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Productivity of French bean as influenced by integrated nutrient and weed management

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Abstract

Twelve combinations of four integrated nutrient management systems {50% NPK through fertilizers + 50% N through FYM (F1), 50% NPK though fertilizers + 50% N through vermicompost (F2), 50% N each through FYM and vermicompost (F3) and 100% NPK through fertilizers (F4)} and three weed management systems (hand weeding twice, pendimethalin 1.20 kg/ha and pendimethalin 0.9 kg/ha + hand weeding) were evaluated for weed control, yield and returns in French bean for the summer seasons of 2004 and 2005 at Palampur. Results of the study revealed that pendimethalin and pendimethalin + hand weeding reduced weed count and dry weight effectively and increased plant height, leaves/plant, plant dry weight, pods/plant, pod yield and net returns. However, pendimethalin was superior to pendimethalin + hand weeding in influencing mean weed count and net returns. 50% NPK through fertilizers + 50% N through FYM gave lowest mean weed dry weight accumulation and highest mean plant height, leaves/plant in 2005, mean crop dry matter and mean net returns. 50% N though FYM + 50% N through vermicompost was equal in influencing mean pods/plant and mean green pod yield. Green pod yield was highest in the treatment combination 50% NPK through fertilizers + 50% N through FYM + pendimethalin + hand weeding in 2005. However, 50% NPK through fertilizers + 50% N through vermicompost + pendimethalin and 50% N each through FYM & vermicompost + pendimethalin or pendimethalin + hand weeding were as good as the above treatment combination in influencing mean green pod yield. 50% NPK though fertilizers + 50% N through vermicompost + pendimethalin (Rs 29375/ha) and 50% NPK though fertilizers + 50% N through FYM + pendimethalin + hand weeding gave higher mean net returns.

Key words: French bean, weed control, fertility management, productivity, net return.

Introduction

In the world, French bean is cultivated in 97 countries for green pods and 119 countries for dry seeds (FAO, 2004). In Himachal Pradesh its cultivation is confined to mid and high hills and has turned to be one of the most important cash crops. Among the various factors of production technology, fertilizers and weed management are crucial. The continuous use of inorganic fertilizers without organic sources has shown gradual decline in the fertilizer use efficiency. Therefore, partial substitution of the total requirement of mineral nutrients with organic sources has been well envisaged (Chattapadhyay and Chatterjee, 2004). Hand weeding is the most common practice for combating weed menace. But pendimethalin alone or at lower rate in integration with hand weeding is the easier and cheaper alternative (Rana *et al.* 1999; Rana 2002a&b). Very limited work has been done on integrated nutrient and weed management. Therefore, the present investigation was carried out to find out the economically viable, environmentally suitable and sustainable nutrient management system in relation to efficient weed management in French bean.

Material and Methods

The field experiment was carried out at Palampur (32°6' N latitude, 76°3'E longitude and 1290 m altitude) during the summer seasons of 2004 and 2005. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 6.0), medium in available N (407.9 kg/ha) and P (18.9 kg/ha) and high in available K content (306.0 kg/ha). During the cropping seasons of 2004 and 2005, respectively, a total of 398.8 and 309.7 mm rainfall was received. The crop experienced 635.3 and 702.2 bright sunshine hours during 2004 and 2005, respectively. The experiment was laid out in split plot design by keeping four fertility treatments in main plots and three weed control treatments in sub plots. The four fertility treatments were comprising of 50% NPK through fertilizers + 50% N through FYM (F1), 50% NPK though fertilizers + 50% N through vermicompost (F2), 50% N though FYM + 50% N through vermicompost (F3) and 100% NPK through fertilizers (F4). The weed control treatments were hand weeding twice (25 and 45 DAS) (W_1), pendimethalin 1.20 kg/ha (W_2) and pendimethalin 0.90 kg/ha + hand weeding (W_3). The crop was sown on 29 April 2004 and 16 April,

2005 and harvesting of green pods in four pickings was completed by 8 July 2004 and 29 June 2005. Variety 'Contender' was sown at 80 kg of seed/ha in lines 30 cm apart at a depth of 4-5 cm. Pre-emergence application of pendimethalin as per the treatment was made with backpack knapsack sprayer using 800 l water/ha. N, P_2O_5 and K_2O (Recommended dose was 50, 100 and 50 kg/ha, respectively) were applied through urea and fertilizer grade 12:32:16. FYM as per the treatment was applied at field preparation. Vermicompost was applied at seeding. Whole amount of fertilizers was applied as basal. Weed count and dry weight was recorded at 25 DAS, 45 DAS and at final picking. Yields were harvested from net plot (62 m x 1.2 m). Economics of the treatments was computed based upon the prevalent market prices.

