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Growth and yield response of French bean (*Phaseolus vulgaris* L.) to colour plastic mulching and different drip irrigation levels

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Abstract
An experiment was carried out during *Rabi* (October, 2016 to January, 2017) to examine the effect of different plastic color mulches *viz.*, white on black, silver on black and complete black on growth and of yield of French bean (*Phaseolus vulgaris* L.) variety Arka Komal under different drip irrigation levels. The irrigation levels used were 60, 80, 100 and 120 per cent of ET. The trial consisted of sixteen treatments replicated four times. The experiment was laid out in spilt plot design. Among coloured plastic mulches, white on black plastic mulch produced highest plant height (38.68 cm), number of branches (6.00), yield per plant (252.71 g) and yield per hectare (11.14 t ha^{-1}).Among the irrigation levels, 80 per cent ET recorded highest values for plant height (33.73 cm), number of branches (7.13), yield per plant (300.67 g) and yield per hectare (14.06 t ha^{-1}). The interaction effect revealed that white on black plastic mulch with 80 per cent ET exhibited better plant height(33.73 cm), number of branches (7.13), yield per plant (300.67 g) and yield per hectare (14.06 t ha^{-1}) compared to other treatments.

Keywords: Plastic colour mulches, drip irrigation, growth parameters, yield

Introduction
French bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family Fabaceae and its origin is from Central and South America (Swiader *et al*., 1992) [22]. It is also known as kidney bean, snap bean, pinto bean, green bean, navy bean, pole bean, wax bean, string bean and bonchi (Hossain, 2007) [7]. The vitamins A and C present in green beans are an excellent antioxidant that reduces the amount of free radicals in the body and prevents the buildup of plaque in arteries and veins. The green pods are rich source of proteins, minerals and vitamins (Punia *et al*., 2008) [17]. Beans are often the main source of protein, and a significant source of minerals for low- income population (Laparra *et al*., 2009) [10]. Water is a basic resource on earth for all living organisms including mankind. Water is an essential prerequisite for development and survival of plants. Environment process of biosphere is also regulated by water. Normally, groundwater and surface water are used for irrigation and when water available in these sources is utilized artificially for supplying the required quantity tocrops, it is called irrigation. It is estimated that losses of water and applied nutrients under conventional methods are more than 30 to 40 per cent (Rajaraman and Pugalendhi, 2013) [18]. Efficient water delivery systems can contribute towards increased crop yield, improve crop water and fertilizer use efficiency (Badr *et al*., 2010) [10] Improving water use efficiency (WUE) without any reduction in productivity to satisfy present and future requirements of a high population is a very important issue. This may help minimize water consumption, reduce losses of irrigation water, and increase cultivated area. Badr *et al*. and Saleh *et al*. (2012) [19] recommend the use of modern irrigation systems such as drip or subsurface drip irrigation, instead of traditional surface irrigation. This technology not only uses each drop of water most efficiently but also results in good crop growth and yield. Drip irrigation is now being used in row crops such as cabbage, potato, cassava, etc. in water scarcity areas. Drip irrigation is an effective way to supply water to roots of plant and save water, while maintaining high yield and excellent product quality. It can easily be used for fertigation through which fertilizer is placed to the active root zone and crop requirement can be met accurately (Paramsivam *et al*., 2001 [16] and Neilsen *et al*., 2004) [14]. There can be considerable saving of irrigation water by

adopting drip irrigation method (Balakrishnan, 2006) [4], since water can be applied almost precisely and directly to the root zone without wetting the entire surface area (Bafna *et al*., 1993) [3]. The benefits of drip irrigation may include better crop survival, minimal yield variability and improved crop quality (Martin *et al*. 1994) [11].

