Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 252-254
Received: 06-05-2019
Accepted: 10-06-2019

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Production constraints analysis of *kharif* French bean (*Phaseolus vulgaris* L.) in vertisols

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Abstract
A field experiment was conducted during *kharif* season of 2018 - 2019 at Experimental farm, Department of Agronomy, College of Agriculture, Latur (MS) to study the effect of production constraints on growth and yield of French bean. The results indicated that adoption of full package of practices (fertilizer + weeding + insect pest management) resulted in significantly higher seed yield (1111 kg ha^{-1}). Among the various single factor production constraints fertilizer application was found to be most crucial factor caused yield losses up to 34%followed by insect pest management (24%) and weeding (13%). Regarding the combination of two factor production constraints the treatment where fertilizer application and weeding was not done resulted in reduction in French bean yield by 53% as compared to full package of practices and found to be as a major resource constraints in French bean production, followed by combined constraint weeding + insect pest management and fertilizer+ insect pest management which caused yield losses upto 52% and 45%, respectively.

Keywords: Production constraints, resource constraints, yield losses, french bean

Introduction
Common bean (*Phaseolus vulgaris* L.) is a herbaceous annual plant grown worldwide for its for its edible grain, green leaves and green pods. However the dry seeds are the ultimate economic product (Anonymous, 2001) [1]. In world French bean is cultivated on an area of 282 M ha with a production of 18.95 million tonnes, in which Brazil rank first. In India French bean is cultivated on an area 3.94 million ha with a production and productivity of 2.8 million tonnes and 7.1 q/ ha respectively (Anonymous 2006) [2]. The productivity of French bean is low in Maharashtra. The low yield of French bean is associated with lack of major production factors like fertilizer application, weeding and insect pest management. Inadequate supply of nutrients is one of the most important production factor associated with low productivity. It requires large quantity of phosphorus for optimum growth and yield. Weed management is a major constraint in dry bean production. It is an established fact that weeds, due to their competition for water, light and nutrients reduce crop yields, but little is known about the physiological interaction between crop plants and weeds that brings about the yield reduction (Aspinall and Milthorpe, 1959) [3]. As other legumes, the insect pests are the major threat for the yield and quality of the pods in French bean. Numerous insect pests attack all parts of French bean crop during all stages of crop growth viz. from seedling to maturity and also in the storage stage. Keeping in view, the present investigation was carried out to study the impact of major constraints on growth and yield of French bean.

Material and Methods
A field experiment was conducted during *kharif* season of 2018 at Experimental Farm of Agronomy section, College of Agriculture, Latur. The soil of the experimental site was clay in texture, low in available nitrogen (121.86 kg ha^{-1}), medium in available phosphors (22.42 kg ha^{-1}) and high in potassium (311.38 kg ha^{-1}) with moderately alkaline in reaction (8.5 p^{H}).The experiment was laid out in Randomized Block Design with three replications. The treatments were T_1: Full package of practices, T_2: T_1 - Fertilizer, T_3: T_1- Weeding, T_4: T_1 – Insect Pest Management, T_5: T_1 - (Fertilizer + Weeding), T_6: T_1 - (Fertilizer + Insect Pest Management) and T_7: T_1 - (Weeding + Insect Pest Management). Sowing was done by dibbling by using seed rate 75 kg ha^{-1}. The gross and net plot size was 4.8 m x 4.2 m and4.2 m x 3.9 m respectively. The total rainfall received during growth period of French bean was 271.8 mm with 13 rainy days. The recommended dose of fertilizer was 120:60:60 kg NPK ha^{-1} applied as per treatments through Urea, single super phosphate and MOP. Other cultural practices were done as per treatments. Statistical analysis of the data was carried out by using standard analysis of variance (Panse and Sukhatme 1967) [7].

Result and Discussion

Growth and growth attributes

The data presented in Table No.1 revealed that the growth attributes *viz*., plant height, number of branches per plant, leaf area per plant and dry matter accumulation per plant were influenced significantly due to different production constraints .The application of full package of practices (T_1) recorded significantly higher values of plant height, number of branches per plant and dry matter accumulation per plant over rest of all treatments. Among different single production constraints the treatment T_3 where weeding is not conducted showed significantly higher plant height over treatment T_2 where fertilizer application is not done. In combined production constraints lowest value of plant height, number of branches per plant and dry matter accumulation per plant were observed with treatment T_5 where fertilizer application and weeding is not conducted. It might be due to role of phosphorus in cell division which could be responsible for the increase in plant height. These findings are in conformity with that of Namakka *et al.* (2016) [6]. Highest plant height was probably resulted from effective weed control causing maximum nutrient utilization by the crop plants and hence maximum plant height was recorded with full package of practices (T_1). Hanumanthappa *et al.,* (2012) [4] noticed similar results on French bean. The positive effect of full dose of NPK on number of branches per plant could be due to the significant role of the element on cell division and cell elongation which resulted in to the production of more lateral buds that developed into branches. Similar results were stated by Namakka *et al*., (2016) [6], Shahid *et al*., (2015) [10]. Though the treatment of full package of practices recorded highest leaf area per plant but it was found at par with the treatment T_3 where weeding is not done and found significantly superior over rest of the treatments. Among single production factors the treatment T_2 where fertilizer application is not done recorded significantly lowest value of leaf area per plant over the treatment T_3 where weeding was not done. Among various combined production constraints treatment T_5 where fertilizer application and weeding was not done recorded lowest value of leaf area per plant. It might be due to the competition of the crops with the weeds for moisture and nutrients such that the plant could not produce more number of leaves so as to conserve available moisture for critical growth stages which was responsible for the reduced leaf area recorded when weeding was not done. Similar results were also observed by Patel *et al*., (2017) [8].