Results and Discussion

French bean was infested with a large number of broad-leaved weeds and the most important were *Commelina benghalensis*, *Euphorbia thymifolia*, *Xanthium strumarium* and *Solanum nigrum*. *Digitaria sanguinalis* and *Echinochloa colona* were the only grassy weeds found growing in association with French bean crop. However, *D. sanguinalis* was the predominant weed. In general weed intensity was higher in 2004 as compared to 2005. The crop during 2004 was sown by the last week of April, which coincided with peak emergence of weed species, whereas seeding was completed by mid of April during 2005. Also rainfall was fairly higher during 2004 which might have resulted in higher weed population.

Weed control measures

Total weed count was lowest in pendimethalin at 1.2 kg/ha during both the years. Mean total dry weight accumulation followed the trend of count and was also lowest in pendimethalin at 1.20 kg/ha. Superiority of pendimethalin in controlling weeds in French bean has been reported (Rana *et al.,* 1999; Singh and Tripathi, 2003). This was followed by pendimethalin at 0.9 kg/ha + hand weeding which also significantly reduced total mean weed count and dry weight accumulation over hand weeding twice. The superiority of herbicidal weed control over manual weeding has also been reported (Kumar *et al.,* 1997; Rana *et al.*,1999). It is pertinent to note that superimposition of hand weeding with half the dose of pendimethalin was superior to pendimethalin at higher dose alone in reducing total weed dry matter accumulation during 2004.

Pendimethalin is a pre-emergence herbicide, therefore, control weeds from the beginning i.e before the start of the critical period of crop weed competition. Whereas, by the time hand weeding is done, weeds offer competition may be overlapping a part of critical period of weeds-crop competition. Thus, owing to superior weed control right from early stages of crop growth, pendimethalin 1.20 kg/ha and pendimethalin 0.90 kg/ha + hand weeding significantly increased growth and yield attributes of French bean over hand weeding twice. Plant height, leaves/plant, crop dry weight and pods/plant were significantly higher under pendimethalin 1.20 kg/ha and pendimethalin 0.90 kg/ha + hand weeding, both were at par with each other during both the years. Growth and yield attributes were reflected in green pod yield of French bean. Several workers (Mishra *et al.,* 1999; Rana *et al.,* 1999; Sharma *et al.,* 2004) have also documented significant increase in French bean yield owing to improved growth and yield attributes. Pendimethalin and pendimethalin + hand weeding resulted in significantly higher green pod yield over hand weeding twice during both the years. Pendimethalin 0.90 kg/ha with hand weeding was as good as pendimethalin 1.20 alone for increasing French bean green pod yield during 2004 and on pooled basis, indicating that hand weeding could economize the dose of the herbicide by 25%. However, pendimethalin at 1.20 kg/ha was superior to pendimethalin at 0.90 kg/ha + hand weeding during 2005. Pendimethalin at 1.20 kg/ha and pendimethalin at 0.90 kg/ha + hand weeding increased mean green pod yield of French bean by 48.5 and 41.8%, respectively, over hand weeding twice. Because of low application cost and higher green pod yield, pendimethalin at 1.20 kg/ha fetched highest mean net return followed by pendimethalin + hand weeding. This was followed by pendimethalin + hand weeding during both the years. Due to higher cost of imposition of hand weeding, there was a net loss of over three thousand under hand weeding twice treatment during 2004.

Fertility treatments

Total weed count was significantly lower in 50% NPK (F) + 50% N (FYM) and 100% NPK (F) over the remaining fertility treatments. This indicated that where the fertility scheduling followed vermicompost {50% NPK (F) + 50% N (VC) and 50% N (FYM) + 50% N (VC)} had more weeds per unit area. It may be ascribed due to the

reason that VC may help in dissemination of weed seeds, if the substrate used for its preparation contain weed plants at their ripening/ seed stage and proper measures for the separation of these weed seeds are not taken care. Bansal and Rana (2006) have given detailed description about the separation of weed seeds in the process of preparation of vermicompost. Mean weed dry weight accumulation was lowest in 50% NPK (F) + N (FYM). However, 100% NPK (F) was statistically at par with 50% NPK (F) + 50% N (FYM) in reducing weed dry weight accumulation in 2004.

