

EFFECT OF DIFFERENT LEVELS OF IRRIGATION AND PHOSPHORUS PLACEMENT ON THE YIELD AND WATER USE EFFICIENCY OF FRENCH BEAN

M. N. Rahman¹, M. R. Amin², M. T. Rahman³, R. A. Begum⁴ and A. T. M. A. I. Mondol⁵

ABSTRACT

A field experiment was conducted at the Regional Agricultural Research Station (RARS), Hathazari during the rabi seasons 2005-2006 and 2006-2007 to study the effect of irrigation and phosphorus placement on the yield and water use efficiency of french bean (*Phaseolus vulgaris* L.). Twelve treatment combination comprising 4 levels of irrigation (I₀: no irrigation, I₁: one irrigation at vegetative stage, I₂: two irrigation; the first one at vegetative and the second one at flowering stage and I₃: three irrigation; the first one at vegetative, the second one at flowering and the third one at pod development stage) and 3 levels of phosphorus placement (P₁: broadcast, P₂: same furrow placement and P₃: side placement) were assigned in a split plot design with three replications. The significantly highest pod yield (11.94 t ha⁻¹) was obtained with three irrigation (I₃). The maximum number of pods per plant (14.31) was recorded with treatment P₂ (same furrow placement). Pod weight per plant was found maximum (42.09 g) in the same treatment. The highest significant pod yield (11.56 t ha⁻¹) was recorded with treatment P₂. The interaction effect of irrigation and phosphorus placement was found not significant. However highest pod yield (12.06 t ha⁻¹) was obtained from P₂I₃ treatment.

Keywords: French bean, irrigation, water use efficiency

INTRODUCTION

The french bean belongs to the family Leguminosae is reported to be a native of central and south America (Swaider *et al*, 1992). This crop is widely cultivated in the temperate and subtropical regions and also in many part of the tropics (Purseglove, 1987). Recently the feasibility of cultivating this crop in different parts of Bangladesh has been started in a small scale (Rashid, 1993). Because of high nutritive value, good taste and wide range of use, the popularity of french bean is increasing day by day in Bangladesh. It is a nutritious vegetable containing protein, carbohydrates, fibre, minerals, vitamins etc. essential for human health (Aykroyd, 1963). As a legume roots of French bean root system has nodules with nitrogen fixing bacteria. It can also be used in the crop rotation system in the field. Soil nutrient content and nutrient management is a key factor for crop production. Phosphorus is a major essential plant nutrient. Parodi *et al*, (1977) observed that 50 kg P ha⁻¹ was the maximum requirement for french bean. Eira *et al*, (1974) revealed that the economic rate of P application for French bean was 55 kg ha⁻¹. Like other rabi crops it also requires irrigation. The irrigation and phosphorus

¹Lecturer, Dept. of Soil Science, ²Professor, Dept. of Agricultural and Industrial Engineering HSTU, Dinajpur, ³Scientific Officer, Soil Science Division, RARS, Ishurdi, Pabna, ⁴Principal Scientific Officer and ⁵Scientific Officer, Soil Science Division, BARI, Gazipur, Bangladesh

management influences production of French bean. Different irrigation levels and depth of P placement increases the yield of pea (IARI, 1997). The present investigation has been therefore under taken to find out the appropriate irrigation schedule and phosphorus placement method for French bean production.

MATERIALS AND METHODS

A field experiment with french bean was conducted at the Regional Agricultural Research Station (RARS), Hathazari, (AEZ-18) during rabi seasons 2005-2006 and 2006-2007. Twelve treatment combination comprising 4 levels of irrigation (I_0 : no irrigation, I_1 : one irrigation at vegetative stage, I_2 : two irrigations; the first one at vegetative and the second one at flowering stage and I_3 : three irrigations; the first one at vegetative, the second one at flowering and the third one at pod development stage) and 3 levels of phosphorus placement (P_1 : broadcast, P_2 : same furrow placement and P_3 : side placement) were assigned in a split plot design with three replications. Phosphorus placement was assigned in the main plot and irrigation in the sub plot. The unit plot size was $4 \times 3 \text{ m}^2$ and planting space was $25 \text{ cm} \times 15 \text{ cm}$. Chemical properties of initial soil sample of the experimental field are presented in Table 1.

