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AGRONOMY

Response of land configurations, IW/CPE ratios and integrated nutrient supply systems on growth function, yield and water use efficiency of French bean (*Phaseolus vulgaris* L. PDR-14)

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Abstract

Field experiments were conducted during two consecutive years of 2010-11 and 2011-12 at Agronomy Research Farm of NDUA&T, Faizabad (UP.) India to study the response of land configurations, IW/CPE ratios and integrated supply systems on growth function, yield and nutrient study of french bean (*Phaseolus vulgaris* L.) under indo-gangetic eastern plains zone of Uttar Pradesh. Significant increase was observed for plant height, number of branches and dry matter accumulation per plant at 60 and 90 days after sowing and at harvest under 1.0 IW/CPE moisture regime nourished with 75% RDF through chemical fertilizers + 25% N through biocompost at raised bed configuration. Higher growth attributes resulted maximum yield and yield attributes of French bean with sowing at raised beds, application of 75% RDF+25% N through biocompost and IW/CPE ratio of 1.0 as compared to rest of the treatments. Increasing moisture regimes decreased the water use efficiency and it was highest under sowing on raised beds, moisture regime at 0.6 IW/CPE ratio and 75 % RDF through chemical fertilizers + 25 % N through biocompost nutrient supply system. Higher yields of French bean was obtained with treatment combinations of sowing on raised beds, moisture regime at 1.0 IW/CPE ratio and 75 % RDF through chemical fertilizers + 25 % N through biocompost and it was most remunerative and sustainable under Indo-gangetic plains of UP.

Highlights

- Under raised bed land configuration growth functions and yields were more under 1.0 IW/CPE ratio moisture regime coupled with the application of 75% RDF + 25% N through biocompost nutrient supply system.
- Increasing frequency of irrigation at various growth stages decreased efficient utilization of water and water use efficiency (WUE) was maximum under 0.6 moisture regime where less amount of water was applied.

Keywords: IW/CPE ratio, integrated supply system, growth, yield, and water use efficiency.

In India, French bean was grown on an area of 10.8 mha., production of 4.87 mt. and productivity of 450.9 kg ha^{-1} during 2010-11 (www.faostat.org). The stagnation in the production of pulses was noted over the past two decades. This is mainly attributed due to the low yield

Table 1. Response of land configurations, IW/CPE ratios and integrated nutrient supply systems on growth attributes of French bean (Two years pooled data).

Treatment	Plant height (cm)			Number of branches plant^{-1}			Dry matter accumulation plant^{-1}(g)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
Land configuration									
Flat Bed	31.50	40.77	44.90	3.08	4.07	4.09	9.05	12.65	14.46
Raised Bed	42.60	52.84	58.25	4.01	5.31	5.33	11.79	16.44	18.78
S.Em.±	0.26	0.28	0.31	0.03	0.04	0.04	0.09	0.25	0.28
C.D. at 5%	0.81	0.90	0.99	0.10	0.13	0.13	0.30	0.78	0.89
Moisture regimes (IW/CPE ratios)									
0.6	32.92	41.85	46.08	3.12	4.13	4.15	9.18	12.99	14.83
0.8	36.97	46.66	51.44	3.55	4.69	4.72	10.44	14.51	16.58
1.0	41.25	51.90	57.20	3.96	5.24	5.26	11.64	16.14	18.44
S.Em.±	0.31	0.35	0.38	0.04	0.05	0.05	0.11	0.30	0.34
C.D. at 5%	0.99	1.10	1.21	0.12	0.16	0.16	0.36	0.95	1.09
Nutrient Substitution									
100% RDF (120:60:40 kg NPK ha^{-1})	42.57	53.15	58.85	4.07	5.28	5.31	11.96	15.97	18.25
75 % RDF + 25 % N through FYM.	36.59	45.88	50.79	3.53	4.60	4.62	10.37	14.60	16.68
50 % RDF + 50 % N through FYM.	30.43	37.84	41.86	2.91	3.80	3.81	8.56	12.12	13.85
75 % RDF + 25 % N through Biocompost.	43.84	56.18	61.02	4.16	5.65	5.68	12.32	16.73	19.11
50 % RDF + 50 % N through Biocompost	32.82	40.98	45.35	3.17	4.12	4.14	9.29	13.32	15.21
S.Em.±	0.16	0.20	0.22	0.01	0.02	0.02	0.04	0.19	0.22
C.D. at 5%	0.46	0.58	0.63	0.04	0.05	0.05	0.11	0.56	0.65

Table 2. Response of land configurations, IW/CPE ratios and integrated nutrient supply systems on yield attributes and yield of French bean (Two years pooled data).

