (Martin *et al.,* 1994).

Plastic mulching has become a globally applied agricultural practice for its instant economic benefits such as higher yields, earlier harvests, improved fruit quality and increased water-use efficiency. The sustainability of plastic mulching remains vague in terms of both an environmental and agronomic perspective. The quantification of micro plastics in soil remains challenging due to the lack of appropriate analytical techniques. The cost and effort of recovering and recycling used mulching films may offset the aforementioned benefits in the long term. French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Fabaceae and originated in Central and South America (Swiader *et al.,* 1992). It is also known as kidney bean, snap bean, pinto bean, green bean, navy bean, pole bean, wax bean, string bean (Hossain, 2007).

Materials and Methods

The experiment was carried out during *rabi* 2016-17 at research field, College of Agricultural Engineering, Raichur. The experiment was laid out in split plot design with 16 treatments and 4 replications on black soil. The main treatments were irrigation levels *viz.,* drip irrigation at 60 per cent ET (I_1), drip irrigation at 80 per cent ET (I_2), drip irrigation at 100 per cent ET (I_3) and drip irrigation at 120 per cent ET (I_4) along with different coloured plastic mulches as sub treatment *viz.,* white on black plastic mulch (M_1), silver on black plastic mulch (M_2), black plastic mulch (M_3) and without mulch (M_0). The irrigation was applied daily based on the cumulative pan evaporation data of previous day and information obtained from the agro-meteorological data. The objective of the experiments was to find out suitable irrigation level and colour plastic mulch for water saving and economics of French bean.

Treatment details

Main treatments

I_1- water application at 60 per cent ET using drip irrigation

I_2- water application at 80 per cent ET using drip irrigation

I_3- water application at 100 per cent ET using drip irrigation

I_4- water application at 120 per cent ET using drip irrigation

Sub-treatments

M_0 –Without mulch
M_1– White on black plastic mulch
M_2 – Silver on black plastic mulch
M_3 –Black plastic mulch

Results and Discussion

Water is a basic resource on earth for all living organisms including mankind and for development and survival of plant community. Drip irrigation can potentially provide high application efficiency and achieve high application uniformity. Both are important in producing uniformly high crop yields and preserving water quality when both water and chemicals are applied through the irrigation system.

Water saving through drip irrigation

The experimental results revealed that there was considerable amount of water saving by using different irrigation levels.

Table.1 Depth of water applied to French bean under different levels of drip irrigation during *Rabi* 2016-17

Month	Depth of water applied at different irrigation levels, mm			
	I_1 (60% ET)	I_2 (80% ET)	I_3 (100% ET)	I_4 (120% ET)
28 to 31st October 2016	1.03	1.37	1.72	2.06
November, 2016	19.80	26.41	33.07	39.67
December, 2016	50.25	67.01	83.78	100.56
January, 2017	39.86	53.13	66.53	79.80
Total	**110.94**	**147.92**	**185.10**	**222.09**
Per cent saving over I_3	40.06	20.08	0.00	-19.98

Table.2 Water requirement, water saving and water use efficiency of French bean crop during 2016-17

Sl. No.	Treatment	Quantity of water applied, cm	Water saving, %	Yield, q ha^{-1}	WUE, q ha^{-1} cm^{-1}
1	Drip irrigation at 60% ET+ white on black plastic mulch	12.75	40.06	100.00	7.84
2	Drip irrigation at 60% ET + silver on black plastic mulch	12.75	40.06	86.10	6.75
3	Drip irrigation at 60% ET + black plastic mulch	12.75	40.06	97.50	7.64
4	Drip irrigation at 60% ET + without mulch	12.75	40.06	98.90	7.75
5	Drip irrigation at 80% ET + white on black plastic mulch	16.89	20.08	157.40	9.31
6	Drip irrigation at 80% ET + silver on black plastic mulch	16.89	20.08	149.90	8.87
7	Drip irrigation at 80% ET + black plastic mulch	16.89	20.08	135.20	8.00
8	Drip irrigation at 80% ET + without mulch	16.89	20.08	120.00	7.10
9	Drip irrigation at 100% ET + white on black plastic mulch	21.11	0.00	114.90	5.44
10	Drip irrigation at 100% ET + silver on black plastic mulch	21.11	0.00	104.60	4.95
11	Drip irrigation at 100% ET + black plastic mulch	21.11	0.00	100.30	4.75
12	Drip irrigation at 100% ET + without mulch	21.11	0.00	116.60	5.52
13	Drip irrigation at 120% ET + white on black plastic mulch	25.34	-19.98	73.40	2.89
14	Drip irrigation at 120% ET + silver on black plastic mulch	25.34	-19.98	88.50	3.49
15	Drip irrigation at 120% ET + black plastic mulch	25.34	-19.98	68.20	2.69
16	Drip irrigation at 120% ET + without mulch	25.34	-19.98	57.80	2.28

