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Weed Dynamics and Productivity of French Bean (*Phaseolus vulgaris* L.) as Influenced by Organic Sources of Nutrients and Weed Management

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ABSTRACT

Background: Balancing productivity, profitability and environmental health is a key challenge for maintaining agricultural sustainability. The use of locally available agro-inputs in agriculture by avoiding or minimizing the use of synthetically compounded agro-chemicals appears to be one of the probable options to sustain the agricultural productivity. Widespread use of herbicides has resulted in purported environmental and health problems as well as residual toxicity issues in succeeding crops. At present, the awareness on safe food is increasing. So, keeping this point in view the present investigation was carried out to evaluate the influence of organic sources of nutrients and weed management on growth, yield and weed flora of Frenchbean.

Methods: A field experiment was conducted during summer season of 2016 and 2017. The present investigation was laid out in split plot design with six sources of nutrients in main plot and four weed management treatments in sub plots.

Result: Application of treatment T_5 recorded significantly higher growth parameters, yield attributes, fresh pod yield, net returns and B:C ratio of French bean which was statistically at par with T_3 and T_2. Amongst the weed management treatments, treatment W_1 resulted in significantly lowest species wise and total weed density and biomass, highest weed control efficiency, lowest weed index, highest growth, yield attributes and fresh pod yield of French bean which was statistically at par with W_2 and W_0. However, the highest net returns and B:C ratio were obtained in weed free plots.

Key words: Mustard seed meal, Rice bran, Weed index, Weed control efficiency, Weed management.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is a leguminous crop, belonging to the Fabaceae family with chromosome number of 2n = 22. French bean provides direct economic returns to the growers in the form of pods used as a vegetable and grain for human beings as well as fodder for animals. It is considered to be a very rich source of proteins and vitamins and provides carotenoids like beta-carotene, neoxanthin, lutein and violaxanthin required for a healthy diet. It also contains antioxidants which help to scavenge free radicals and also benefits our cardio vascular system (Whankate *et al.* 2021). Adoption of organic agriculture practices can address the growing global awareness on quality food, good health and safe environment and thus there has been a paradigm shift and interest to adopt organic crop production systems which are ecologically and economically viable and socially justified. Cultivation of crops under organic condition is the positive step for quality food production. Integration of organic sources is the important aspect in nutritional management of the crop for achieving higher productivity, good quality of food and soil health. Use of organic sources of nutrients to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture, hence organic matter should be replenished by adding organic nutrients. It has been also realised that besides organic nutrient management weed infestation is the major problem. Weed is the major yield limiting factor in crop production and yield losses are high in general and organic culture in particular. Higher infestation of weeds in crop tends to decrease crop yield by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. Organic producers ranked weed management research as their top priority and have many challenges because their weed control tools are mostly limited to cultural methods (Bond and Grundy, 2001), with a strong dependence on excessive tillage, cultivation and hand-hoeing for weed control. Because there are only a few organically approved herbicides, optimizing their application may increase their potential usefulness for organic production systems. Considering the above facts, investigation was carried out to evaluate the organic sources

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of nutrients and weed management on growth, yield and weed flora of French bean.

