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K Saileela
Department of Agronomy, College of Agriculutre, Rajendranagar, PJTSAU, Telangana, India

Raji Reddy D
Department of Agronomy, College of Agriculutre, Rajendranagar, PJTSAU, Telangana, India

Devender Reddy M
Department of Agronomy, College of Agriculutre, Rajendranagar, PJTSAU, Telangana, India

Uma Devi M
Department of Agronomy, College of Agriculutre, Rajendranagar, PJTSAU, Telangana, India

Correspondence
K Saileela
Department of Agronomy, College of Agriculutre, Rajendranagar, PJTSAU, Telangana, India

Fertigation and irrigation level effect on water use efficiency and yield performance of bush beans (*Lablab purpurium* var. Typical.)

K Saileela, Raji Reddy D, Devender Reddy M and Uma Devi M

Abstract
A field experiment was conducted at Water Technology Centre, College of Agriculture, 0Rajendranagar, Hyderabad during rabi season 2009-10 to study effect of varying fertigation (Nitrogen and Potash (K_2O) kg ha^{-1}) and irrigation levels on performance of bush bean (*Lablab purpurium* var. typical L.) through drip irrigation. The Main plot treatments consisted of four irrigation levels viz., Surface irrigation at IW/CPE ratio 1.0, Drip irrigation at 100% E_{pan}, Drip irrigation at 80% E_{pan} and Drip irrigation at 60% E_{pan} and three fertigation levels in sub treatments viz., No N & K application, 50 kg N and 50 kg K_2O ha^{-1} and 100 kg N and 100 kg K_2O ha^{-1}**.** The results revealed that yield attributing characters included number of pods per plant and pod length were maximum in all the three pickings when irrigation was scheduled at 100% E_{pan} with application of 100 kg N and 100 kg K_2O $ha^{-1.}$ Similarly significantly higher green pod yield (3556 kg ha^{-1}) was realized by scheduling irrigation at 100 % E_{pan} which was 9.5% and 22% higher than the irrigation scheduling at 80% and 60% $E_{pan,}$ respectively. However, drip irrigation scheduling at 60% E_{pan} recorded significantly higher water Use Efficiency (7.2 kg ha-mm^{-1}) over drip irrigation at 100 %, 80 % E_{pan} and surface irrigation at IW/CPE = 1.0.
Irrespective of the irrigation levels, gradual increment in fertigation level from no fertilizer application to100 kg ha^{-1} N and K_2O increased water use efficiency (6.1 kg ha-mm^{-1}) and yield. The increase in the yield was to the extent of 4 and 21 % more than application of 50 kg N + 50 kg K_2O ha^{-1} and no fertilizer application, respectively.

Keywords: Fertigation, drip irrigation levels, bush bean, water use efficiency, yield

Introduction
The growing scarcity and rising value of water in a river basin induce farmers to seek ways to increase water productivity and economic efficiency. The water is becoming scarce in many parts of the state limiting agricultural development. The efficient technologies help to establish greater control over water delivery and improve water productivity in projecting future water demands. Micro Irrigation (MI) technologies such as drip and sprinkler are the key components in improving the water productivity, and efficient usage of groundwater. sprinkler irrigation and drip irrigation systems can cut water use by 30 to 60 percent. Crop yields often increase at the same time because plants are effectively 'spoon-fed' the optimal amount of water (and often fertilizer) when they need it (FAO 2002) [2]. Fertilizers are costly inputs and efficient use of these costly inputs not only reduces cost of cultivation and improves the quality, yield but also reduces the ground water pollution when given at root zone through drip irrigation. Bush bean (*Lablab purpurium* var. typical L.) belonging to the family Fabaceae is an important shy nodular high value crop (Hegde and Srinivas, 1989) [4]. The crop can be used as pulse, vegetable and forage and mainly grown for its green pods while the dry seeds are used in various vegetable preparations. Water and fertilizer requirement of bush bean has received very little attention; so far. Further, irrigation through drip system can improve the water and fertilizer use efficiency. Considering the importance of inorganic nitrogen (N) and potash (K) fertigation, through drip system in quantity and quality of produce, the present investigation was carried.