Owing to lower weed population and better availability and utilization of applied nutrients, 50% NPK (F) + 50% N (FYM) resulted in highest mean plant height, mean crop dry weight accumulation and leaves/plant in 2005. Growth and development of the crop have a considerable affect of yield contributing characters, which in turn determine the yield of the crop. 50% NPK (F) + 50% N (FYM) and 50% N (FYM) + 50% N (VC) gave significantly higher pods/plant in 2005 and on pooled basis. 100% NPK (F) resulted in lowest pods/plant in 2005. Mean green pod yield was significantly higher following the application of 50% NPK (F) + 50% N (FYM) and 50% N each through FYM and vermicompost. But in 2005, 50% NPK (F) + 50% N (FYM) recorded highest green pod yield. Increase in French bean yield due to improved growth and yield contributing characters was observed by several workers (Rana *et al* 2001; Singh and Verma 2002). It is pertinent to highlight that whereas, INM, organic and pure inorganic fertility management treatments were equal in influencing yield during 2004, INM and organic nutrient management treatments were superior to inorganic during 2005. Pure inorganic while fetched highest net return during 2004, but had lowest net returns during 2005 which doubt its sustainability. The mean net return was highest under 50% NPK (F) + 50% N (FYM) followed by 100% NPK (F).

Interaction

The mean count and dry weight of weeds were significantly lower due to pendimethalin and pendimethalin + hand weeding over hand weeding twice in all the fertility levels except 50% NPK (F) + 50% N (FYM). Pendimethalin + hand weeding was superior to pendimethalin alone in 50% NPK (F) + 50% N (FYM), 50% N (FYM) + 50% N (VC) and 100% NPK (F) during 2004. This may be ascribed to the fact that weeds survived after pre-emergence application of the herbicide at low rate, were weeded out with hands to get rid of them. Rana (2002a) and Prajapati *et al.* (2003 & 2004) reported similar findings. Among all treatment combinations, 50% NPK (F) + 50% N (FYM) + pendimethalin + hand weeding resulted in lowest mean weed dry matter accumulation. The combinations of 100% NPK (F) + pendimethalin + hand weeding, 50% NPK (F) + 50% N (FYM) + hand weeding and all fertility levels in integration with pendimethalin were statistically at par in reducing total mean weed dry matter accumulation.

The superior weed control owing to pendimethalin and pendimethalin + hand weeding in comparison to hand weeding twice was reflected in terms of growth, yield attributes, yield and returns at each fertility level. 50% NPK (F) + 50% N (FYM) and 100% NPK (F) in integration with pendimethalin + hand weeding remaining at par with 50% NPK (F) + 50% N (VC) + pendimethalin resulted in significantly higher mean plant height and mean number of leaves/plant. 50% NPK (F) + 50% N (FYM) + pendimethalin + hand weeding remaining at par with 50% NPK (F) + 50% N (VC) + pendimethalin gave significantly higher mean dry matter accumulation. Pendimethalin and pendimethalin + hand weeding in all schedules of fertility except 50% NPK (F) + 50% N (FYM) and 50% N (FYM) + 50% N (VC) in 2005 gave significantly higher pods/plant and green pod yield over hand weeding twice. Pod yield was significantly highest in the treatment combination 50% NPK (F) + 50% N (FYM) + pendimethalin + hand weeding in 2005. However, 50% NPK (F) + 50% N (VC) + pendimethalin and 50% N (FYM) + 50% N (VC) + pendimethalin or pendimethalin + hand weeding were as good as the above treatment combination in influencing pods/plant and mean pod yield. The comparatively low cost of application of pendimethalin at higher rate alone than its low rate along with hand weeding tended to fetch significantly higher net returns due to 50% NPK (F) + 50% N (VC) + pendimethalin (Rs 29375/ha. But 50% NPK (F) + 50% N (FYM) + pendimethalin + hand weeding (Rs 28261/ha) was at par with the above combination in influencing mean net return.

Therefore, it is inferred that integrated nutrient management involving 50% nutrients supply from fertilizers and 50% from FYM/VC along with pendimethalin 1.20 kg/ha or pendimethalin at 0.90 kg/ha + hand weeding for weed control may be the most effective.