Mulching is an appropriate approach to conserve moisture besides improving crop yield. Reduction in evaporation from crop field through polyethylene mulch enhances both productivity and WUE by creating a barrier between soil surface and adjacent atmosphere. Mulching minimizes the evaporation loss from soil surface and thus utilizes the conserved moisture for higher transpiration, improves yield and WUE of crop (Agele *et al*., 2002) [1]. 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 (Mohammed Ali 2009) [12]. Soil mulching not only reduces the soil evaporation and weed growth but also improves the aerial environment around the plants which facilitate plant growth and yield. Use of mulches for early crop offers great scope in such a situation because of conserving moisture and improving soil temperature (Singh and Kamal, 2012) [21].

Vegetable crops that are well suited for production with plastic mulch are typically high value row crops such as tomatoes, peppers, melons, squash, and cucumbers. French bean is extensively cultivated in India and world over. There is a need to assess the performance of this commercial vegetable crop using different drip irrigation levels and different coloured mulches. Hence this study was undertaken.

Material 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 four replications. 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). The sub treatments consisted of different coloured plastic mulches *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 objective of the experiment was to find out suitable irrigation level and colour plastic mulch for growth and yield of french bean.

The land was ploughed, harrowed and brought to fine tilth. Well decomposed farmyard manure was applied to the soil and mixed thoroughly. Raisedbeds of 5 mt. length, 1 mt. width and 0.10 mt height were prepared. Polythene mulch sheets were spread on the beds and the sides of the polythene sheets were inserted tightly inside the soil. Holes were made on the mulch sheets, according to the spacing of the crop, prior to sowing of seeds. Seeds of French bean variety Arka Komal procured from Indian Institute of Horticultural Research, Bangalore were sown on the beds at a spacing of 60 cm. x 30 cm, Recommended dose of fertilizers were applied viz. to the beds.

The observations were recorded on five randomly selected plants from each treatment. Growth parameters were recorded at 15 days, 30 days,45 days and 60 days after sowing. The yield parameters were recorded as and when harvesting was done Analysis of variance was performed following the statistical method described by Panse and Sukhatme and significance of differences among treatment means were calculated at 5% level of significance.

Result and Discussion

Growth Parameters

Mulch colours had significant effect on plant height of French beans and the data are presented in Table 1.At 60 DAS the plant height was highest in treatment consisting of white on black plastic mulch (38.68 cm) followed by silver on black plastic mulch (35.60 cm). The plant height was minimum in treatment without mulch (21.10 cm).The positive influence of white on black mulch on plant height might be due to the fact that the incident radiation entered through the white polythene mulch, but very little amount of outgoing radiation could go back to the environment, (Kumar *et al*., 2010) [9] and the slight improvement in the soil temperature underneath the white mulch might have contributed for better plant height.

In irrigation levels, maximum plant height of 33.73 cm was observed in treatment where irrigation at 80 % ET was provided followed by irrigation at 100 % ET (32.17 cm) and minimum plant height (27.14 cm) was observed in treatment where irrigation at 120% ET was provided. With respect to interaction effect, significantly highest plant height of 42.75cm was recorded in treatment consisting of white on black plastic mulch and irrigation of 80% ET while lowest plant height of 17.70 cm was recorded under the treatment without mulch and irrigation at 120 % ET. Gupta *et al.* (2010) [6] reported that higher plant height in drip irrigation at 80 per cent ET might be due to the optimum availability of moisture and air at appropriate soil temperature. This, further might have facilitated the production of better roots, resulting in better nutrient uptake from the soil.

The data pertaining to effect of irrigation levels and coloured plastic mulches and their interaction on number of day to 50 per cent flowering are presented in Table 1. Significantly maximum number of days to fifty per cent flowering (38.72 days) was documented in the treatment where irrigation was provided with 120 % ET. Significantly minimum numbers of days to fifty per cent flowering (34.75 days) was documented in the treatment where irrigation was provided with 80 % ET.As far as the plastic mulches were concerned, treatment with no mulch took significantly maximum number of days for 50 per cent flowering (43.68 days) and treatment with white on black plastic mulch took significantly minimum number of days for 50 per cent flowering (31.88 days). The number of days to fifty per cent flowering ranged from 46.13 days (maximum) in treatment consisting of irrigation at 120 % ET without mulch to 31.25 (minimum) in treatment consisting of irrigation at 80 % ET with white on black plastic mulch. White mulch reflects more of photosynthetic light, than the other mulches, and this light could have contributed for the enhanced function of photo chrome system within a plant (Shinde *et al.,* 2006). This could have resulted in earlier flowering.