Materials and Methods

The field experiment was conducted at WTC, College of Agriculture, Rajendranagar, Hyderabad during *rabi* 2009 to study the performance of drip irrigation and N and K

Fertigation levels on performance of bush bean. The soil was sandy clay loam in texture, ideal in bulk density (1.2 g cc), moderately rapid in saturated hydraulic conductivity (8.2 cm h^{-1}) with field capacity of 19.4 %, permanent wilting point of 7.4 % and available water capacity of 12%, slightly alkaline in reaction (pH-7.8), non saline (0.38 ds m^{-1}), medium in organic carbon (0.65%) with low in available nitrogen (225 kg N ha^{-1}), medium in available phosphorus (32.2 kg P_2O_5 ha^{-1}) and potassium (327.3 kg K_2O ha^{-1}). The experiment was laid out in a strip plot design with three replications. There were 12 treatment combinations compromising four irrigation levels in main plots *viz.*, Surface irrigation at IW/CPE ratio 1.0, Drip irrigation at 100% E_{pan}, Drip irrigation at 80% E_{pan} and Drip irrigation at 60% E_{pan} and three fertigation levels in sub treatments *viz.*, No N & K application, 50 kg N and 50 kg K_2O ha^{-1} and 100 kg N and 100 kg K_2O ha^{-1}. Bush bean was sown as paired row planting at a spacing of 80 cm between pair, 40 cm between rows and plant-to-plant spacing was 15 cm. The laterals of 16 mm diameter were laid at 1.2 m apart with spacing of 50 cm between two inline emitters of 4 L h^{-1} discharge. Under fertigation, N and K_2O were applied in the form of prilled urea (PU) and white muriate of potash (MOP) respectively, while a common dose of phosphorus was applied as basal dose at 100 kg P_2O_5 ha^{-1} to all treatments through single superphosphate (SSP). During fertigation, entire quantity of PU and MOP was applied in seven equal doses. A total of three green pod pickings were done. The observations on yield parameters like number of pods and pod length were taken at all three pickings. Total green pod yield (3 pickings) were recorded and water use efficiency was computed by using the following formula.

$$\text{Water Use Efficiency (kg ha}^{-1}\text{mm}^{-1}) = \frac{\text{pod yield (kg ha}^{-1})}{\text{Water applied (mm)}}$$

Results and Discussion

Yield Attributes: Number of pods per plant

Different irrigation levels, fertigation levels and their interaction exerted significant influence on number of pods per plant at three pickings. Among the irrigation levels maximum number of pods in all the three pickings was observed with drip irrigation scheduling at 100% E_{pan} and it was on par with scheduling irrigation at 80% E_{pan}. The lowest numbers of pods were recorded with surface irrigation in all three pickings (Table-1). 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) [2]. Among the fertigation levels, increment in N and K levels significantly enhanced number of pods per plant and maximum number of pods at all the three picking was observed with 100:100 N and K_2O kg ha^{-1} level and was significantly superior to next lower level of 50:50 N and K_2O kg ha^{-1} similarly 50:50 N and K_2O produced significantly more number of pods over no N and K application. Maximum number of pods obtained in all the three pickings when irrigation was scheduled at 100% E_{pan} with application of 100:100 N and K_2O kg ha^{-1}. At 100:100 N and K_2O kg ha^{-1}fertigation level, scheduling of irrigation at 100% E_{pan} or 80% E_{pan} resulted in same number of pods per plant in first and second picking. 100% E_{pan} irrigation level with application of 100:100 N and K_2O kg ha^{-1} only resulted in production of maximum number of pods per plant.

Table 1: Effect of irrigation and fertigation (N and K) levels on number of pods per plant of bush bean at First, second and third picking.

