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Effect of different farming practices on productivity, profitability and produce quality of black gram- garden pea cropping sequence

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Abstract

Continuous and imbalanced use of costly chemical fertilizers as a source of nutrients in mid hill farming systems has led to decreased nutrient use efficiency which results in either yield stagnation or decrease in yield. Alternative low-input farming practices have emerged in pockets across the world promising reduced input costs and higher yields for farmers, chemical-free food for consumers and improved soil fertility. The present study was carried out during 2018-19 and 2019-20 on black gram-garden pea cropping system, wherein eight different farming practices were evaluated in RBD. The results revealed significantly higher grain and straw yield, and quality of produce with recommended NPK+FYM (soil test based fertilizer application) over other farming practices. The economic analysis of black gram and garden pea showed that, though the highest net returns were obtained from treatment wherein 50% NPK + 50% FYM (integrated) was applied, however, highest benefit cost ratio was recorded in treatment sole application of NPK in both the crops during both years of study.

Key words: Productivity, profitability, quality, garden pea, black gram.

Food legumes constitute an important source of dietary proteins of the people in Asia, Africa, Latin America and other developing countries of the world. The important grain legumes grown in India are chickpea, pigeon pea, green gram, black gram, cowpea, lentil and peas etc. Among these grain legumes, black gram and garden pea are the most important crops grown in India, in an area of 54.29 lakh ha and 540.5 thousand ha with an annual production of 35.62 lakh tonnes and 5422.1 thousand million tonnes, respectively (Anonymous 2018). Blackgram, (*Vigna mungo* (L), Hepper), an ancient and well known leguminous crop of Asia, is popular because of its nutritional values of high seed protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. Pea (*Pisum sativum* L.) is highly nutritive, containing high percentage of protein, carbohydrates, vitamins and rich in minerals, grown for both fresh and dried seed. Being a leguminous crop, it fixes nitrogen symbiotically with *Rhizobium* bacteria and thus has low nitrogen requirements. Pea can be consumed either fresh, canned, pulse, frozen or in dehydrated forms. The positive effect of legumes in cropping systems is not solely due to biological nitrogen fixation (BNF) but also due to several other associated mechanisms, such as increased nutrient availability, improved soil structure, reduced disease incidence and increased mycorrhizal colonization (Dhulgande *et al*. 2011). In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated application from alternate sources of nutrient for sustaining the desired crop productivity (Tiwari, 2002). Organic manures improve soil physical, chemical and biological properties and thus enhance crop productivity vis-a-vis maintain soil health. Choice of combination of different sources of organic and inorganic nutrients for enhancement of yield in black-gram-garden pea cropping sequence has been a matter of interest for rendering sustainability to the

agricultural productivity. The present study was thus, taken up with the objective to explore the effect of different farming practices on growth, quality and yield of blackgram –garden pea copping sequence.

Materials and Methods

A field experiment was conducted during 2018-19 and 2019-20 at the experimental farm of Himachal Pradesh Krishi Vishvavidyalaya, Hill Agricultural Research and Extension Centre, Bajaura, Kullu, India. The experimental farm is situated at 31.8°N latitude and 77°E longitude at an elevation of 1090 m above mean sea level. The soils under study are slightly acidic in nature (pH: 6.43) with silty clay loam texture, low in available nitrogen (262 kg ha^{-1}), high in available phosphorus (34.6 kg ha^{-1}), medium in organic carbon (7.8 g kg^{-1}) and medium in available potassium (180.2 kg ha^{-1}).The experiment had eight treatments viz. T_1-soil application of *jeevamrit* at 15 days interval, T_2-soil application of *jeevamrit* at 30 days interval, T_3-FYM alone, T_4-NPK alone (soil test-based fertilizer application), T_5-recommended NPK + FYM (soil test-based fertilizer application), T_6-integrated (50% NPK + 50% FYM), T_7-farmers' practice (40% of RDF), T_8-absolute control, which were replicated thrice in RBD. The garden pea crop (cv. Azad Pea-1) was sown on 31st October 2018 and 07th November 2019 at the seed rate of 60 kg ha^{-1} with a spacing of 45 cm × 7.5 cm. The black gram crop was sown on 18th July 2018 and 23rd July 2019 at the seed rate of 18 kg ha^{-1} with a spacing of 45 cm × 10 cm. Standard practices of Subhash Palekar Natural Farming were followed in T_1 and T_2. T_3 received only FYM application. Soil test-based fertilizers were applied in T_4 (only NPK) and T_5 (NPK +FYM). Under T_6, 50% RDF was applied, and 50% fertilizers were supplemented through organic manure (FYM). The current farmers' practice was 40% of recommended NPK (T_7). No fertilizers or organic manure was applied in control plot (T_8). The sources of N,P and K fertilizer were urea, single super phosphate and muriate of potash. Recommended doses of NPK fertilizers and FYM for garden pea and blackgram are N50:P60:K60 kg ha^{-1} + 10 t ha^{-1} FYM for pea and N20:P40:K20 kg ha^{-1} + 10 t ha^{-1} FYM for blackgram.