Treatments	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Seed Yield (q/ha)	Haulm Yield (q/ha)
Land configuration					
Flat Bed	8.62	7.19	4.64	17.67	25.30
Raised Bed	11.18	9.26	6.02	22.95	34.28
S.Em.±	0.06	0.05	0.03	0.34	0.61
C.D. at 5%	0.19	0.15	0.10	1.08	1.93
Moisture regimes (IW/CPE ratios)					
0.6	8.85	7.37	4.76	18.13	25.97
0.8	9.87	8.24	5.32	20.26	29.65
1.0	10.98	9.05	5.91	22.54	33.74
S.Em.±	0.07	0.06	0.04	0.42	0.75
C.D. at 5%	0.23	0.18	0.13	1.33	2.36
Nutrient Substitution					
100% RDF (120:60:40 kg NPK ha^{-1})	10.56	8.80	5.83	22.48	34.05
75 % RDF + 25 % N through FYM.	9.82	8.14	5.25	20.27	28.93
50 % RDF + 50 % N through FYM.	8.10	6.75	4.33	16.83	23.00
75 % RDF + 25 % N through Biocompost.	12.24	10.15	6.55	23.47	36.99
50 % RDF + 50 % N through Biocompost	8.77	7.27	4.69	18.49	25.96
S.Em.±	0.04	0.04	0.02	0.28	0.60
C.D. at 5%	0.12	0.12	0.06	0.80	1.70

potential of pulses. For increasing overall production, besides increasing area and productivity of traditional pulses attention also needs to be paid for introduction of non-traditional pulses (Gupta, et.al. 1996). French bean (*Phaseolus vulgaris* L.) is one of the important pulse crops, which has a high yield potential of 18 to 25 q ha^{-1} depending upon cultivar. Sowing on raised bed also has edge over flat sowing particularly under saline and alkali conditions, because it leads to shifting of salts besides the raised bed, leaving a salt free space for good crop stand at early stages of crop growth and facilitates microbial activities. Good aeration leads to easy and hasten rate of mineralization with greater nutrient and water use efficiencies. Lack of awareness among the farmers about the consequences of irrational use of water and lack of appropriate tools and instruments for regulated and uniform application of the desired quantity of water at the appropriate time are the major causes of low water-use efficiency at the field-level (Prihar *et. al.* 1974). Further, suggested that an IW/CPE ratio approach is relatively more practical than other meteorological approaches. French bean respond well to inorganic fertilizers especially nitrogen because it does not nodulate either with native rhizobia or with commercially produced cultures. Inoculation with specific strains of *Rhizobium phaseoli* is necessary to overcome one of the limitations in the establishment of French bean (*Phaseolus vulgaris* L.) in India (Gaur and Rao, 1984). Therefore a study was conducted to enumerate the exact irrigation schedule, integration of organic and inorganic manures and land configuration under problem soils avoiding salinity hazards.

