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Effect of Irrigation and Mulch on Bushbean Production in the Hill Valley

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Abstract: An experiment was conducted in a split plot design with 8 irrigation levels with or without mulch to determine optimum level of irrigation or mulch of Dwarf French bean (Bushbean) during two consecutive cropping seasons. Straw mulch significantly increased plant height, number of pods per plant, pod yield and profitability. Irrigation influenced most of the yield attributes except pod size and number of seeds per pod. The maximum number of pods and Benefit Cost Ratio (BCR) (5.03) was obtained from fortnightly flood irrigation (6 mm) with mulch while maximum pod yield (19.77 t ha^{-1}) was obtained from half-weekly sprinkler irrigation (3 mm). The lowest yield (10.87 t ha^{-1}) was obtained from control (no irrigation) without mulch. There was no significant effect of irrigation and mulch on pod size and number of seeds per pod.

Key words: Bushbean, mulch, pod

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) derived from a wild species *Phaseolus-arborigenesis* Burkat originated from southern Mexico and Middle America[1], is the second legume vegetable in the world and newly introduced as winter vegetables in Bangladesh. In Bangladesh, the dwarf and bushy type of French bean is called Bushbean. In the hilly areas of Bangladesh, the soil texture generally varies from sandy loam to loam and comparatively low temperature prevails during the winter season with less rainfall, which are most suitable for Bushbean cultivation. Its cultivation is increasing due to its high nutritive value and export opportunity. At present, it is one of the most important export vegetables in Bangladesh. The average yield of Bushbean is very low[2] in Bangladesh and this can be improved through the cultivation of high yielding varieties and improved cultivation procedures. Parthasarathi[1] reported that French beans are susceptible to water stress at all stages of growth and development. Water management is one of the important factors to obtain higher yield. Vitkov[3] observed that the demand of water and nutrient was higher at the time of flowering and decreased thereafter. In the hilly area, water stress is a common phenomenon for all crops in the dry season. It required judicial and economic use of water for profitable crop production. The use of water can be more economic and yield of Bushbean can be increased through use of appropriate mulch with optimum irrigation level. There is no recommendation of irrigation and mulch because no research has so far been done in this area on Bushbean. The study was therefore, undertaken I) to determine optimum irrigation levels to maximize quality and yield of Bushbean and ii) to know the effect of mulch with different levels of irrigation and in water scarcity condition on French bean cultivation for higher pod yield of Bushbean in the valleys of eastern hilly region of Bangladesh.

MATERIALS AND METHODS

The experiment was carried out at Agricultural Research Station, Raikhali, Chandraghona, Rangamati hill district during November 2000 to March 2002. Raikhali, Rangamati is situated in the Southeastern part of Bangladesh (Latitude 22°24'N and 91°57'E Longitude). The soil of the experimental plot was silty loam with pH 5.5 having low organic matter (0.70%) and moderate (3.79 cm h^{-1}) percolation rate. The weather data of the station are presented in Table 1.

A split plot design was followed with 16 treatments under two factors. Factor A including 8 irrigation levels viz., I_1 = two flood irrigation (6 mm i.e. 6 L m^{-2})/week, I_2 = two sprinkler irrigation (3 mm i.e. 3 L m^{-2})/week, I_3 = one flood irrigation/week, I_4 = one sprinkler irrigation/week, I_5 = one flood irrigation/two

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Table 1: Rainfall, humidity and temperature at ARS, Raikhali in the cropping season

	Components							
	Rainfall (mm)		Humidity (%)		Temperature (max.)		Temperature (min.)	
Months	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
October	95.5	100.0	78.96	77.64	31.45	33.41	23.54	24.80
November	11.0	20.0	80.13	81.00	28.90	29.53	20.03	20.83
December	0.0	0.0	81.12	82.03	23.93	29.32	14.06	17.80
January	0.0	0.0	80.46	81.38	24.77	24.70	11.58	13.16
February	4.5	0.0	73.50	82.32	26.03	26.39	15.71	12.96
March	0.0	24.7	73.36	77.09	31.66	30.41	17.50	17.32