In soil test based fertilizer application treatments, NPK were applied on the basis of soil test values as basal application. An increase of 25 % in nitrogen (T_4 and T_5). In case of phosphorus, the dose was reduced to 25% of RDF. The data generated from the field and laboratory studies were subjected to statistical analysis using the technique of analysis of variance for randomized block design as described by Gomez and Gomez (1984), and were tested at 5 per cent level of significance to interpret the treatment differences. The green pods of pea obtained at all pickings were recorded and summed up to determine total pod yield and expressed as q ha^{-1}. The dry straw yield was recorded after the final harvest. Yield of grain and straw of black gram from net plot was recorded after drying the bundles under sun to a standard moisture condition and the grain and straw yield recorded after the crop harvest. Nitrogen was estimated by modified Micro-Kjeldahl method and protein content was obtained by multiplying the per cent nitrogen content with the factor 6.25 (FAO 2003). Seeds of fresh pods from second picking were crushed in pestle-mortar and the liquid extract obtained was used to record the total soluble solids with the help of ERMA hand refractrometer in ^{o}Brix.

Economic analysis

The economic analysis of different experimental treatments was carried out by taking into account the prevailing market prices of inputs/outputs used. Year wise gross returns, net returns and benefit cost ratio was calculated using following formulae:

Gross returns (Rs ha^{-1}) = Marketable yield (q ha^{-1}) × Price (Rs kg^{-1}) × 100

Net returns (Rs ha^{-1}) = Gross returns (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

$$\text{Benefit cost ratio} = \frac{\text{Net returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation Rs ha}^{-1}} \times 100$$

Results and Discussion

Grain yield

The data on the effect of different farming practices on grain yield of black gram and green pod yield of garden pea has been presented in Table1. The results indicated significant variations among the treatments during both the years of study. However, T_1 (Soil application of *Jeevamrit* at 15 days interval) and T_2 (Soil application of *Jeevamrit* at 30 days interval) were at par, but found superior in comparison to control (T_8). Further the data

demonstrated that the maximum blackgram grain yield of 9.47 q ha^{-1}, 9.74 q ha^{-1} and 9.61 q ha^{-1} was observed in the year 2018, 2019 and for pooled data, respectively, were obtained with the application of NPK+FYM (T_5) . The control treatment (T_8) had minimum grain yield of 5.63 q ha^{-1}, 5.61 q ha^{-1} and 5.62 q ha^{-1}, respectively during 2018, 2019 and for pooled data. The different farming practices increased black gram grain yield over absolute control from 15.3 % to 68.2 % in 2018, 17.1 % to 73.6 % in 2019 and 16.2 % to 71 % in pooled yield. Similarly, maximum pea green pod yield of 119.3 q ha^{-1}, 121.1 q $ha^{-1}$and 120.2 q $ha^{-1}$was observed in T_5 treatment (NPK+FYM) which was statistically at par with T_6 (50% NPK + 50% FYM) and minimum of 76.6 q ha^{-1}, 74.9 q ha^{-1} and 75.7 q ha^{-1} was obtained in absolute control (T_8) plot in the year 2018-19, 2019-20 and for pooled data, respectively. The observed increase in green pod yield among different farming practices over absolute control varied from 24.8 % to 55.7 % in 2018-19, 28.9 % to 61.7 % in 2019-20 and 26.9 % to 58.8 % in pooled yield, respectively.

Straw Yield

In depth exploration of the data in Table 2 demonstrated that application of NPK+FYM (T_5) recorded maximum blackgram straw yield of 24.5 q ha^{-1} in 2018, 25.5 q ha^{-1} in 2019 and 25.0 q ha^{-1} in case of pooled yield, whereas, absolute control treatment (T_8) had minimum straw yield of 16.5 q ha^{-1}, 15.8q $ha^{-1}$and 16.2q ha^{-1}, respectively during 2018, 2019 and pooled. The observed increase in straw yield due to different treatments over absolute control varied from 4.6 % to 48.2 % in 2018, 14 % to 61.2 % in 2019 and 19.2 % to 54.6 % in pooled, respectively. Similar trend was also observed in case of straw yield of garden pea with maximum yield of 46.2 q ha^{-1}, 47.9 q $ha^{-1}$and 47.1q ha^{-1} being recorded with NPK+FYM (T_5) and minimum of 29.4 q ha^{-1} ,27.7q ha^{-1} and 28.5 q ha^{-1} in control (T_8) plot during the year 2018-19, 2019-20 and for pooled data, respectively. The extent of increase in straw yield among different farming practices over absolute control ranged from 22.6 % to 57.3 % in 2018-19, 34.8 % to 72.9 % in 2019-20 and 28.5 % to 64.9 % in pooled, respectively .