Materials and Methods

A field experiment was conducted at Research Farm of AICRP-IFS, Chatha, SKUAST-Jammu during *summer* season of 2016 and 2017 in split-plot design with 3 replications. The soil of experimental field was clay loam having initial pH 8.04, organic carbon (0.55%) and available nitrogen (N), phosphorous (P) and potassium (K) of 220.40, 18.25 and 118 kg ha^{-1}, respectively. The experimental soil was also sufficient in available secondary nutrients *i.e.* sulphur (18.75 mg kg^{-1}) and micronutrients *i.e.* zinc (0.85 mg kg^{-1}), copper (0.48 mg kg^{-1}), iron (27.65 mg kg^{-1}) and manganese (20.26 mg kg^{-1}). The treatments consisted of six sources of nutrients in main plot *viz.* T_1: 50% recommended (Rec.) NPK through fertilizer + 50% N through farm yard manure (FYM) + inorganic source of micronutrients as per soil test, T_2: 100% Rec. N through different organic sources each equivalent to 1/3 of Rec. N *i.e.* FYM+ vermicompost + non edible oil cake, T_3: 100% organics (100% Rec. N through different organic sources each equivalent to 1/3 of Rec. N *i.e.* FYM+ vermicompost + non edible oil cake) + bottle gourd as trap crop for French bean, T_4: 50 % Rec. N through vermicompost + biofertilizers for N + rock phosphate to substitute the P requirement + phosphate solubilizing bacteria, T_5: 100% organics (100% Rec. N through different organic sources each equivalent to 1/3 of Rec. N *i.e.* FYM+ vermicompost + non edible oil cake) + VAM and T_6: 100 % Rec. NPK + secondary and micronutrients based on soil test through inorganic fertilizer and sub plots comprised of four weed management treatments *viz.* W_0: Weed Free, W_1: Mustard Seed Meal @ 5 t ha^{-1}, W_2: Rice Bran @ 4 t ha^{-1} and W_3: Weedy Check. The inorganic sources used were urea, daimmonium phosphate and muriate of potash to supply N, P and K, respectively. The recommended dose of fertilizers for French bean was 50:100:50 NPK (kg ha^{-1}). Full quantity of P and K were applied as basal dose and N was applied in split doses. Fifty per cent of N was applied as basal and the rest was applied in 2 equal splits at 25 and 45 days after sowing. Secondary and micronutrients were not applied in inorganic treatments due to their sufficient range in the soil. The organic sources of nutrients used in the experiment were FYM (N, P, K 0.52, 0.23, 0.55%), vermicompost (N, P, K 2.32, 1.15, 1.50%), neem cake (N, P, K 2.89, 0.84, 1.51%), rock phosphate (25.5% P) and biofertilizers such as *Azotobacter* for supplying N @ 10 kg ha^{-1}, phosphate-solubilizing bacteria (PSB) @ 10 kg ha^{-1} and vesicular-arbuscular mycorrhiza (VAM) @ 5 kg ha^{-1}. French bean variety 'Contender' was sown at a spacing of 60 cm x 20 cm using a seed rate of 80 kg ha^{-1}. Need based irrigation was given. Mustard seed meal and rice bran were applied as pre-plant incorporation (PPI) 10 days before sowing of French bean. Hand weeding (30 mandays ha^{-1}) was done in weed free plots with the help of *khurpi*. A quadrat of 1 m^2 was used to take observation on species wise weed density and biomass through random sampling in each plot at 60 days after sowing (DAS). The species wise and total number of weeds were counted in each plot separately and analyzed after subjecting the original data to square-root transformation. For weeds dry biomass, species wise weeds were collected at 60 DAS from 1 m^2 area were dried under the sun and then in oven at 70^{o}C for 48 h and weighed. Weed control efficiency (at 60 DAS) and weed index were calculated based on the data recorded in French bean as per standard formula (Mishra and Mishra, 1997). Plant height (cm) and dry matter accumulation (g m^{-2}) were measured at 60 days after sowing of the crop. Number of pods plant^{-1}, pod length (cm) and average pod weight (g) were recorded during picking of pods. The fresh pod yield was recorded at different pickings from 10.8 m^2 net plot area. The net returns were computed by deducting the total cost of cultivation from the gross returns as per treatments. While the benefit: cost ratio was calculated by dividing the net returns with the cost of cultivation for different treatments. However, for better understanding, original values of weed density and weed biomass are given in parenthesis. All the data obtained were statistically analyzed using the F-test (Gomez and Gomez, 1984). Critical difference (CD) values at P=0.05 were used to determine the significance of differences between mean values of treatments.

Results and Discussion

Weed flora

Weed flora in the experimental field consisted of narrow leaf weeds *viz.*, *Cynodon dactylon*, *Digitaria sanguinalis* and broad leaf weeds *viz., Amaranthus* spp and sedge weed *Cyperus* spp during both the years of study.