week, I_6 = one sprinkler irrigation/two week, I_7 = traditional (farmers practice/one flood irrigation (6 mm) before flowering), I_8 = Control or no irrigation and the factor B including straw mulch (M_1) or without mulch (M_2). The unit plot size was 2×5 m with 25×10 cm plant spacing accommodating 400 plants plot^{-1}. The land was manured and fertilised with compost, N, P_2O_5 and K_2O @ 5000, 50, 75 and 60 kg ha^{-1} in the form of compost, urea TSP and MP. The entire amount of compost, TSP and half of urea and MP were applied at the time of land preparation and rest of urea and MP was applied at 30 days after planting. Weeding and other cultural practices were done as and when necessary. Scheduled irrigation was started from 4th weeks after germination and it was continued up to 10th week. In this system, I_1 and I_2 required 14, I_3 and I_4 required 7, I_5 and I_6 required 14 and I_7 required only one irrigation in the cropping season. Irrigation was done by watering cane and it was considered as sprinkler irrigation method. Flood irrigation was done by power pump where, source of water is river, with shower for sprinkler irrigation and flood irrigation without shower. Data were taken from randomly selected 20 plants for individual plant performance and from one square meter for per hectare yield.

RESULTS AND DISCUSSION

Effect of irrigation: Days to flowering and plant height of Bushbean were influenced by irrigation. Flowering delayed with the deviation form moderate irrigation. Early flowering (42.9 DAP = days after planting) was observed in traditional irrigation (single flood irrigation at flowering). Sharp and Davies[4] reported that water stress had no influence on harvest time and pod size but affected on yield. Ahlawat and Sharma[5] reported that increase of irrigation frequency increased the number of seeds/pod and 100 seed wt. Maximum plant height 53.1 cm was obtained from half-weekly sprinkler (3 mm) irrigation (Table 2). Irrigation had no significant effect on pod size. Number of pods, fresh pod yield and Benefit Cost Ratio were significantly affected by irrigation. In 2000-01, the maximum number of pod 17.9 pods/plant was harvested from the plots having fortnightly flood irrigation while in 2001-02, it was 14.2 pods/plant with half-weekly sprinkler or weekly flood irrigation (Table 3). The average number of pods per unit area as well as pod yield was the maximum (390 pods m^{-2}, 19.47 t ha^{-1}) with weekly flood (6 mm/week) irrigation. Wagner *et al.*[6] found maximum yield of *Phaseolus vulgaris* with five irrigations at 7 days interval plus NPK fertiliser. Awad *et al.*[7] obtained the highest seed yield of bush snap beans giving the irrigation at 50% soil moisture depletion. Todorov[8] reported that application of irrigation at 70% field capacity positively affected 1000 seed wt. and increased seed yield by 24.15% in *Phaseius vulgaris*. The minimum number of pod 10.5 pods/plant, 249 pods m^{-2} and 80 t ha^{-1} was obtained from control (no irrigation). In 2000-01, plenty of rainfall observed in the growing period of the crop. So there was no severe water deficiency in the cropping period. As a result the control (no irrigation) plot gave a reasonable yield 16.38 t ha^{-1} in 2000-01. The maximum BCR 6.07 was obtained in 2000-01 with fortnightly flood irrigation and it was 3.89 in 2001-02 with an average of 4.94 from the same irrigation level. These findings are almost similar to the report of Loureiro *et al.*[9] who reported that irrigation rate affected plant height and pod number but had no effect on seed number and 100 seed weight in Brazil. Mauk[10] found 121% higher yield of snap beans with high irrigation at –0.6 bar soil water potential over control.

Effect of mulch: Straw mulch increased plant height, number of pods per plant and yield but showed no significant effect on pod size and number of seeds/pod except the pod length in 2001-02. In 2001-02, longer pods 14.3 cm recoded from the mulched plot compared to control 13.3 cm (Table 2). Mulched crop flowered earlier 42.9 DAP than non-mulched 44.1 DAP crop. Significantly higher plant height 52.4 cm was measured with the straw mulch and it was lower 48.2 cm without mulch. Significantly higher number of pods and pod yield as well as BCR was obtained from straw mulched crop over non-mulched control. The maximum number of pods 14.5 pods/plant, 352 pods m^{-2}, pod yield 17.73 t ha^{-1}