Irrigation levels (I)	Fertilizer levels											
Epan	First picking				Second picking				Third picking			
	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean
S.I.	5	8	9	7.3	4.8	7	7.2	6.4	3.4	5.2	6.3	5
Drip 100 % E Pan	8.3	10	11.8	10	7.9	9.2	10.2	9.1	7.3	8.4	9.5	8.4
Drip 80 % E Pan	8.5	9.5	11.2	9.8	7.6	9.1	9.7	8.8	7.6	8.4	8.5	8.1
Drip 60 % E Pan	7.7	8.8	9.3	8.6	7	7.4	8.6	7.7	6.7	7.4	8.2	7.4
Mean	7.4	9.1	10.3		6.8	8.2	8.9		6.2	7.4	8.1	
	I	F	I at same F	F at same I	I	F	I at same F	F at same I	I	F	I at same F	F at same I
S.Em ±	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.3	0.1	0	0.2	0.2
C.D (0.05)	0.3	0.4	0.7	0.8	0.5	0.3	0.7	0.7	0.5	0.1	0.5	0.2

S.I - Surface irrigation at IW/CPE ratio 1.0; (I)*- Irrigation levels; (F) **- Fertigation levels

Pod length

Pod length in all the three pickings was significantly affected by irrigation and fertigation (N and K_2O) levels. Pod length irrespective of the treatments decreased as the number of pickings progressed. Among three pickings, maximum pod length (10.1 cm) was recorded at first picking followed by second (10.0 cm) and third picking (9.2 cm) with drip irrigation scheduled at 100 % E_{pan} and was significantly superior to all other irrigation treatments (Table-2). Increase in frequency of irrigation improved pod length of bush bean. Among fertilizer (N and K) levels in all three pickings, 100:100 N and K_2O kg ha^{-1} level recorded maximum pod length and it was significantly superior over all other fertigation (N and K levels). Lowest pod length was recorded with no application of N and K. In all the three pickings, when irrigation was scheduled at 100% E_{pan}, maximum pod length was recorded only at 100:100 N and K_2O kg ha^{-1} level. Similarly when 100:100 N and K_2O level was applied pod length with surface irrigation and drip irrigation scheduling at 60% E_{pan} was on par.

Table 2: Effect of irrigation levels and fertigation (N and K) levels on pod length at first, second and third pickings of bush bean (cm).

Irrigation levels (I)*	Fertigation levels (F)**											
	First picking				Second picking				Third picking			
Epan	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean
S.I.	8.6	9.4	9.8	9.3	8.3	9.2	9.2	8.9	8.2	9	9.1	8.8
Drip 100 % E_{pan}	9.4	10.4	11.2	10.3	8.8	10.2	11	10	8.5	9.2	10	9.2
Drip 80 % E_{pan}	7.4	8.6	10	8.7	8.3	8.4	8.4	8.4	7.5	7.3	8.5	7.8
Drip 60 % E_{pan}	8.4	9.3	9.9	9.2	8.1	9.1	9.5	8.9	7.5	8.7	9	8.4

Mean	8.5	9.4	10.2		8.4	9.2	9.5		7.9	8.6	9.2	
	I	F	I at same F	F at same I	I	F	I at same F	F at same I	I	F	I at same F	F at same I
S.Em ±	0.07	0.04	0.09	0.12	0.08	0.04	0.1	0.14	0.08	0.07	0.14	0.15
C.D (0.05)	0.23	0.11	0.29	0.23	0.28	0.11	0.34	0.24	0.29	0.2	0.43	0.41

S.I - Surface irrigation at IW/CPE ratio 1.0; (I)*- Irrigation levels; (F) **- Fertigation levels