The effect of irrigation levels, coloured plastic mulches and their interaction on number of branches are presented in Table1. Maximum number of branches (7.13) was recorded in treatment where irrigation at 80 % ET was provided followed by irrigation at 100 % ET (6.38). Minimum number of branches (4.50) was recorded in treatment where irrigation at 120 % was provided. Among plastic mulches, maximum number of branches was recorded where white over black mulch was used (6.00) and minimum number of branches were recorded where no mulch was used (5.06). When the interaction effect was observed, it was found that significantly maximum number of branches (7.50) was recorded in treatment where irrigation with 80% ET was provided and white on black plastic mulch was used, while minimum number of branches (3.75) were recorded in treatment where irrigation with 120% ET was provided and black plastic mulch was used

The positive influence of white on black colour plastic mulch on number of branches might be due to improved plant light environment and better spectral reflection of light, as coloured plastic mulches contributed for increasing the temperature, suppressing the weed growth and making good quantity of moisture available for plant growth. In addition to this, the optimum temperature at soil surface and root zone of the plants might also exercise favourable effect. Optimum irrigation and mulching might have affected the temperature and provided favourable micro climate around the plants resulting in increased photosynthetic activity, which further might have contributed for more number of branches.

Yield

Yield is the ultimate result of several factors, which would contribute directly or indirectly to the plant growth. The effect of irrigation levels and colour plastic mulches on crop yield is presented in Table2 .It is apparent from data that different irrigation levels, plastic colour mulches and their interactions have exhibited significant effect on yield. As regards of irrigation levels, significantly maximum yield per plant, per plot and per hectare (300.67 g plant, 7.03 kg plot and 14.06 t ha^{-1}, respectively) were recorded when irrigation was provided with 80 % ET followed by irrigation at 100% ET. Minimum yield per plant, per plot and per hectare(167.04 g plant, 3.60 kg plot and 7.20 t ha^{-1}, respectively) was recorded when irrigation was applied at 120 % ET .This might be due to more vigorous and luxuriant vegetative growth, which favored better partitioning of the assimilates from source to sink. These results are in accordance with Durge *et al*., (1997) [5]. When different colour mulches were observed, it was found that white on black plastic mulch produced maximum yield per plant, per plot and per hectare (252.71 g plant, 5.57 kg plot, 11.14 t ha^{-1}., respectively) followed by silver on black plastic mulch. Minimum yield per plant, per plot and per hectare (193.47 g plant, 4.92 kg plot and 9.83 t ha^{-1}., respectively) was recorded when no mulch was used.

Among the interaction effects the treatments consisting of irrigation at 80 per cent ET and white on black plastic mulch (I_2M_1) recorded the maximum yield per plant, per plot and per hectare (383.14 g, 7.87 kg and 15.74 t ha^{-1}, respectively) and the minimum yield per plant, per plot and per hectare (123.50 g, 2.89 kg and 9.83 t ha^{-1}, respectively) was recorded in the treatment consisting of irrigation at 120 % ET and no plastic mulch (I_4M_0). Drip irrigation provides appropriate moisture at field capacity, better root development in terms of number and spread of roots, luxuriant growth of plant due to better nutrient uptake, thus resulting in better growth and development and ultimately higher yield (Mukherjee *et al.*, 2010) [13]. Imamsaheb *et al*., 2014 [8] studied Drip irrigation in different vegetable crops and found that drip irrigation with 80 per cent ET produced significantly maximum yield as compared to other irrigation levels studied.