Weeds density and biomass

Statistically non-significant results were observed with respect to species wise and total weed density, species wise and total biomass of weeds among different sources of nutrients. However, treatment T_5 recorded the lowest species wise and total weed density, species wise and total biomass of weeds (Table 1 and 2). Significant reduction in weed density and weed biomass were observed in weed free plots as compared to weedy check plots (Table 1 and 2). Among the organic weed management treatments, treatment W_1 significantly reduced the species wise and total weed density, species wise and total weed biomass which was however at par with application of W_2 over W_3 treatment. This could be attributed to better efficacy and due to presence of glucosinolates in mustard seed meal and enzymatic hydrolysis to isothiocyanates, thiocyanate, nitriles and other compounds which may be partly responsible for phytotoxic effect and did not allow the weeds to germinate and even resulted in rapid depletion of carbohydrates reserves of weeds already germinated through rapid respiration, senescence of leaves, reduction in leaf area and diminution of photosynthesis process. These results are in close conformity to the findings of Boydston and Al-khatib (2006) and Boydston *et al.* (2008).

Weed control efficiency

Among the organic weed management treatments in frenchbean, treatment W_1 recorded highest weed control efficiency at harvest followed by W_2 in the descending order (Table 3). The higher values of weed control efficiencies in these treatments could be attributed to lower weed population and weed dry weight owing to better efficacy which might have shifted the fulcrum in favour of crop plants and therefore might have resulted in better crop growth over weedy check plots.

Weed index

Among the organic weed management treatments in French bean, W_1 recorded the lowest weed index followed by W_2 in comparison to W_3 plots (Table 3). This can probably be

Table 1: Effect of organic sources of nutrients and weed management treatments on species wise and total weed density (no. m^{-2}) in frenchbean at 60 DAS (pooled data of two years).

Treatments	*Cynodon dactylon*	*Digitaria sanguinalis*	*Amaranthus* spp.	*Cyperus* spp.	Other weeds	Total weed density
Sources of nutrients						
T_1	2.94(8.98)	2.84(8.46)	3.30(12.64)	3.64(14.96)	2.58(6.72)	6.42(51.76)
T_2	2.93(8.92)	2.81(8.33)	3.27(12.42)	3.63(14.88)	2.58(6.68)	6.38(51.23)
T_3	2.92(8.85)	2.81(8.31)	3.26(12.38)	3.62(14.79)	2.57(6.63)	6.37(50.97)
T_4	2.97(9.15)	2.87(8.68)	3.35(13.01)	3.67(15.18)	2.61(6.83)	6.49(52.85)
T_5	2.92(8.82)	2.80(8.21)	3.24(12.22)	3.62(14.75)	2.57(6.61)	6.35(50.62)
T_6	2.95(9.05)	2.84(8.52)	3.31(12.74)	3.65(15.05)	2.59(6.77)	6.44(52.14)
SEm±	0.06	0.05	0.07	0.05	0.06	0.08
CD at 5%	NS	NS	NS	NS	NS	NS
Weed management						
W_0	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)
W_1	3.38(10.45)	2.98(7.89)	3.19(9.28)	3.99 (14.97)	2.75(6.55)	7.07(49.13)
W_2	3.42(10.73)	3.03(8.20)	3.29(9.85)	4.04(15.33)	2.78(6.74)	7.20(50.86)
W_3	3.95(14.67)	4.31(17.58)	5.67(31.15)	5.52(29.44)	3.81(13.55)	10.36(106.39)
SEm±	0.03	0.04	0.05	0.03	0.02	0.05
C.D. at 5%	0.09	0.11	0.15	0.10	0.06	0.14

Interaction: Non significant; DAS-Days after sowing; Data transformed using square root √x+1 and values in parenthesis are original.

Table 2: Effect of organic sources of nutrients and weed management treatments on species wise and total weed biomass (g m^{-2}) in frenchbean at 60 DAS (pooled data of two years).