Yield attributes and yield

Yield attributes viz., number of pods, dry weight of pods, seed yield per plant and seed yield (kg/ha) were significantly affected by different treatments (Table No.2). The application of full package of practices recorded significantly highest number of pods per plant, dry weight of pods per plant, seed yield per plant and seed yield (kg/ha) over rest of the production constraints. Among various single production constraints the treatment where fertilizer is not applied (T_2) recorded significantly lowest number of pods per plant, dry weight of pods per plant, seed yield per plant and seed yield (kg/ha) over the treatment where weeding is not done (T_3) and found at par with the treatment where insect pest management practices not done (T_4). Among various combined production constraints the treatment T_5 where fertilizer application and weeding is not done recorded lowest value of number of pods per plant, dry weight of pods per plant, seed yield per plant and seed yield (kg/ha). It might be due to the increased supply of nitrogen and its higher uptake by plants might have stimulated the rate of various physiological processes in plants and led to increased yield parameters. These results are in conformity with the findings of Mehta *et al*., (2001) [5], Roy *et al.* (2014) [9].

Among single production constraints the treatment where fertilizer was not applied (T_2) recorded per cent reduction in yield to the tune of 34% as compared to full package of practices, followed by treatment T_4 where insect pest management practices were not done (T_4) and the treatment where weeding is not conducted (T_3). Regarding combined production constraints the treatment T_5 where fertilizer application and weeding was not done resulted in reduction in yield of French bean up to 53%, closely followed by treatment T_7 where weeding and insect pest management practices were not done (52%) and T_6 where fertilizer application and insect pest management practices were not conducted (45%).

Based on above studies it is concluded that among various production constraints fertilizer application as a single constraint and fertilizer application + weeding as a combined constraint noticed as the major constraints in French bean production.

Table 1: Plant height plant^{-1}, number of branches plant^{-1}, leaf area plant $^{-1}$and dry matter plant $^{-1}$ influenced by resource constraints

Treatment details	Plant height plant^{-1} (cm)	No. of branches plant^{-1}	Leaf area plant^{-1} (dm^2)	Dry matter plant^{-1} (g)
T_1:Full package of practices	28.17	7.47	12.67	30.07
T_2: T_1-Fertilizer	18.99	5.17	10.07	17.73
T_3: T_1-Weeding	23.90	6.27	11.67	23.30
T_4:T_1-Insect pest management	23.10	5.37	10.83	19.70
T_5:T_1-(Fertilizer + Weeding)	18.70	5.10	9.80	11.83
T_6:T_1-(Fertilizer +Insect pest management)	19.63	5.27	10.37	14.70
T_7:T_1-(Weeding +Insect pest management)	18.97	5.20	10.13	13.17
SEm±	1.02	0.28	0.37	1.09
C.D. at 5%	3.15	0.85	1.14	3.37
General Mean	21.63	5.69	10.79	18.64

Table 2: Effect of number of pods plant^{-1}, dry weight of pods plant^{-1}, seed yield plant^{-1}, seed yield kg ha^{-1}, and Per cent reduction in yield on yield attributing characters

Treatments	Number of pods plant^{-1}	Dry weight of pods plant^{-1}(g)	Seed yield plant^{-1}(g)	Seed yield (kg ha^{-1})	Percent reduction in yield (%)
T_1: Full package of practices	18.03	15.83	10.03	1111	-
T_2: T_1-Fertilizer	12.17	10.04	5.40	724	34
T_3: T_1-Weeding	14.83	12.38	7.50	956	13

T_4: T_1-Insect pest management	14.20	11.46	7.47	843	24
T_5: T_1-(Fertilizer + Weeding)	10.10	5.49	4.67	516	53
T_6:T_1-(Fertilizer + Insect pest management)	11.83	8.62	5.20	609	45
T_7: T_1-(Weeding + Insect pest management)	12.10	7.66	4.73	530	52
SEm±	0.80	0.65	0.39	50	-
C.D. at 5%	2.48	2.01	1.21	153	-
General Mean	13.32	10.21	6.43	756	-

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