Table 2: Effect of Irrigation and mulch on the performance of Bushbean

Treatments	Days to flowering			Plant height (cm)			Seeds /pod	Length of pod (cm)			Width of pod (cm)		
Irrigation	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled	Pooled	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled
I_1	42.0	47.0	44.5	55.8a	48.9a	52.4a	4.6	12.5	14.2	13.4	0.73	0.80	0.76
I_2	41.0	47.0	44.0	57.3a	48.8a	53.1a	4.3	12.9	14.2	13.6	0.77	0.76	0.76
I_3	40.0	46.3	43.2	55.8b	46.ab	51.2a	4.5	12.7	13.8	13.3	0.75	0.80	0.77
I_4	41.0	46.3	43.7	56.7a	43.7ab	50.2a	4.5	12.7	14.3	13.5	0.77	0.80	0.78
I_5	39.0	46.7	42.8	58.4a	45.1ab	51.8a	4.5	12.5	14.0	13.2	0.72	0.84	0.80
I_6	40.0	46.5	43.3	56.5a	41.5ab	49.0ab	4.2	12.6	13.9	13.2	0.74	0.83	0.78
I_7	40.0	45.8	42.9	55.7b	41.0ab	48.4ab	4.2	12.6	13.7	13.2	0.76	0.81	0.78
I_8	41.0	46.5	43.7	53.2b	39.5b	46.4b	4.2	12.4	13.3	12.9	0.76	0.78	0.77
Mulch													
M_1	40.0	45.8b	42.9b	57.1a	47.6a	52.4a	4.4	12.6	14.0	13.3	0.75	0.81	0.78
M_2	41.0	47.2a	44.1a	55.2b	41.2b	48.2b	4.4	12.7	13.9	13.3	0.75	0.81	0.78
CV%	5.19	2.30	3.74	3.95	6.79	6.79	10.34	4.14	4.11	4.13	5.19	5.63	5.41
Level of Significance	NS	*	*	*	*	*	NS	NS	*	NS	NS	NS	NS

* are significant at 5 and 1% level. NS= Non significant. Means followed by same letter(s) are not differ statistically

Table 3: Effect of irrigation and mulch on the yield performance of Bushbean

Treatments	No. of pods plant			No. of pods m^{-2}			Pod yield t ha^{-1}			BCR		
Irrigation	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled
I_1	15.7ab	13.2ab	14.5ab	413.0ab	319.0a	366.0a	19.32bc	14.40b	16.86bc	4.21c	3.09ab	3.65b
I_2	16.1a	14.2a	15.2a	453.0a	287.0a	370.0a	21.43ab	16.97a	19.20a	4.57bc	3.63a	4.10ab
I_3	16.5a	14.2a	15.4a	482.0a	298.0a	390.0a	21.88ab	16.97a	19.47a	5.56ab	3.81a	4.63a
I_4	17.7a	12.9ab	15.3a	480.0a	235.0ab	357.0a	21.50ab	13.40b	17.45b	5.46ab	3.40a	4.43ab
I_5	17.9a	12.5b	15.2a	478.0a	243.0ab	361.0a	22.07a	14.13b	18.10ab	6.07a	3.89a	4.94a
I_6	13.4bc	12.3b	11.8c	387.0b	206.0b	297.0ab	17.40cd	11.67c	14.53c	4.78bc	3.20ab	3.99ab
I_7	16.1a	10.1c	13.0b	389.0b	250.0ab	320.0ab	16.82cd	11.03c	13.92cd	4.96b	3.16ab	4.06ab
I_8	12.6c	8.4d	10.5d	318.0b	179.0b	249.0b	16.38d	9.23d	12.80d	4.96b	2.88b	3.92b
Mulch												
M_1	16.48a	12.5a	14.50a	445.0a	259.0a	352.0a	21.15a	14.32a	17.73a	5.09	3.44	4.27
M_2	14.77b	11.3b	13.0b	423.0b	246.0b	334.0b	18.05b	12.63b	15.34b	5.04	3.32	4.18
CV%	18.45	12.17	11.31	10.13	9.79	9.96	9.46	7.66	8.56	8.78	7.34	8.06
Level of Significance	**	**	**	*	*	*	**	**	**	*	*	*

* and ** are significant at 5 and 1% level. NS = Non significant. Means followed by same letter(s) are not differ statistically

and BCR 4.27 was obtained from straw mulched crop and it was lowest 13 pods/plant, 334 pods m^{-2}, 15.34 t ha^{-1} and 4.18 without mulch (Table 3). The higher yield in mulching condition might be the cause that continuous moisture supply helps to proper supply of water and nutrient to enhance growth and development of the plant.