Table 1. Effect of weed control methods and fertility levels on weed count, weed dry weight accumulation, plant height and leaves/plant of French bean

	Weed count (No./m^2)			Weed dry weight (g/m^2)			Plant height (cm)			Leaves/plant		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
Weed control methods												
Hand weeding	34.7 (1211)	17.5 (305)	27.5 (758)	227.7	126.7	177.2	33.2	35.3	34.3	7.8	14.3	11.1
Pendimethalin 1.2 kg/ha	11.4 (132)	13.5 (181)	12.5 (157)	185.7	57.7	121.6	40.9	37.5	39.2	13.9	17.0	15.5
Pendimethalin 0.9 kg/ha + HW	15.5 (242)	14.9 (228)	15.3 (235)	156.7	116.0	136.4	41.8	37.9	39.9	13.6	16.4	15.0
LSD (P=0.05)	0.9	0.8	0.6	14.1	6.4	7.3	1.8	1.2	0.9	1.2	0.8	0.7
Fertility treatments												
50% NPK (F) + 50% N (FYM)	19.1 (459)	14.6 (216)	17.3 (338)	164.7	60.8	112.8	40.0	39.7	39.9	12.2	17.5	14.8
50% NPK (F) + 50% N (VC)	21.9 (589)	15.8 (253)	19.4 (421)	229.5	134.6	182.1	39.8	33.6	36.7	10.9	13.7	12.3
50% N (FYM) + 50% N (VC)	21.9 (601)	16.1 (263)	19.6 (432)	212.7	88.4	150.6	35.6	38.9	37.2	11.9	16.4	14.1
100% NPK (F)	19.2 (463)	14.7 (220)	17.4 (342)	153.2	116.4	134.8	39.1	35.6	37.4	12.3	16.0	14.1
LSD (P=0.05)	1.7	NS	1.0	16.5	11.4	10.0	2.8	1.5	1.9	NS	0.8	1.4

F, fertilizers; VC, vermicompost; FYM, Farmyard manure; Data on weed count transformed to square root ($\sqrt{x+1.0}$) transformation.
Figures in parentheses are the means of original values; NS, Non-significant

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Table 2. Effect of weed control methods and fertility levels on plant dry matter accumulation, pods/plant, pod yield and net return of French bean

	Plant dry matter (g/m^2)			Pods/plant			Green pod yield (kg/ha)			Net returns (Rs/ha)		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
Weed control methods												
Hand weeding	114	197	155	11.4	15.3	13.3	2013	3588	2800	-3082	12105	4511
Pendimethalin 1.2 kg/ha	214	236	228	16.4	18.5	17.4	3966	4352	4159	21593	23998	22796
Pendimethalin 0.9 kg/ha + HW	204	228	216	17.4	18.3	17.8	3908	4030	3969	19135	19683	19409
LSD (P=0.05)	13	10	9	1.1	0.8	0.6	278	279	211	2788	2535	2068
Fertility treatments												
50% NPK (F) + 50% N (FYM)	186	279	232	15.3	19.6	17.4	3281	5303	4292	12300	31697	21998
50% NPK (F) + 50% N (VC)	169	198	184	15.0	16.8	15.9	3136	3659	3397	11373	15063	13218
50% N (FYM) + 50% N (VC)	159	232	195	14.1	18.8	16.5	3164	4848	4006	3181	18397	10789
100% NPK (F)	196	171	183	15.9	14.1	15.0	3601	2150	2875	23341	9225	16283
LSD (P=0.05)	21	12	8	NS	1.4	1.4	NS	353	376	5187	3287	3515

F, fertilizers; VC, vermicompost; FYM, Farmyard manure; NS, Non-significant

Table 3. Integrated effects of weed control methods and fertility levels on count and dry weight accumulation of weeds and plant height and leaves/plant of French bean