Table 1. Effect of different farming practices on grain yield (q ha^{-1})

Treatment	Grain yield (q ha^{-1})					
	Blackgram			Pea		
	2018	2019	Pooled	2018-19	2019-20	Pooled
T_1	6.72	6.82	6.77	99.6	100.6	100.1
T_2	6.49	6.57	6.53	95.6	96.5	96.1
T_3	7.19	7.33	7.26	102.7	103.9	103.3
T_4	8.23	8.55	8.39	111.5	113.2	112.4
T_5	9.47	9.74	9.61	119.3	121.1	120.2
T_6	8.87	9.15	9.01	115.6	117.3	116.4
T_7	7.70	7.93	7.82	107.1	108.7	107.9
T_8	5.63	5.61	5.62	76.6	74.9	75.7
CD (P=0.05)	0.45	0.47	0.27	4.12	4.64	4.15

T_1- Soil application of *Jeevamrit* at 15 days interval, T_2- Soil application of *Jeevamrit* at 30 days interval,T_3- FYM alone, T_4- NPK alone (Soil test based fertilizer application), T_5- Recommended NPK + FYM (Soil test based fertilizer application), T_6- Integrated (50% NPK + 50% FYM), T_7- Farmers' Practice (40% of RDF),T_8- Absolute control

Table 2. Effect of different farming practices on straw yield (q ha^{-1})

Treatment	Straw yield (q ha^{-1})					
	Blackgram			Pea		
	2018	2019	Pooled	2018-19	2019-20	Pooled
T_1	18.1	18.9	18.5	38.4	39.7	39.0
T_2	17.3	18.0	17.7	36.0	37.3	36.7
T_3	19.8	20.6	20.2	39.8	41.2	40.5
T_4	21.9	22.8	22.3	42.4	44.0	43.2
T_5	24.5	25.5	25.0	46.2	47.9	47.1
T_6	22.9	23.8	23.3	43.9	45.5	44.7
T_7	20.7	21.5	21.1	41.1	42.6	41.9
T_8	16.5	15.8	16.2	29.4	27.7	28.5
CD (P=0.05)	0.82	0.62	0.66	1.23	1.28	0.82

T_1- Soil application of *Jeevamrit* at 15 days interval, T_2- Soil application of *Jeevamrit* at 30 days interval,T_3- FYM alone, T_4- NPK alone (Soil test based fertilizer application), T_5- Recommended NPK + FYM (Soil test based fertilizer application), T_6- Integrated (50% NPK + 50% FYM), T_7- Farmers' Practice (40% of RDF),T_8- Absolute control

Total soluble solids (TSS)

The different farming practices significantly influenced the grain quality of garden pea grain in terms of total soluble solids (Table 3).Total soluble solids in grains of garden pea ranged from 15.0^{0}Brix to 13.1^{0}Brix, 15.3^0 Brix to 13.4^{0}Brix and 15.2^0 Brix to 13.3^0 Brix in 2018-19, 2019-20 and pooled, respectively with maximum values under treatment T_5 (RDF NPK+FYM) which recorded TSS to the extent of 15.0^0 Brix in 2018-19, 15.3^0 Brix in 2019-20 and 15.2^{0}Brix in pooled and lowest of 13.1^{0}Brix, 13.4^{0}Brix and 13.3^0 Brix in control (T_8). In terms of percentage, the increase in TSS among different treatments over absolute control was 2.3 to 14.5% in 2018-19, 1.5 to 14.2 % in 2019-20 and 1.9% to 14.3 for pooled data.