Treatments	*Cynodon dactylon*	*Digitaria sanguinalis*	*Amaranthus* spp.	*Cyperus* spp.	Other weeds	Total weed biomass
Sources of nutrients						
T_1	2.58(6.67)	2.75(7.82)	3.09(11.01)	3.13(10.69)	2.32(5.09)	5.74(41.28)
T_2	2.57(6.59)	2.72(7.66)	3.05(10.73)	3.11(10.58)	2.31(5.04)	5.68(40.60)
T_3	2.55(6.50)	2.72(7.63)	3.05(10.69)	3.10(10.48)	2.30(4.98)	5.67(40.28)
T_4	2.62(6.88)	2.79(8.10)	3.16(11.47)	3.16(10.96)	2.35(5.23)	5.83(42.64)
T_5	2.55(6.46)	2.70(7.51)	3.02(10.49)	3.09(10.42)	2.29(4.95)	5.63(39.84)
T_6	2.59(6.75)	2.76(7.90)	3.11(11.14)	3.14(10.80)	2.33(5.15)	5.77(41.75)
SEm±	0.04	0.02	0.05	0.04	0.03	0.06
CD at 5%	NS	NS	NS	NS	NS	NS
Weed management						
W_0	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)
W_1	2.74(6.52)	2.88(7.35)	2.91(7.57)	3.27(9.74)	2.45(4.99)	6.09(36.17)
W_2	2.81(6.90)	2.96(7.76)	3.04(8.32)	3.35(10.23)	2.50(5.24)	6.27(38.45)
W_3	3.76(13.14)	4.12(15.98)	5.36(27.80)	4.86(22.65)	3.33(10.07)	9.52(89.63)
SEm±	0.03	0.03	0.04	0.03	0.02	0.05
C.D. at 5%	0.08	0.07	0.12	0.08	0.06	0.16

Interaction: Non significant; DAS - Days after sowing; Data transformed using square root √x+1 and values in parenthesis are original.

ascribed to improved growth and ultimately yield of crop due to the higher nutrient content by the application of mustard seed meal and rice bran and also as a consequence of effective control of weeds and reduction in the crop weed competition which might have enabled the crop to achieve better resource utilization and can be associated with lower weed count and dry weight.

Growth parameters

Between the various sources of nutrients, application of treatment T_5 recorded significantly highest plant height and dry matter accumulation which was statistically at par with T_3 and T_2 (Table 4). The significant improvement in growth parameters *i.e.* plant height and dry matter accumulation might be due to combined application of FYM, vermicompost and neem cake leading to higher availability of nitrogen which improved the plant growth due to the fact that nitrogen after being taken up by the plant is converted in to amino acids which are the building blocks of protein which might have led to increase in the rate of meristematic activity resulting in better growth characters. These results were in close conformity with findings of Sarma *et al.* (2011). Among

Table 3: Effect of organic sources of nutrients and weed management treatments on weed control efficiency, weed index and economics in frenchbean.

Treatments	Weed control efficiency (%)	Weed index (%)	Net returns (Rs ha^{-1})	B:C ratio
Sources of nutrients				
T_1	55.18	7.09	987.50	0.01
T_2	55.54	5.99	14406.50	0.17
T_3	55.61	5.43	14449.50	0.17
T_4	54.38	7.47	8031.00	0.11
T_5	55.66	5.54	49392.00	0.59
T_6	54.93	7.25	-2433.50	-0.03
SEm±	-	-	-	-
CD at 5%	-	-	-	-
Weed management				
W_0	100.00	0.00	47310.00	1.02
W_1	61.65	-3.03	-44203.00	-0.31
W_2	59.22	-1.21	6039.50	0.07
W_3	0.00	30.08	25243.50	0.62
SEm±	-	-	-	-
C.D. at 5%	-	-	-	-

Table 4: Effect of organic sources of nutrients and weed management on growth, yield attributes and pod yield of frenchbean (pooled data of two years).