	Count			Dry weight			Plant height (cm)			Leaves/plant		
	W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3
2004												
50% NPK (F) + 50% N (FYM)	32.5 (1060)	10.4 (108)	14.5 (209)	175.2	198.7	120.3	36.8	40.6	42.7	8.9	13.0	14.7
50% NPK (F) + 50% N (VC)	36.4 (1324)	12.5 (156)	17.0 (288)	275.7	170.9	241.9	34.3	46.8	38.4	6.8	16.7	9.1
50% N (FYM) + 50% N (VC)	37.4 (1400)	12.7 (161)	15.5 (243)	281.3	200.5	156.3	26.5	39.0	41.2	6.6	14.0	15.0
100% NPK (F)	32.6 (1061)	10.1 (101)	15.1 (227)	178.7	172.5	108.5	35.3	37.3	44.9	9.1	12.1	15.6
LSD (P=0.05)	1.8$		2.3#	28.1$		28.2#	3.6$		4.0#	2.5$		3.2#
2005												
50% NPK (F) + 50% N (FYM)	17.0 (289)	14.1 (199)	12.7 (161)	77.1	38.7	66.7	36.1	40.0	42.9	16.6	16.8	18.9
50% NPK (F) + 50% N (VC)	17.7 (312)	13.2 (173)	16.6 (275)	179.5	61.3	163.5	32.6	35.3	32.9	13.5	15.6	11.9
50% N (FYM) + 50% N (VC)	17.9 (321)	13.2 (173)	17.1 (293)	108.7	43.5	113.1	38.8	39.5	38.3	16.5	16.8	15.9
100% NPK (F)	17.3 (299)	13.4 (180)	13.3 (181)	141.6	86.7	120.9	33.7	35.4	37.5	10.6	18.7	18.7
LSD (P=0.05)	1.6$		2.3#	12.7$		15.4#	2.3$		2.4#	1.6$		1.6#
Mean												
50% NPK (F) + 50% N (FYM)	25.9 (675)	12.4 (153)	13.6 (185)	126.1	118.7	93.5	36.5	40.3	42.8	12.8	14.9	16.8
50% NPK (F) + 50% N (VC)	28.6 (818)	12.8 (165)	16.8 (281)	227.6	116.1	202.7	33.4	41.0	35.7	10.1	16.1	10.5
50% N (FYM) + 50% N (VC)	28.4 (861)	13.0 (167)	16.4 (268)	195.0	122.0	134.7	32.6	39.2	39.8	11.5	15.4	15.5
100% NPK (F)	26.1 (680)	11.9 (141)	14.3 (204)	160.1	129.6	114.7	34.5	36.3	41.2	9.9	15.4	17.1
LSD (P=0.05)	1.2$		1.4#	14.6$		15.5#	1.8$		2.4#	1.4$		1.8#

F, fertilizers; VC, vermicompost; FYM, Farmyard manure; $, LSD for weed control measures at the same fertility treatment;
LSD for fertility treatments at same or different weed control measure

Table 4. Integrated effects of weed control methods and fertility levels on crop dry weight accumulation, pods/plant, pod yield and net return of French bean

	Crop dry weight (g/m^2)			Pods/plant			Green pod yield (kg/ha)			Net return (Rs/ha)		
	W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3
2004												
50% NPK (F) + 50% N (FYM)	154.5	192.6	210.0	13.1	15.3	17.5	2508	3453	3884	2410	15840	18651
50% NPK (F) + 50% N (VC)	104.0	257.5	145.0	11.4	18.5	15.2	1813	4771	2823	-4646	30828	7937
50% N (FYM) + 50% N (VC)	62.1	193.5	221.6	7.8	16.1	18.4	1138	3980	4372	-20087	13270	16361
100% NPK (F)	134.8	210.5	241.2	13.2	15.8	18.6	2591	3659	4552	9996	26436	33592
LSD (P=0.05)	25.8$		29.7#	2.1$		2.3#	556$		696#	5576$		6784#
2005												
50% NPK (F) + 50% N (FYM)	255.0	273.3	309.1	16.8	20.3	21.7	4913	5157	5838	25214	32004	37871
50% NPK (F) + 50% N (VC)	171.5	239.5	183.8	15.9	17.8	16.7	3260	4797	2919	8696	27922	8569
50% N (FYM) + 50% N (VC)	214.2	259.2	221.8	16.7	20.9	19.0	4591	5170	4784	13088	23945	18157
100% NPK (F)	146.2	172.5	195.4	11.7	14.9	15.7	1588	2283	2578	1420	12119	14136
LSD (P=0.05)	19.2$		19.5#	1.6$		1.9#	558$		574#	5070$		5273#
Mean												
50% NPK (F) + 50% N (FYM)	204.8	233.0	259.6	14.9	17.8	19.6	3710	4305	4861	13812	23922	28261
50% NPK (F) + 50% N (VC)	137.8	248.5	164.4	13.7	18.2	15.9	2537	4784	2871	2025	29375	8253
50% N (FYM) + 50% N (VC)	138.2	226.4	221.7	12.2	18.5	18.7	2865	4575	4578	-3499	18608	17259
100% NPK (F)	140.5	191.5	218.3	12.5	15.4	17.2	2090	2971	3565	5708	19277	23864
LSD (P=0.05)	18.2$		16.8#	1.3$		1.7#	421$		508#	4136$		4862#

F, fertilizers; VC, vermicompost; FYM, Farmyard manure; $, LSD for weed control measures at the same fertility treatment;
LSD for fertility treatments at same or different weed control measure

Meeting out nutrient requirement purely through inorganics appeared to be most unsustainable in French bean production. Similarly, managing weeds through manual weeding not only increase production costs, but considerably lowers the yield in comparison to herbicidal or integrated weed management strategy.

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