Materials and Methods

A field experiment was conducted during two consecutive years of 2010-11 and 2011-12 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP.) to study the impact of abiotic stress on growth, yield and moisture utilization pattern of French bean under saline-alkali soils of UP. Geographically, experimental site falls under sub-tropical zone in Indo-gangetic plains having alluvial calcareous soils and lies between 26.47°N latitude and 82.12°E longitude at an altitude of 113.0 meters above the mean sea level. The region receives mean annual precipitation of about 1280 mm. Out of which nearly 80% is received from mid June to end of September. The winter season is very cold, where as summer are hot and dry. Westerly hot winds start from the end of April and continue till the onset of monsoon. The treatment combinations comprised with two land configuration viz., M_1- flat and M_2- raised bed, three irrigation schedules (I_1-0.6, I_2-0.8 and I_3-1.0 IW/CPE ratio) and five nutrient supply system (S_1- 100 % RDF as 120:60:40 kg/ha NPK through chemical fertilizers, S_2- 75 % RDF + 25 % N through FYM, S_3- 50 % RDF + 50 % N through FYM, S_4- 75% RDF + 25 % N through biocompost and S_5- 50 % RDF + 50 % N through biocompost) were conducted with split plot design where land configuration and irrigation schedules were allocated to main plots while nutrient supply system were assigned to sub plots and replicated thrice. The experimental soil was silty loam (silt >56 %) in texture with indicating slightly alkaline in reaction with medium in organic carbon (0.28-0.32 %), low in available nitrogen (107.50-118.15 kg ha^{-1}) and medium in phosphorus (15.78-18.25 kg ha^{-1}) and high in available potassium (245.70-285.90 kg ha^{-1}). French bean cultivar PDR-14 was sown in first fortnight of October with aforesaid treatment and their combinations with 30×10 row to row and plant to plant spacing. Crop was fertilized as per respective treatments where half of inorganic N, full phosphorus, potash and organic N were applied at the time of sowing and remaining half nitrogen in two installments one at after first irrigation and second at pod initiation stage. Gap filling and thinning were done wherever necessary and harvesting was done when crop was fully matured. Observations on growth characters viz., plant height, number of branches, dry matter accumulation per plant at 60, 90 DAS and at harvest and yield attributes (number of pods, pod length and number of seeds per pod), yield (seed and haulm $ha.^{-1}$) at harvest stage were recorded. Moisture utilization pattern and water use efficiency were also computed according to prescribed method as suggested by Ramdas, (1957).

Table 3. Responce of different moisture regimes on total water use (TWU) of French bean.

Moisture Regimes (IW/ CPE Ratio)	Number of Irrigation	Depth Of Irrigation (cm)	Total Water Applied (cm)	Effective Rainfall (cm)	Total Water Use (cm)
2010-11					
0.6	2	5	10	1.65	11.65
0.8	3	5	15	1.65	16.65
1.0	4	5	20	1.65	21.65
2011-12					
0.6	2	5	10	8.04	18.04
0.8	3	5	15	8.04	23.04
1.0	4	5	20	8.04	28.04

Table 4. Response of different treatment combinations on water use efficiency of French bean.

Treatment combinations	Consumptive Use (cm)		Grain yield (kg/ha)		Water Use Efficiency ($kg^{-1}ha^{-1}cm$)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
$M_1I_1S_1$	24.17	25.91	1531	1817	63.34	70.13
$M_1I_1S_2$	24.17	25.91	1380	1639	57.10	63.26
$M_1I_1S_3$	24.17	25.91	1193	1312	49.36	50.64
$M_1I_1S_4$	24.17	25.91	1568	1928	64.87	74.41
$M_1I_1S_5$	24.17	25.91	1310	1442	54.20	55.65
$M_1I_2S_1$	31.62	33.62	1800	2138	56.93	63.59
$M_1I_2S_2$	31.62	33.62	1623	1928	51.33	57.35
$M_1I_2S_3$	31.62	33.62	1404	1544	44.40	45.93
$M_1I_2S_4$	31.62	33.62	1845	2268	58.35	67.46
$M_1I_2S_5$	31.62	33.62	1542	1697	48.77	50.48
$M_1I_3S_1$	46.88	48.46	2046	2402	43.64	49.57
$M_1I_3S_2$	46.88	48.46	1845	2167	39.36	44.72
$M_1I_3S_3$	46.88	48.46	1595	1735	34.02	35.80
$M_1I_3S_4$	46.88	48.46	2096	2549	44.71	52.60
$M_1I_3S_5$	46.88	48.46	1752	1907	37.37	39.35
$M_2I_1S_1$	24.17	25.91	2176	2503	90.03	96.60
$M_2I_1S_2$	24.17	25.91	1962	2257	81.18	87.11
$M_2I_1S_3$	24.17	25.91	1697	1807	70.21	69.74
$M_2I_1S_4$	24.17	25.91	2230	2655	92.26	102.47
$M_2I_1S_5$	24.17	25.91	1864	1986	77.12	76.65
$M_2I_2S_1$	31.62	33.62	2341	2691	74.04	80.04
$M_2I_2S_2$	31.62	33.62	2110	2427	66.73	72.19
$M_2I_2S_3$	31.62	33.62	1825	1943	57.72	57.79
$M_2I_2S_4$	31.62	33.62	2398	2855	75.84	84.92
$M_2I_2S_5$	31.62	33.62	2004	2136	63.38	63.53
$M_2I_3S_1$	46.88	48.46	2572	2957	54.86	61.02
$M_2I_3S_2$	46.88	48.46	2319	2667	49.47	55.04
$M_2I_3S_3$	46.88	48.46	2005	2136	42.77	44.08
$M_2I_3S_4$	46.88	48.46	2635	3137	56.21	64.73
$M_2I_3S_5$	46.88	48.46	2202	2347	46.97	48.43

