Role of Irrigation and Nitrogen Levels on Yield, Nutrient Content, Uptake and Economics of French Bean (*Phaseolus vulgaris* L.) Under Middle Gujarat Condition

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A field experiment was conducted at Anand (Gujarat) during *rabi* season of the year 2013 on sandy loam soil (pH 7.2, OC 0.53 %, available nitrogen 242.32 kg ha^{-1}, available phosphorus 21.40 kg ha^{-1} and available potash 172.00 kg ha^{-1}) to evaluate the role of irrigation and nitrogen levels on yield, economic, nutrient uptake and content of French bean (*Phaseolus vulgaris* L.) crop. It consisted of twelve treatment combinations comparing of four irrigation scheduling (0.6, 0.8, 1.0 IW: CPE ratio and irrigation at branching, flowering, pod development and seed formation stages) three levels of nitrogen (80, 120 and 160 kg N ha^{-1}). The experiment was laid out in split plot design and it was replicated four times to evaluate the effect of irrigation scheduling and nitrogen levels on productivity and quality of French bean. The results revealed that application of irrigation at 1.0 IW: CPE has significant effect on seed (1205 kg ha^{-1}) straw (1523 kg ha^{-1}) yields, harvest index (43.81 %) and quality parameters like protein content (22.57%), N content (3.61%) and nitrogen uptake by seed (43.65) as well as available soil nitrogen (261.21 kg ha^{-1}) and economic retune, while maximum water use efficiency was noted in treatment where irrigation applied at 0.6 IW: CPE ratio. Among the different nitrogen levels, application of N applied at 120 kg ha^{-1} noted higher seed (1130 kg ha^{-1}) and straw (1465 kg ha^{-1}) yields, protein content (22.05 %), N content (3.53 kg ha^{-1}) and N uptake from seed (40.17 kg ha^{-1}), higher economic return, while application of nitrogen @ 160 kg ha^{-1} gave positive response to harvest index (43.90) and water use efficiency (4.92 kg ha mm^{-1}).

Keywords: French bean, Yield, Irrigation, Nitrogen and Water use efficiency.

India is the largest producer of pulses, accounting for about 25 per cent of the global share. French bean is an important non-traditional grain legume grown during *rabi* season for its tender green pods with high protein, carbohydrate, mineral, calcium and iron content. Modern agronomy plays a key role in production and sustainability of these pulses.

French bean, belongs to family of leguminosae and occupies a primer place among grain legumes in world including India, for its edible beans. In India, pulses are least preferred by farming because of high risk and less remunerative than cereals consequently the production of the pulses is sufficiently low and doesn't meet the daily requirement of the growing production.

Among the different strategies to increase pulses production, the introduction of promising pulse crop such as rajma (*phaseolus vulgaris* L.) to non-traditional areas holds on the options. Dry seed contain 22-25 % protein, 11.70 % fat and 70 % carbohydrates. The green pods contain 1-2.4 % protein. These common beans are annual plants are cultivated throughout the world for their edible beans.

Water is the main constituent of the protoplasm comparing upto about 90-95 percent of its total weight. In the absence of water,

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protoplasm becomes inactive and is even killed. Irrational use of water and lace of appropriate tools for regulated and uniform application of the desired quantity of water at appropriate time are the major cause of low water use efficiency at field level Prihar *et.al.* 1974 and Kumar and Singh 2014 also suggested that irrigation scheduling through IW: CPE ratio approach is relatively more practical than other meteorological approach. Different organic constitutes of the plants such as carbohydrates, protein, nucleic acid and enzymatic substance lose their physical and chemical properties in absence of water. Water participates directly in many metabolic processes. Water helps in maintain turgidity of cells which is must for proper activity of life. Water also regulates the temperature.

Irrigation is the artificial application of water to the land or soil. French bean is highly sensitive to soil water balance and slight stress may result in to reduced yield. Moisture stress at critical stages and lack of effective nodules are making way for lower yield of French bean crop (Dhar and Singh, 1995).

Scheduling irrigation to this crop is mostly based on physiological growth stages and the latest approach of scheduling irrigation through water depth: cumulative pan evaporation (IW: CPE) ratio has not yet been tried in almost states in India. Therefore, it is important to compare the previous methods with the latest approach of scheduling irrigation to identify the most suitable frequency, time and depth of irrigation for higher yield of French bean. However, results have revealed that high yield can obtained from French bean provided proper irrigation schedule based on IW: CPE ratio. Thus, proper irrigation schedule plays a significant role on yield and protein content of French bean.