Higher yield in white on black colour plastic mulch application could be ascribed due to difference in plant light environment among the coloured mulch treatments under field condition. Application of water through drip irrigation with 80 percent ET and use of white on black colour plastic mulch, enhanced plant growth, which further facilitated the accumulation of more carbohydrates, resulting in increase in number of pods. This ultimately resulted in higher yields as higher transpiration rate from the broader leaf and reduced evaporation from the soil surface due to the use of plastic mulches might contribute for increase in yield.(Tiwari *et al.* 2003 [23] and Vijay Kumar *et al.* 2012) [24].

Table 1: Effect of colour plastic mulches and different irrigation levels on growth prameters of French bean

	Plant height (cm.)					**Number of branches**					**Days for 50 % flowering**				
Treatments	**I_1**	**I_2**	**I_3**	**I_4**	**Mean**	**I_1**	**I_2**	**I_3**	**I_4**	**Mean**	**I_1**	**I_2**	**I_3**	**I_4**	**Mean**
M_0	20.00	24.45	22.25	17.70	21.10	5.50	7.25	6.00	5.50	6.06	41.95	41.38	45.25	46.13	43.68
M_1	36.13	42.75	40.00	35.83	38.68	5.75	7.50	6.25	4.50	6.00	31.75	31.25	31.50	33.00	31.88
M_2	35.30	37.50	36.65	32.95	35.60	5.25	7.00	6.50	4.25	5.75	31.50	31.38	33.75	35.75	33.09
M_3	26.80	30.23	29.78	22.10	27.23	6.00	6.75	6.75	3.75	5.81	38.25	35.00	37.75	40.00	37.75
Mean	29.56	33.73	32.17	27.14		5.63	7.13	6.38	4.50		35.86	34.75	37.06	38.72	
	SEM ±			CD at 5 per cent		SEM ±			CD at 5 per cent		SEM ±			CD at 5 per cent	
Main treatment	0.68			2.37		0.14			0.47		0.68			2.36	
Sub treatment	0.67			1.97		0.37			1.07		0.58			1.69	
I at same M	1.35			NS		0.74			NS		1.16			3.37	
M at the same or different I	1.51			NS		0.75			NS		1.34			3.92	

Table 2: Effect of colour plastic mulches and different irrigation levels on yield parameters of French bean

Treatment	**Yield Per plant (g)**					**Yield Per plot (kg)**					**Yield Per hectare (t ha^{-1})**				
	I_1	**I_2**	**I_3**	**I_4**	**Mean**	**I_1**	**I_2**	**I_3**	**I_4**	**Mean**	**I_1**	**I_2**	**I_3**	**I_4**	**Mean**
M_0	197.79	224.95	227.66	123.50	193.47	4.94	6.00	5.83	2.89	4.92	9.89	12.00	11.66	5.78	9.83
M_1	234.48	383.14	197.31	195.93	252.71	5.00	7.87	5.75	3.67	5.57	10.00	15.74	11.49	7.34	11.14
M_2	218.30	320.36	257.33	163.97	239.99	4.31	7.50	5.23	4.42	5.36	8.61	14.99	10.46	8.85	10.73
M_3	229.69	274.25	267.38	184.70	239.02	4.88	6.76	5.02	3.41	5.02	9.75	13.52	10.03	6.82	10.03
Mean	220.06	300.67	237.42	167.04		4.78	7.03	5.46	3.60		9.56	14.06	10.91	7.20	
	SEM ±			CD at 5 per cent		SEM ±			CD at 5 per cent		SEM ±			CD at 5 per cent	
Main treatment	1.34			4.65		0.08			0.26		0.15			0.52	
Sub treatment	3.75			10.93		0.09			0.26		0.18			0.51	
I at same M	7.49			21.87		0.18			0.51		0.35			1.02	
M at the same or different I	7.61			22.22		0.19			0.56		0.38			1.11	

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