Treatments	Plant height (cm)	Dry matter accumulation (g m^{-2})	No. of pods $plant^{-1}$	Pod length (cm)	Average pod weight (g)	Fresh pod yield (kg ha^{-1})
Sources of nutrients						
T_1	41.05	21.30	9.00	9.96	4.35	3819
T_2	45.55	23.16	9.58	10.55	4.63	4052
T_3	46.15	23.28	9.69	10.65	4.68	4096
T_4	36.35	18.96	8.31	9.27	4.02	3542
T_5	47.05	24.07	9.84	10.80	4.75	4156
T_6	38.15	19.70	8.38	9.35	4.05	3572
SEm±	0.655	0.35	0.14	0.18	0.07	5.50
CD at 5%	2.06	1.10	0.45	0.54	0.23	16.45
Weed management						
W_0	44.55	24.00	9.82	10.81	4.74	4134
W_1	46.00	24.72	10.06	10.96	4.86	4261
W_2	44.71	24.18	9.88	10.87	4.77	4185
W_3	34.25	14.07	6.78	7.76	3.28	2911
SEm±	0.59	0.29	0.13	0.13	0.07	5.20
C.D. at 5%	1.68	0.83	0.38	0.37	0.18	14.90

Interaction: Non significant.

the different weed management treatments, W_1 recorded significantly highest growth parameters of French bean *i.e.* plant height and dry matter accumulation which was statistically at par with W_2 and W_0 treatment. The enhanced growth trend in terms of plant height and dry matter accumulation have happened due to the higher nutrient content of mustard seed meal and better control of weeds leading to efficient utilization of moisture, nutrients, space and light resulting in optimum growth characters. These results are in agreement with the findings of Ibrahim and Mumtaz (2014).

Yield attributes and fresh pod yield

Among the sources of nutrients, application of treatment T_5 recorded significantly highest number of pods plant^{-1}, pod length, average pod weight and fresh pod yield of frenchbean which was remained statistically at par with T_3 and T_2 (Table 4). The increase in yield attributes and marked improvement in dry matter accumulation with these treatments might be due to better translocation of assimilates towards sink, which ultimately increase the pod yield of French bean. These results are in conformity with the findings of Singh *et al.* (2014). Weed management treatments improved all the yield attributes and fresh pod yield of French bean as compared to those observed in weedy check plots (Table 4). Amongst the weed management treatments, W_1 recorded significantly highest number of pods plant^{-1}, pod length, average pod weight and fresh pod yield of French bean which was statistically at par with W_2 and W_0 treatment. This might have happened due to enhancement in the growth parameters under suitable environment situation provided by substantial reduction in inter-generic competition due to weed suppression and better translocation of carbohydrates for higher sink realization in these treatments. Similar findings were also reported by Ullah *et al.* (2008).

Economics

The economic feasibility and usefulness of a treatment can be effectively adjudged in terms of B:C ratio and net returns. Among the sources of nutrients, treatment T_5 registered higher net returns and B:C ratio, owing to higher gross returns as compare to other treatments (Table 3). Amongst weed management treatments, highest net returns and B:C ratio were obtained with weed free treatment. Higher fresh pod yield of French bean in weed free treatment might have been responsible for the highest net returns and B:C ratio. However, treatment W_1 and W_2 recorded the lowest net returns and B:C ratio which was due to higher cost of cultivation in these treatments.

CONCLUSION

Based on the experimental results obtained from two years of study, it can be concluded that application of 100% organics (100% Rec. N through different organic sources each equivalent to 1/3 of Rec. N *i.e.* FYM+ vermicompost + non edible oil cake) + VAM (T_5) produced significantly higher crop yield coupled with organically weed management practice i.e. weed free (W_0) and application of rice bran @ 4 t ha^{-1} (W_2) which not only were economically viable and efficient organic weed management options but also kept dominant weeds below threshold level as corroborated with the higher weed control efficiency.

Conflict of interest: None.

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