Results and Discussion

Growth characters

Land configurations, irrigation schedules and nutrient supply system significantly influenced the growth characters (Table 1). The plant height, number of branches, dry matter accumulation per plant at 60 and 90 days after sowing and at harvest were obtained significantly higher when crop was sown on 15 cm raised bed as compared to flat bed land configuration. These results are in close conformity with results reported by Sangakkara (2004). IW/CPE ratio of 1.0 produced significantly higher plant height at 60, 90 days after sowing and at harvest as compared to other IW/CPE ratios. It was followed by irrigation at 0.8 than 0.6 IW/CPE ratio irrigation schedules. At 60, 90 days after sowing and at harvest growth stages the values of number of branches and amount of dry matter accumulation were significantly more when French bean was irrigated at 1.0 IW/CPE ratio irrigation schedules which was followed by 0.8 and 0.6 IW/CPE ratio irrigation schedules. Similar findings were also reported by Jukte et al (2007). Plant height and number of branches per plant at 60 and 90 days after sowing and at harvest were increased significantly with the application of 75% RDF + 25 % N through biocompost followed by 100 % RDF (120:60:40 kg/ha NPK), 75% RDF + 25 % N through FYM and 50 % RDF + 50% N through biocompost nutrient supply system. Significantly more dry matter accumulation per plant at 60 and 90 days after sowing and at harvest was recorded with 75% RDF + 25% N through biocompost as compared to 100 % RDF (120:60:40 kg/ha NPK), 75% RDF + 25% N through FYM and 50% RDF + 50 % N through biocompost nutrient supply systems. This might be due to slow and steady supply and availability of nutrients through biocompost and FYM with accelerated mineralization under raised bed condition coupled with increased solubility at 1.0 IW/CPE ratio moisture regime. These results are in accordance with the findings of Singh *et al.* (2011).

Yield and yield attributes

Land configurations, irrigation schedules and nutrient supply system significantly influenced the yield and yield attributes (Table 2). Significantly more number of pods per plant, pod length and number of seeds per pod were recorded under raised bed land configuration as compared to flat bed method. Different land configuration revealed that significantly more seed yield, haulm yield were obtained under raised bed land configuration as compared to flat land configuration. Significantly more number of pods per plant, pod length and number of seeds per pod were obtained when crop was irrigated four times under 1.0 IW/CPE ratio than that obtained at 0.8 and 0.6 during both the years of trials. These results are in close conformity with results reported by Sangakkara (2004). Significant increase in number of pods per plant, number of seeds per pod and pod length with four irrigations applied at 1.0 IW/CPE ratio might have resulted significantly higher seed yield under 1.0 IW/CPE ratio than that obtained under 0.8 and 0.6 IW/CPE ratios. Significantly taller plants, more number of branches and greater dry matter accumulation under 1.0 IW/CPE ratio might have led to significantly higher haulm yield, when crop was given four irrigations as compared to delayed and lesser irrigations under 0.8 and 0.6 IW/CPE ratios. Similar results are in close conformity with the findings of Kundu and Sarkar (2009). Significantly more number of pods per plant, pod length and number of seeds per pod, seed and haulm yield were achieved with the application of 75% RDF + 25% N through biocompost followed by 100% RDF (120:60:40 kg/ha NPK), 75% RDF + 25 % N through FYM and 50% RDF + 50% N through biocompost nutrient supply system. The source of manure and fertilizers might be creating clear distinction by making quicker and sustainable availability and supply with combined application of inorganic and organic manures. The increase in yield and yield attributes of French bean may be because of organic sources of manure take enough time to decompose the waste material causing delay in

appearance of impact at varying degree of solubility. Similar results were also reported by Kumar *et al.* (2009) and Subbaiah *et al.* (2009).