Green pod yield

Drip irrigation scheduled at 100% E_{pan} recorded the maximum green pod yield (3556 kg ha^{-1}) and was significantly superior to all other drip irrigation and surface irrigation treatments (Table -3). Regarding fertigation levels, significantly higher green pod yield of bush bean (2985 kg ha^{-1}) was recorded with 100 kg N and 100 kg K_2O ha^{-1} and the lowest (2476 kg ha^{-1}) was recorded with no N and K application (Table 3). Higher rates of nutrients resulted in better translocation of assimilates from source to sink. The increase in yield under drip irrigation at 100% E_{pan} and 100 kg N and 100 kg K through fertigation was due to better performance of all crop growth and yield attributing characters due to optimum availability of soil moisture and nutrients throughout the crop growth period. The increase in yield under 100: 100 kg ha^{-1} N and K_2O through fertigation compared to 50: 50 kg ha^{-1} N & K_2O might be due to the fact that fertigation at higher dose resulted in higher availability of all the three (NPK) major nutrients in the soil solution which led to higher uptake and better translocation of assimilates from source to sink thus increased the yield.

Water Use Efficiency

Differentdrip irrigation levels and fertigation levels exerted significant difference on water use efficiency of bush bean. Irrigation given through drip at the rate of 60% E_{pan} recorded significantly the higher water use efficiency (7.2 kg ha^{-1} mm^{-1}) followed by irrigation at 80% E_{pan} (6.0 kg ha^{-1} mm^{-1}) and the lowest water use efficiency was recorded by irrigation given at IW/CPE ratio 1.0 through surface irrigation. Similar findings of water saving and WUE was observed by Solaimalai *et al*., (2005) [5]. The increase in water use efficiency in all drip irrigated treatments over surface irrigation was mainly due to considerable saving of irrigation water, greater increase in yield of crops and higher nutrient use efficiency. Among the fertigation levels applied 100: 100 kg ha^{-1} N and K_2O through drip resulted in significantly higher water use efficiency followed by 50: 50 kg ha^{-1} N and K_2O (5.5 kg ha^{-1} mm^{-1}). Ahluwalia *et al.* (1993) [1] also reported that the irrigation water use efficiency was greater to the extent of 145 and 155 percent in the drip method compared to the furrow method in tomato and cauliflower respectively.

Table 3: Effect of irrigation and fertilizer (N and K) levels on water use efficiency and total green pod yield of bush bean.

Treatments	**Green pod yield (kg ha^{-1})**				**Water use efficiency (kg ha^{-1} mm^{-1})**			
Irrigation levels (I)*	**Fertilizer levels(F)****							
Epan	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean	N_0K_0	$N_{50}K_{50}$	$N_{100}K_{100}$	Mean
S.I.	2476	2619	2985	2694	3.5	3.7	4.3	3.8
Drip 100 % E Pan	3227	3566	3874	3556	4.8	5.8	5.7	5.2
Drip 80 % E Pan	3001	3234	3508	3248	5.5	6	6.5	6
Drip 60 % E Pan	2690	2903	3163	2919	6.6	7.1	7.8	7.2
Mean	2476	2619	2985	2694	5.1	5.5	6.1	
	I	F	I at same F	F at same I	-	-	-	-
S.Em ±	48	46	58	84	-	-	-	-
C.D (0.05)	167	159	N.S.	N.S.	-	-	-	-

S.I - Surface irrigation at IW/CPE ratio 1.0; (I)*- Irrigation levels; (F) **- Fertigation levels

Summary

The study results revealed that yield attributing characters included number of pods per plant and pod length were maximum in all the three pickings when irrigation was scheduled at 100% E_{pan} with application of 100 kg N and 100 kg K_2O $ha^{-1.}$ Similarly significantly higher green pod yield was realized by scheduling irrigation at 100 % E_{pan} than the irrigation scheduling at 80% and 60% $E_{pan,}$ respectively. However, drip irrigation scheduling at 60% E_{pan} recorded significantly higher water Use Efficiency over drip irrigation at 100 %, 80 % E_{pan} and surface irrigation at IW/CPE = 1.0. Irrespective of the irrigation levels, gradual increment in fertigation level from no fertilizer application to100 kg ha^{-1} N and K_2O increased water use efficiency and yield more than application of 50 kg N + 50 kg K_2O ha^{-1} and no fertilizer application, respectively.

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