Table 1. Chemical properties of initial soil

| pH | OM(%) | Ca | Mg | K | Total N% | P | S | B | Cu | Fe | Mn | Zn |
|----------------|-------|-----|-----|------|----------|----|----|-----|-----|------|----|-----|
| | | | | | | | | | | | | |
| 6.1 | 1.6 | 3.1 | 1.0 | 0.09 | 0.06 | 41 | 25 | 0.2 | 1.9 | 10.8 | 12 | 2.5 |
| Critical level | | 2.0 | 0.8 | 0.2 | - | 14 | 14 | 0.2 | 1.0 | 10 | 5 | 2.0 |

Fertilizer was applied at the rate of 150-50-80-10-2 and 1 kg ha^{-1} of N, P, K, S, Zn and B, respectively. One third nitrogen and the whole amount of N, P, K, S, Zn and B was applied during final land preparation and remaining nitrogen was applied in two equal splits at 25 and 40 DAE. The experiment was sown on 10 November, 2006 with variety BARI French bean-2. Harvesting was started on 27 February and continued up to 07 March, 2007. Data on yield and yield contributing characters were recorded and statistically analyzed.

RESULTS AND DISCUSSION

Effect of irrigation

Different levels of irrigation had significant influence for all the studied characters of French bean except plant height and pod breadth during 2005-06 and except plant height during 2006-07 (Table 2 and 3). The maximum number of pods plant^{-1} (18.16 and 14.87) was observed with treatment I_3 and minimum number (16.40 and 13.33) with treatment I_0 in both the year respectively. Pod weight plant^{-1} was found maximum (54.17 g and 48.54 g) in the same treatment during 2005-06 and 2006-07. Reduced number of pods per plant due to water stress was also reported in field bean (Petersen, 1989). The highest significant pod yield 12.40 t ha^{-1} and 11.94 t ha^{-1} (2005-06 and 2006-07) were obtained with three irrigation (I_3). Higher number of pods and pod weight per plant had contributed to the higher yield of French bean Rahman *et al.* (2000) reported an increase in green pod yield in edible podded pea with an increase in irrigation frequency.

Table: 2 Effects of different levels of irrigation on the growth and yield of French bean at RARS, Hathazari during 2005-2006

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pods plant ⁻¹ (no.) | Pod weight plant ⁻¹ (g) | Pod yield (t ha ⁻¹) |
|----------------|-------------------|-----------------|------------------|--------------------------------|------------------------------------|---------------------------------|
| I ₀ | 34.97 | 11.31 | 1.07 | 16.40 | 31.42 | 9.56 |
| I ₁ | 40.21 | 13.22 | 1.19 | 17.42 | 45.37 | 10.97 |
| I ₂ | 41.50 | 13.25 | 1.20 | 17.87 | 50.40 | 11.91 |
| I ₃ | 42.20 | 13.68 | 1.32 | 18.16 | 54.17 | 12.40 |
| CV(%) | 6.09 | 5.56 | 6.36 | 5.97 | 7.20 | 7.8 |
| LSD(0.05) | NS | 1.94 | NS | 1.68 | 10.80 | 1.12 |

Table: 3 Effects of different levels of irrigation on the growth and yield of French bean at RARS, Hathazari during 2006-2007