Water use efficiency (WUE)

Data revealed (Table 3 and 4) that, increasing moisture regimes from 0.6 to 1.0 IW/CPE ratio increases the total water received from 11.65 to 21.65 cm and 18.04 to 28.04 cm during 2010-11 and 2011-12 respectively. Increase in total water utilization further increased the consumptive use of water which was highest under 1.0 IW/CPE ratio during both the years of study. This results in higher grain yield from 0.6 to 1.0 IW/CPE ratio moisture regime. Water use efficiency ($kg^{-1}ha^{-1}cm$) was decreased with increasing moisture regimes from 0.6 to 1.0 IW/CPE ratio. Treatment combinations of $M_2I_1S_4$ viz. sowing on raised beds, moisture regime at 1.0 IW/CPE ratio and 75% RDF through chemical fertilizers + 25% N through biocompost was found to be most efficient utilizer of water for sustainable seed yield of French bean. Kundu and Sarkar (2009) found that the soil water play crucial role in yield and water use pattern of pulse crops and noted highest water use efficiency with lesser IW/CPE ratio of moisture regime.

Conclusion

Higher yields of French bean can be obtained under moisture regime of 1.0 IW/CPE ratio with application of 75% RDF through chemical fertilizers + 25% N through biocompost nutrient supply system. Sowing at fifteen cm high raised beds was proven to be most effective against water stagnation and alkalinity stress condition. Highest water use efficiency was obtained under treatment combination of $M_2I_1S_1$ (92.26 and 96.60 $kg^{-1}ha^{-1}cm$) and $M_2I_1S_4$ (90.03 and 102.47 $kg^{-1}ha^{-1}cm$) during 2010-11 and 2011-12, respectively.

References

Gaur, Y.D. and Rao, Subba N.S., 1984. The need for Rhizobium phaseoli inoculation to eastablish amarican beans in India. *Current Science* **53**: 430.

Gupta, P.K., Kalyan singh, Singh, U.N., Singh, R.N. and Bohra, J.S., 1996. Effect of moisture regime and fertility level on growth, yield, nutrient turnover and moisture use by French bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Science* **66:** 343-347.

Jukte, V. D., Lad, N. G., Aghav, V. D., Ingle, A. U. and Karad, M. L., 2007. Response of French bean to varying land layout and irrigation schedules. *Journal of Soils and Crops* **17**(1): 78-81.

Kumar, R. P., Singh, O. N., Singh,Yogeshwar, Dwivedi, Sachchidanand and Singh, J. P., 2009. Effect of integrated nutrient management on growth, yield, nutrient uptake and ecnomics of french bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Sciences* **79**(2): 122-128.

Kundu, M. and Sarkar, S., 2009. Growth and evapotranspiration pattern of rajmash (*Phaseolus vulgaris* L.) under varying irrigation schedules and phosphate levels in a hot sub-humid climate. *Agricultural Water Management* **96**(8): 1268-1274.

Prihar, S.S., Gajri, P.R. and Narang, R.S., 1974: Scheduling irrigation to wheat using open pan evaporation. *Indian Journal Agricultural Science* **44**: 567-571.

Ramdas, L.A., 1957: Evaporation and potential evapotranspiration over the Indian sub-continent. *Indian Journal of Agricultural Science* **27**: 137-142.

Sangakkara, U. R., 2004: Effect of tillage and moisture levels on growth, yield and nodulation of common bean (*Phaseolus vulgaris*) and mungbean (*Phaseolus radiatus*) in the dry season. *Indian Journal of Agronomics* **49**(1): 60-63.

Singh, B. K., Pathak, K. A., Verma, A. K., Verma, V. K. and Deka, B. C., 2011. Effects of vermicompost, fertilizer and mulch on plant growth, nodulation and pod yield of French bean (*Phaseolus vulgaris* L.). *Vegetable Crops Research Bulletin* **74**: 153-165.

Subbaiah, P. V., Venkaiah, K., Naidu, M. V. S. and Ramavatharam, N., 2009. Effect of integrated phosphorus management on dry matter production, pod yield, quality and N, P and K uptake of French bean (*Phaseolus vulgaris* L.) in alfisols of Tirupati. *Crop Research* **38**(1/3): 57-60.