Interaction effect of irrigation and mulch: Almost all yield and yield attributes were significantly influenced by the combined effect of irrigation and mulch. Plant height always higher in mulched plots than non-mulched plot and these differences prominant in the low irrigated plots. The effectiveness of mulch was more differentiable in the less irrigated plots in respect to number of pod production and pod yield of Bushbean (Table 4). Application of mulch significantly increased number of pods and pod yield except I_1 (two-flood irrigation/week) where lower 15.19 t ha^{-1} yield was obtained with mulch than without mulch 18.73 t ha^{-1}. Excessive moisture reduced the affectivity of mulch and enhanced foot and root rot disease in moist condition that reduced the yield in I_1M_1 treatment. The maximum pod yield 23.4 t ha^{-1} and BCR 6.10 was obtained from fortnightly flood irrigation with straw mulch in 2000-01 while in 2001-02, the maximum pod yield 19.77 t ha^{-1} was found in half-weekly sprinkler irrigation with straw mulch. This result are in the close conformity of Li *et al.*[11] observed from a study in Korea that the uniformity of sprinkler irrigation and fertiliser application can give a reasonable crop yield through sprinkler irrigation with judicial use of water. Fortnightly flood irrigation with straw mulch gave the maximum average plant height 54.9 cm, number of pods/plant 16.3 and benefit cost ratio 5.03 while maximum number of pods m^{-2} 388 and pod yield 19.77 was obtained from half-weekly sprinkler irrigation with straw mulch.

From the present result, it was revealed that mulch are more appropriate in the water stress condition. Only mulching can provide a reasonable yield of Bushbean where, irrigation facilities are not available (Treatment I_8). Fortnightly flood irrigation with straw mulch was found to be the best for profitably Bushbean production in the eastern hilly area of Bangladesh.

Table 4: Interaction effect of irrigation and mulch on the performance of Bushbean

Treatments					Pod yield (t ha^{-1})			BCR		
Irrigation	Day to flowering*	Plant height (cm)*	No. of pods/plant*	No. of pods m^{-2}*	2000-01	2001-02	Pooled	2000-01	2001-02	Pooled
$I_1 M_1$	43.3b	54.2a	13.5cd	341b	16.9-0f-h	13.47de	15.19d	3.49c	2.76b	3.13c
$I_1 M_2$	45.2a	50.7ab	15.5ab	392a	22.13abc	15.33cd	18.73ab	4.93b	3.41ab	4.17ab
$I_2 M_1$	43.8ab	55.8a	14.9b	388a	20.73abc	18.80a	19.77a	4.24bc	3.84a	4.04b
$I_2 M_2$	44.7a	50.3ab	15.4ab	361ab	21.73abc	15.13cd	18.43ab	4.90b	3.41ab	4.16ab
$I_3 M_1$	43.5ab	52.4ab	15.6a	381a	22.97ab	15.53bc	19.25a	5.56a	3.76a	4.66ab
$I_3 M_2$	42.8b	49.9b	14.9b	300a	20.80a-d	14.40ab	17.60b	5.56a	3.85a	4.71a
$I_4 M_1$	42.8b	51.2ab	16.2a	363d	22.87ab	14.13de	18.50ab	5.53a	3.41ab	4.47ab
$I_4 M_2$	45.0a	48.3b	14.4bc	352b	20.13a-e	12.67e	16.40c	5.38ab	3.39ab	4.39ab
$I_5 M_1$	42.5b	54.9a	16.3a	384a	23.40a	15.13cd	19.27a	6.10a	3.95a	5.03a
$I_5 M_2$	43.2b	48.7b	13.2d	338bc	20.73a-d	13.13e	16.93c	6.03a	3.82a	4.93a
$I_6 M_1$	42.3b	51.1ab	12.7d	304cd	18.60c-f	12.80e	15.70d	4.85b	3.34ab	4.10b
$I_6 M_2$	44.7a	47.0bc	10.7f	285cd	16.20fgh	10.53fg	13.37ef	4.71b	3.06ab	3.89b
$I_7 M_1$	42.7b	49.8b	14.6b	345b	19.70b-f	12.20ef	15.95cd	5.35ab	3.31ab	4.33ab
$I_7 M_2$	43.2b	46.9bc	11.6e	294cd	14.97gh	9.86g	12.42fg	4.56b	3.00ab	3.78b
$I_8 M_1$	43.8ab	48.7b	11.4ef	309cd	17.80d-f	10.60fg	14.20e	5.25ab	3.13ab	4.19ab
$I_8 M_2$	43.7ab	44.0c	9.3g	250d	13.93h	7.86h	10.87h	4.67b	2.63b	3.65bc
CV%	3.74	5.37	9.79	9.96	9.46	7.66	8.56	8.78	7.34	8.06
Level of Significance	*		**	**	**	**	**	*	*	*

* and ** are significant at 5 and 1% level, NS= Non Significant, Means followed by same letter(s) are not differ statistically, * Pooled data of 2000-2001 and 2001-2002

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