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pods plant ⁻¹ (no.) | Pod weight plant ⁻¹ (g) | Pod yield (t ha ⁻¹) 2006-07 |
|----------------|-------------------|-----------------|------------------|--------------------------------|------------------------------------|---|
| I ₀ | 37.63 | 12.55 | 0.87 | 13.33 | 29.85 | 9.63 |
| I ₁ | 40.23 | 12.86 | 0.95 | 13.95 | 33.77 | 10.45 |
| I ₂ | 41.82 | 13.73 | 1.01 | 14.46 | 44.69 | 11.26 |
| I ₃ | 42.63 | 13.98 | 1.08 | 14.87 | 48.54 | 11.94 |
| CV(%) | 8.70 | 10.84 | 7.68 | 5.40 | 9.70 | 6.59 |
| LSD(0.05) | NS | 0.91 | 0.113 | 0.616 | 4.96 | 0.62 |

Effect of phosphorus placement

French bean responded significantly to different placement methods of phosphorus. The maximum number of pods per plant 18.79 and 14.31 were recorded with treatment P₂ (same furrow placement) during 2005-06 and 2006-07. Pod weight per plant was found maximum (48.55 g and 42.09 g) in the same treatment for both the years. The significantly highest pod yield (11.92 t ha⁻¹ and 11.56 t ha⁻¹) was recorded with treatment P₂ for both the years (Table 4 and 5). These findings are in agreement with the findings of IARI, 1997.

Interaction effect

The interaction effect of irrigation and phosphorus placement had no significant effect on french bean (Table 6 and 7). However highest pod yield was obtained from P₂I₃ treatment in both the years, respectively.

Water use efficiency

Water use efficiency (WUE) indicates the economic yield achieved per unit amount of water used. The total water use by French bean varied with the variation of irrigation water applied to the soil. The total water use varied from 168 mm to 247 mm. Total water use was highest with the treatment I₃ (247 mm) and the lowest in I₀ (168 mm).

Table 4. Effects of phosphorus placement methods on the growth and yield of French bean

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pods plant ⁻¹ (no.) | Pod weight/ plant (g) | Pod yield (t ha ⁻¹) |
|----------------|----------------------|--------------------|------------------------|-----------------------------------|-----------------------------|------------------------------------|
| P ₁ | 39.02 | 12.60 | 1.15 | 17.29 | 43.47 | 10.81 |
| P ₂ | 40.49 | 13.31 | 1.24 | 18.79 | 48.55 | 11.92 |
| P ₃ | 38.90 | 12.68 | 1.19 | 17.31 | 43.99 | 10.89 |
| CV(%) | 6.09 | 5.56 | 6.36 | 5.97 | 7.20 | 7.8 |
| LSD (0.05) | NS | 0.817 | NS | 1.24 | 4.37 | 1.04 |

Table 5. Effects of phosphorus placement methods on the growth and yield of French bean

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pods plant ⁻¹ (no.) | Pod weight/ plant (g) | Pod yield (t ha ⁻¹) 2005-06 | Pod yield (t ha ⁻¹) 2006-07 |
|----------------|-------------------------|-----------------------|------------------------|--------------------------------------|-----------------------------|---|---|
| P ₁ | 39.63 | 12.57 | 0.93 | 14.08 | 38.17 | 10.81 | 10.32 |
| P ₂ | 41.91 | 14.03 | 1.02 | 14.31 | 42.09 | 11.92 | 11.56 |
| P ₃ | 40.19 | 13.24 | 0.98 | 14.06 | 37.54 | 10.89 | 10.28 |
| CV(%) | 8.70 | 10.84 | 7.68 | 5.40 | 9.70 | 7.8 | 6.59 |
| LSD (0.05) | NS | NS | NS | 0.224 | 3.12 | 1.04 | 0.77 |

Table 6. Interaction effect of irrigation and phosphorus placement on growth and yield of French bean during 2005-2006