Another limiting factor for the French bean production is fertility status of soil and nitrogen is one of the universal deficient plant nutrient in Indian soils. Nitrogen is one of the major integral part of chlorophyll, which is the primary factor absorber of light energy needed for photosynthesis. The supply of nitrogen to related carbohydrate utilization.

The objective of the study was to investigate the effect of the application of different levels of nitrogen, phosphorus and potassium on yield, nutrient content and uptake of French bean.

MATERIALS AND METHODS

The experiment was conducted on French bean at Agronomy Farm of Anand Agricultural University, Anand during *rabi* season of the year 2013. The soil of experimental site was loamy sand in texture with pH 7.12 low in organic carbon (0.53 %), nitrogen (242.32 kg ha^{-1}) and phosphorus (21.40 kg ha^{-1}) and medium in potash (172.0 kg ha^{-1}). The experiment was laid out in the split plot design consisting of twelve treatments i.e four levels of irrigation (I_1: 0.6 IW: CPE ratio; I_2: 0.8 IW: CPE ratio; I_3: 1.0 IW: CPE ratio and I_4: Irrigation at branching, flowering, pod development and seed formation stage) and three levels of nitrogen (N_1: 80kg ha^{-1}, N_2: 120 kg ha^{-1} and N_3: 160 kg ha^{-1}) with three replication. Irrigation water of 50 mm (measured with the help of Parshall flume) was allowed to run in each plot at each irrigation. Calculated quantity of N was applied through urea in two splits, while entire quantity of P with a basal dose of 60 kg P_2O_5 ha^{-1} through diammonium phosphate was applied at sowing. An early maturity French bean cultivar (Gujarat Rajma-1) was utilized for sowing purpose. All agronomical practices were adopted as per recommendation for the crop.

Data were recorded on French bean grain yield at harvesting time from individual plot base and convert into hectare. Take same sample for analysis of seed qualities analysis. For soil analysis take soil sample as per analytical processor from the individual experimental plot. Protein content in grains was determined by multiplying the total nitrogen content by empirical factor 6.25 (Mckenzie and Wallace, 1954), nitrogen content was estimated by Micro- Kjeldahl method (Jackson, 1973) and uptake of nitrogen was computed by multiplying corresponding yields of crop and the percent N (Jackson, 1973). The response of seed yield per unit of irrigation water used at varying levels was worked out by dividing per hectare seed yield obtained under various treatment with the total consumptive use of water (mm) of the respective treatment and it was recorded as Water use efficiency (kg ha-mm^{-1}) by yield (kg ha^{-1}) divided by evapotranspiration (mm).

RESULTS AND DISCUSSION

The data pertaining to seed and straw yields was significantly influenced by irrigation levels. Significantly the highest seed yield (1205 kg ha^{-1}) and significantly higher straw yield (1523 kg ha^{-1}) noted in treatment I_3 (1.0 IW: CPE ratio). The increasing seed yield under treatment I_3 was the tune of 42, 11.47 and 9.44 per cent over treatments I-$_1$, I_2 and $I_{4,}$ respectively. The increase in seed yield might be due to increase in irrigation frequency and consumptive use because of increased number of irrigations. Thus, there was progressive increase in seed yield due to favorable soil moisture condition and better availability of soil moisture at higher frequency of irrigation throughout the crop growth period, which remarkable stimulate the yield attributes and finally seed yield. The second reason might be due to increase in number of irrigation applied at shorter interval and total consumptive use of water. The remarkable increase in straw yield was mainly due to adequate moisture supply throughout the entire crop growth period, which resulted into better growth and development. The results are in agreement with Chaudhari *et.al.* (2010) and Reddy *et.al.* (2010).

Significantly higher harvest index (43.81 %) was observed in treatment I_3 (1.0 IW: CPE ratio) followed by I_2 and I_4 treatment. Increasing higher harvest index might be due to higher seed yield (Table.1). Water use efficiency refers largely to the production of economic produce of crop per unit of water used by it throughout the life of crop. Significantly higher water use efficiency (5.63 kg ha mm^{-1}) was observed under treatment I_1 (0.6 IW: CPE ratio). The water use efficiency decreased with succeeding critical crop growth stages as frequent irrigation applied under these treatment increased moisture loss due to evaporation. Lower water use efficiency associated with higher soil moisture status was probably due to proportionally greater increase in seasonal water use then those in the seed yield is always stain to be at potential rate under adequate water supply, while seed yield increase at decreasing rate. Similar results are observed by Dhar and Singh (1995) and Nandan and Prasad (1998).