Table.3 Effect of colour plastic mulching and drip irrigation on economics of French bean during 2016-17

Treatment	Crop yield, t ha^{-1}	Cultivation cost, Rs ha^{-1}	Total returns, Rs ha^{-1}	Net returns, Rs ha^{-1}	Benefit cost ratio
I_1M_0	9.89	75,958	2,96,700	2,20,742	2.90
I_1M_1	10.00	96,678	3,00,000	2,03,322	2.10
I_1M_2	8.61	96,678	2,58,300	1,61,622	1.67
I_1M_3	9.75	96,678	2,92,500	1,95,822	2.02
I_2M_0	12.00	75,958	3,60,000	2,84,042	3.73
I_2M_1	15.74	96,678	4,72,200	3,75,522	3.88
I_2M_2	14.99	96,678	4,49,700	3,53,022	3.75
I_2M_3	13.52	96,678	4,05,600	3,08,922	3.19
I_3M_0	11.66	75,958	3,49,800	2,73,842	2.83
I_3M_1	11.49	96,678	3,447,00	2,48,022	2.65
I_3M_2	10.46	96,678	3,13,800	2,17,122	2.24
I_3M_3	10.03	96,678	3,00,900	2,04,222	2.11
I_4M_0	5.78	75,958	1,73,400	97,442	1.28
I_4M_1	7.34	96,678	2,20,200	1,23,522	1.27
I_4M_2	8.85	96,678	2,65,500	1,68,822	1.74
I_4M_3	6.82	96,678	2,04,600	1,07,922	1.11

The depth of water applied for 60, 80, 100 and 120 per cent of ET was 110.94 mm, 147.92 mm, 185.10 mm and 222.09 mm, respectively. The per cent of water saving over 100 per cent ET was 40.06, 20.08 and -19.98 for 60, 80 and 120 per cent ET, respectively represented in Table 1. This might be due to the fact that maximum amount of water would be stored in the root zone and deep percolation losses would be minimum at lower irrigation levels (Tagar *et al.*, 2012 and Gupta *et al.*, 2010).

Water use efficiency

The maximum total depth of water (25.34 cm) was applied in drip irrigation at 120 per cent ET treatment, while the minimum total depth of water (12.75 cm) was applied in 60 per cent ET through drip irrigation treatment with 40 per cent water saving (Singh and Kumar 2007). An examination of the same showed that the maximum WUE was obtained in white on black plastic mulch with 80 per cent ET (9.31 q ha^{-1} cm^{-1}) while the minimum WUE of 2.28 q ha^{-1} cm^{-1} was noticed under no mulch treatment with 120 per cent ET (Table 2.) the same was observed by Paul *et al.*, 2013 and Biswas *et al.*, 2015.

Economics

The results on the economics of the French bean cultivation are presented in Table 3. Scrutiny of the same showed that highest cost of cultivation per hectare Rs. 96,678 was incurred with the treatment of colour plastic mulches. Whereas the lowest cost of cultivation Rs. 75,958 was noticed in the treatment without plastic mulch. The maximum net returns per hectare Rs. 3,75,522 were obtained under white on black plastic mulch with 80 per cent ET. The results showed that the highest benefit-cost (BC) ratio of 3.88 was obtained under drip irrigation (Tiwari *et al.*, 1998, Bhatt *et al.*, 2011 and Reddy *et al.*, 2012)) at 80 per cent ET with white on black plastic mulch while the lowest

BC ratio of 1.11 was recorded in treatment drip irrigation at 120 per cent ET with black plastic mulch. It is concluded that drip irrigation at 80% ET with white on black plastic mulch resulted in significantly high yield, water use efficiency and maximum benefit cost ratio. The drip irrigation system giving a saving of 40 per cent of water and the economic analysis of all the treatments revealed that the ideal combination of highest net returns and benefit cost (BC) ratio was drip irrigation at 80 per cent ET with white on black plastic mulch.

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