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pod plant ⁻¹ (no.) | Pod wt. plant ⁻¹ (g) | Pod yield (t ha ⁻¹) |
|--|----------------------|--------------------|------------------------|----------------------------------|------------------------------------|------------------------------------|
| T ₁ = P ₁ I ₀ | 34.63 | 10.94 | 1.06 | 15.67 | 30.07 | 9.01 |
| T ₂ = P ₁ I ₁ | 34.95 | 11.18 | 1.08 | 17.55 | 30.44 | 9.28 |
| T ₃ = P ₁ I ₂ | 35.33 | 11.80 | 1.12 | 17.99 | 32.94 | 10.39 |
| T ₄ = P ₁ I ₃ | 38.61 | 12.57 | 1.78 | 18.15 | 50.56 | 10.72 |
| T ₅ = P ₂ I ₀ | 41.63 | 13.01 | 1.14 | 17.51 | 42.51 | 10.77 |
| T ₆ = P ₂ I ₁ | 40.39 | 14.07 | 1.26 | 18.59 | 43.03 | 11.40 |
| T ₇ = P ₂ I ₂ | 40.72 | 14.45 | 1.30 | 18.87 | 51.37 | 11.97 |
| T ₈ = P ₂ I ₃ | 40.29 | 14.53 | 1.34 | 19.54 | 52.34 | 12.24 |
| T ₉ = P ₃ I ₀ | 43.49 | 12.77 | 1.17 | 16.20 | 40.49 | 10.51 |
| T ₁₀ =P ₃ I ₁ | 42.47 | 13.03 | 1.26 | 17.93 | 53.11 | 11.34 |
| T ₁₁ =P ₃ I ₂ | 41.91 | 13.98 | 1.35 | 18.24 | 56.80 | 11.91 |
| T ₁₂ =P ₃ I ₃ | 41.98 | 14.04 | 1.35 | 18.70 | 57.60 | 11.95 |
| CV(%) | 6.09 | 5.56 | 6.36 | 5.97 | 7.20 | 7.8 |
| LSD (0.05) | NS | NS | NS | NS | NS | NS |

Table 7. Interaction effect of irrigation and phosphorus placement on growth and yield of French bean during 2006-2007

| Treatments | Plant height (cm) | Pod length (cm) | Pod breadth (cm) | Pod plant ⁻¹ (no.) | Pod wt. plant ⁻¹ (g) | Pod yield (t ha ⁻¹) 2005-06 | Pod yield (t ha ⁻¹) 2006-07 |
|-------------------------------|-------------------|-----------------|------------------|-------------------------------|---------------------------------|---|---|
| P ₁ I ₀ | 37.50 | 11.86 | 0.87 | 13.19 | 29.02 | 9.01 | 9.32 |
| P ₁ I ₁ | 39.08 | 12.39 | 0.92 | 13.96 | 32.41 | 9.28 | 9.98 |
| P ₁ I ₂ | 40.89 | 12.80 | 0.96 | 14.41 | 42.98 | 10.39 | 11.02 |
| P ₁ I ₃ | 41.44 | 13.22 | 0.98 | 14.77 | 48.29 | 10.72 | 11.25 |
| P ₂ I ₀ | 38.06 | 13.41 | 0.92 | 13.64 | 31.69 | 10.77 | 11.03 |
| P ₂ I ₁ | 41.92 | 13.93 | 0.98 | 14.02 | 38.25 | 11.40 | 11.15 |
| P ₂ I ₂ | 43.36 | 14.36 | 1.02 | 14.55 | 47.34 | 11.97 | 11.84 |
| P ₂ I ₃ | 44.31 | 14.43 | 1.16 | 15.03 | 49.39 | 12.24 | 12.06 |
| P ₃ I ₀ | 37.73 | 12.39 | 0.82 | 13.15 | 28.84 | 10.51 | 9.83 |
| P ₃ I ₁ | 39.68 | 12.26 | 0.94 | 13.88 | 30.65 | 11.34 | 10.22 |
| P ₃ I ₂ | 41.22 | 14.02 | 1.04 | 14.42 | 43.19 | 11.91 | 10.91 |
| P ₃ I ₃ | 42.14 | 14.28 | 1.11 | 14.78 | 48.30 | 11.95 | 11.16 |
| CV(%) | 8.70 | 10.84 | 6.36 | 5.40 | 9.70 | 7.8 | 6.59 |
| LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |

The highest water use efficiency varied from 46.52 to 57.32 kg ha⁻¹/mm. The highest water use efficiency (57.32 kg ha⁻¹/mm) was obtained with non-irrigated condition (Table 8). Soil water depletion was decreased with increased irrigation water. Khade *et al.* (1990) reported increased WUE with increase in irrigation frequency while Nandan and Prasad (1998) found the maximum WUE with one irrigation than 2 or 3 irrigations in French bean.