Irrigation scheduling exhibited their significance on protein content. Treatment I_3 (1.0 IW: CPE ratio) recorded significantly higher protein content (22.57%) as compare to other irrigation treatment. Higher protein obtained under more number of irrigation might be due to higher availability of moisture in root zone, which enhanced absorption of nutrient during growth period. The results are in agreement with Gupta *et.al.* (1996). Date presented in Table-1 indicated that significantly higher nitrogen content in seed (3.61 %) and significantly the highest nitrogen uptake in seed (43.65 kg ha^{-1}) was recorded in I_3 (1.0 IW : CPE ratio) treatment. Higher nitrogen content in seed might be due to more number of irrigation attributed higher availability of moisture in the root zone, which enhanced absorption of nutrients. The increase in solubility of nutrients with increase in water content is also responsible for higher uptake of nutrients especially nitrogen. Secondly, the conductivity of the soil increases with the increase in moisture content of soil and vice-a-versa. Thus, nutrients which are moving along with the stream of moisture which is termed as mass flow transport of nutrient increases when conductivity of the soil is high. Therefore, it is obvious that when moisture content is more, the rate at which nutrients reach to root surface is high which in turn contributes to high N uptake. Higher uptake of nitrogen might be due to higher production of seed and straw yields under irrigation at 1.0 IW: CPE ratio. The results are in agreement with Gupta *et al.* (1996) in French bean crop and Hosamani and Janawade (2007) in groundnut crop.

A perusal of data presented in Table-1 indicated that irrigation levels did not affected on available nitrogen status after harvesting crop.

Effect of nitrogen level

Significantly response of nitrogen was found on seed and straw yields of French bean. Data presented in Table-01 revealed that application of nitrogen (N_2) noted significantly higher seed (1130 kg ha^{-1}) and straw (1465 kg ha^{-1}) yields compared to other nitrogen levels but it was statistically at par with treatment N_3 (160 kg N ha^{-1}). The significant improvement in seed and straw yields due to required nitrogen fertilization can further be evidenced by the fact there was positive and significant correlation existed between seed and straw yields, yield as well as growth attributes. The significant improvement in seed yield (Table-1) due to required nitrogen fertilization can be

Table 1. Effect of irrigation and nitrogen on yield, quality parameters and net realization of French bean

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Protein content (%)	N content in seed (%)	N uptake by seed (kg ha^{-1})	WUE (kg ha mm^{-1})	Available N (kg ha)	Net realization (Rs.ha^{-1})	BCR
Irrigation Scheduling based on IW: CPE ratio (I)										
I_1	844	1231	40.65	20.65	3.30	27.92	5.63	242.78	13440	1.64
I_2	1081	1482	42.09	21.81	3.49	37.74	5.41	247.08	22675	2.06
I_3	1205	1523	43.81	22.57	3.61	43.65	4.02	261.21	26876	2.22
I_4	1101	1435	43.45	21.94	3.51	38.72	3.34	246.15	23572	2.11
S. Em. ±	26	29	0.72	0.27	0.04	0.97	0.10	7.04	-	
C.D. at 5%	82	94	2	0.85	0.14	3.10	0.33	NS	-	
C.V.%	8.41	7.13	5.84	4.25	4.25	9.06	7.68	9.78	-	
Nitrogen levels (N)										
N_1	915	1352	40.25	21.21	3.39	31.08	4.00	240.17	16460	1.79
N_2	1130	1465	43.35	22.05	3.53	40.17	4.86	256.17	24586	2.15
N_3	1128	1437	43.90	21.97	3.52	39.77	4.92	251.57	23961	2.10
S. Em. ±	16	23	0.50	0.22	0.03	0.57	0.06	6.07	-	-
C.D. at 5%	47	67	2	0.63	0.10	1.67	1.18	NS	-	-
C.V.%	6.00	6.37	4.68	3.96	3.96	6.19	5.40	9.74	-	-

evidenced by the fact that the increased accumulation of nitrogen in vegetative parts possibly with improved metabolism led to greater translocation of these nutrients to reproductive organs of the crop. Increasing levels of nitrogen up to 120 kg ha^{-1} increased the nitrogen content of seed. Since protein content of seed is essentially a manifestation of nitrogen content (3.53 %) and Nitrogen uptake (40.17 kg ha^{-1}), increased seed nitrogen content due to nitrogen fertilization resulted in to higher protein content. It could also be explained in terms of greater synthesis of amino acids and nitrogen fertilization. The status of available N in the soil was found to be non-significant during investigation. The findings of this investigation are in closed conformity of results obtained by Gupta *et al.* (1996) and Shubhashree *et.al.* (2011). Harvest index (43.90%) was higher treatment N_3 (160 kg ha^{-1}), which was remained at par with treatment N_2. Increasing levels of nitrogen up to 160 kg ha^{-1} (N_3) increased the water use efficiency (4.92 kg ha mm^{-1}). Nitrogen fertilization increased evaporation probably due to more leaf area which increased transpiration losses. The finding of this investigation closed conformity of results obtained Nandan and Prasad (1998).

Increasing levels of nitrogen upto 120 kg ha^{-1} increased the nitrogen content in seed (3.53 %) and nitrogen uptake by seed (40.17 kg ha^{-1}). The positive influence of nitrogen fertilization on nitrogen content appears due to improved nutritional environment both in the root zone and plant system. Increasing availability of nitrogen in root zone coupled with increased metabolic activities at the cellular level probably increased the nitrogen uptake and accumulation of the same in vegetative parts. Increased seed and straw yield coupled with higher nitrogen content in plant seemed to have increased the uptake of nitrogen by seed due to nitrogen fertilization. Similar results were obtained by shubhashree *et.al*. (2011). Treatment N_2 obtained higher protein content (22.05%). Increased seed nitrogen content due to nitrogen fertilization resulted in to higher protein content. It could be also explained in terms of greater synthesis of amino acids and other reason is improvement in nitrogen content of seed due to nitrogen fertilization (Table-1). Similar results were also coated by Rana *et.al.* (1998). Nitrogen level failed to exhibit any significant variation to affect the available nitrogen from soil after harvest of crop.

Table 2. Interaction effect of irrigation scheduling and levels of nitrogen on water use efficiency (kg ha-mm^{-1}) of French bean

N	Water use efficiency (kg ha-mm^{-1})		
I	N_1	N_2	N_3
I_1	5.05	5.83	6.01
I_2	4.86	5.47	5.89
I_3	3.05	4.69	4.31
I_4	3.05	3.49	3.46
S. Em. ±	0.12		
C.D. at 5%	0.36		
C.V.%	5.40		

Table 3. Interaction effect of irrigation scheduling and levels of nitrogen on nitrogen uptake by seed of French bean

N	Nitrogen Uptake by seed (kg ha^{-1})		
I	N_1	N_2	N_3
I_1	24.63	28.63	30.50
I_2	33.17	37.39	42.66
I_3	32.28	53.06	45.60
I_4	34.24	41.61	40.31
S. Em. ±	1.15		
C.D. at 5%	3.34		
C.V.%	6.19		

Interaction effect

Interaction effect between irrigation and nitrogen levels found to be significant (Table-2). The highest water use efficiency (6.01) was noted in treatment combination I_1N_3. This might be due to production of relatively higher grain yield with minimum water use and at higher levels of nitrogen. The highest nitrogen uptake by seed (53.06 kg ha^{-1}) was obtained under treatment combination I_3N_2 which might be due to adequately available nutrient with soil moisture (Table-3).

Economics

Data presented in Table-1 clearly indicated that irrigation levels I_3 (1.0 IW: CPE ratio) fetched maximum net realization (Rs. 26876 kg ha^{-1}) with higher BCR (2.22) followed by I_4 treatment. Where, nitrogen level N_2 (120 kg ha^{-1}) accrued maximum net realization (Rs. 24586 ha^{-1}) with BCR of 2.15 followed by N_3 treatment. Treatment combination I_3N_2 registered significantly the highest net realization Rs. 33653 ha^{-1} with BCR 2.44.

CONCLUSION

From the foregoing study, it is concluded that for securing higher yield and net return from French bean should be irrigated (50 mm depth water) at 1.0 IW : CPE ratio with one common irrigation for establishment of plant with application of 120 kg N ha^{-1}.

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