Table 8. Water use efficiency of French bean under different level of during 2006-2007

| Treatment | No of irrigation | Irrigation water applied (mm) | Effective rainfall (mm) | Soil moisture depletion (mm) | Total water use (mm) | Water use efficiency (kg ha ⁻¹ mm) |
|----------------|------------------|-------------------------------|-------------------------|------------------------------|----------------------|---|
| I ₀ | 0 | 0 | 9.0 | 159 | 168 | 57.32 |
| I ₁ | 1 | 40 | 9.0 | 147 | 196 | 53.32 |
| I ₂ | 2 | 80 | 9.0 | 132 | 221 | 50.95 |
| I ₃ | 3 | 120 | 9.0 | 118 | 247 | 46.52 |

CONCLUSION

From two years result, it may be recommended that three irrigations; the first one at vegetative, the second one at flowering and the third one at pod development stage and same furrow placement of phosphorus are suitable for french bean cultivation in Young Meghna Estuarine Floodplain (AEZ-18) soils.

REFERENCES

- Aykroyd WR. 1963. ICMR Special Rept. Series 42. (Cited from Vegetable Crops. eds. Bose, T.K.; M.G. Som and J. Kabir. 1993. Nays Prokash, 206 Bidhan Sarani, Calcutta 700006, India).
- Eira PADa, Pessanha GG, Britto DPPDe S and Carbajal AR. 1974. Pesquisa gropecuasias Brasileira, 9: 121-124. (Cited from Vegetable Crops. eds. Bose, T.K.; M.G. Som and J. Kabir. 1993. Nays Prokash, 206 Bidhan Sarani, Cacutta 700006, India).
- IARI (Indian Agricultural Research Institute) 1997. Effect of different irrigation levels and depth of P placement on the yield and water use efficiency of pea. IARI annual report, 1997.pp. 62-63.
- Khade VN, Patil BP, Talathi PG and Khanvilkar SA. 1990. Response of field bean to irrigation at critical growth stages. Horticultural Abst. 60(8): 712.
- Nandan R and Prasad UK. 1998. Effect of irrigation and nitrogen on growth, yield, nitrogen uptake and water-use efficiency of French bean (*Phaseolus vulgaris*). Indian J. Agril. Sci. 67 (11) : 75-80.
- Parodi AE, Opazo AJD and Mosjidis CH J. 1977. Agriculture Tecnica, 37: 12-18. (Cited from Vegetable Crops. eds. Bose, T.K.; M.G. Som and J. Kabir. 1993. Nays Prokash, 206 Bidhan Sarani, Cacutta 700006, India).
- Petersen ACJr. 1989. Effect of water stress on *Phaseolus vulgaris* L. and *Phaseolus acutifolius* var. *Latifolius*. Horticultural Abst. 59(4) : 333.
- Purseglove JW. 1987. Tropical crops. Dicotyledons. Longman, New York. pp. 132-136.
- Rahman MH, Khaliq QA, Hamid A, Miajh MNI and Haque MM. 2000. Irrigation and planting density effects on dry matter production and yield in edible podded pea. Bangladesh. J. Agril. Res. 25(1) : 161-167.
- Rashid MM. 1993. Sabjii Biggan (in Bengali). Ist ed. Bangla Academy. Bangladesh. pp. 387-390.
- Swaidar JM, Ware GW and Mc Collum JP.. 1992. Producing vegetable crops. 4th ed. Interstate Publishers. Inc. Danville, Illinois, USA. pp. 233-249.