Table 3. Effect of different farming practices on total soluble solids (TSS)

Treatment	TSS (^{0}Brix)		
	Pea		
	2018-19	2019-20	Pooled
T_1	13.8	13.9	13.9
T_2	13.4	13.6	13.5
T_3	14.0	14.1	14.0
T_4	14.5	14.6	14.5
T_5	15.0	15.3	15.2
T_6	14.8	14.9	14.9
T_7	14.3	14.4	14.3
T_8	13.1	13.4	13.3
CD (P=0.05)	0.27	0.18	0.15

T_1- Soil application of *Jeevamrit* at 15 days interval, T_2- Soil application of *Jeevamrit* at 30 days interval,T_3- FYM alone, T_4- NPK alone (Soil test based fertilizer application), T_5- Recommended NPK + FYM (Soil test based fertilizer application), T_6- Integrated (50% NPK + 50% FYM), T_7- Farmers' Practice (40% of RDF),T_8- Absolute control

Grain protein content

The data presented in table 4 revealed that protein content of black gram and garden pea grain was significantly influenced by the application of different organic and inorganic sources, during both the years of study. The data demonstrated that the application of NPK+FYM (T_5) recorded maximum protein content of 11.9 % in 2018, 12.2 % in 2019 and 12.0 % in pooled content in black gram which was statistically at par with T_6 (50% NPK + 50% FYM) and T_4 (NPK alone) in pooled analysis. The control treatment (T_8) had minimum protein content of 10.4 %, 9.9 % and 10.1 %, respectively during 2018, 2019 and pooled. The observed increase in protein content due to different treatments over absolute control varied from 7.0 % to 14.4 % in 2018, 15.2 % to 23.4 % in 2019 and 10.9 % to 18.7 % for pooled content. Similar trend was also observed in case of garden pea and maximum protein content of 12.1%, 12.6 % and 12.3 % was found in NPK+FYM (T_5) treatment which was statistically at par with T_6 (50% NPK + 50% FYM) in case of pooled analysis and minimum of 10.7 % , 10.4 % and 10.5 % in the year 2018-19, 2019-20 and for pooled data, respectively for absolute control (T_8) treatment. The comparison of treatments with absolute control showed that they increased grain protein content by 6 % to 13.7 % in 2018-19, 12.2 % to 20.5 % in 2019-20 and 9.1 % to 17.1 % in pooled data.

Economics of black gram

The adoption of technology in modern agriculture can only be feasible and acceptable to farmers if it is economically viable. The treatment-wise cost of cultivation and return analysis (B: C ratio) of black gram and pea have been depicted through table 5. The

Table 4. Effect of different farming practices on protein content

Treatment	Protein content (%)					
	Blackgram			Pea		
	2018	2019	Pooled	2018-19	2019-20	Pooled
T_1	11.3	11.5	11.4	11.4	11.9	11.7
T_2	11.1	11.4	11.3	11.3	11.7	11.5
T_3	11.4	11.6	11.5	11.6	12.1	11.8
T_4	11.7	12.0	11.8	11.9	12.4	12.1
T_5	11.9	12.2	12.0	12.1	12.6	12.3
T_6	11.8	12.0	11.9	12.0	12.4	12.2
T_7	11.6	11.8	11.7	11.8	12.2	12.0
T_8	10.4	9.9	10.1	10.7	10.4	10.5
CD (P=0.05)	0.27	0.98	0.24	0.37	0.45	0.16

T_1. Soil application of *Jeevamrit* at 15 days interval, T_2. Soil application of *Jeevamrit* at 30 days interval,T_3. FYM alone, T_4. NPK alone (Soil test based fertilizer application), T_5. Recommended NPK + FYM (Soil test based fertilizer application), T_6. Integrated (50% NPK + 50% FYM), T_7. Farmers' Practice (40% of RDF),T_8. Absolute control

Table 5. Effect of different farming practices on economics of black gram

Treatment	Cost (Rs ha^{-1})	2018			2019		
		Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	62650	135677	73,027	1.17	137697	75047	1.20
T_2	58250	131031	72,781	1.25	132647	74397	1.28
T_3	75825	145305	69,480	0.92	147999	72174	0.95
T_4	53761	166179	112,418	2.09	172710	118949	2.21
T_5	78761	191361	112,600	1.43	196681	117920	1.50
T_6	65030	179174	114,144	1.76	184897	119867	1.84
T_7	62189	155540	93,351	1.50	160253	98064	1.58
T_8	50825	113726	62,901	1.24	113322	62497	1.23
CD (P=0.05)	-	-	9456.03	0.15	-	9486.75	0.16

T_1. Soil application of *Jeevamrit* at 15 days interval, T_2. Soil application of *Jeevamrit* at 30 days interval,T_3. FYM alone, T_4. NPK alone (Soil test based fertilizer application), T_5. Recommended NPK + FYM (Soil test based fertilizer application), T_6. Integrated (50% NPK + 50% FYM), T_7. Farmers' Practice (40% of RDF),T_8. Absolute control

economic analysis of black gram presented in table 5 showed that, though the highest net returns of Rs 114144 and 119867 ha^{-1} were obtained for treatment T_6 (50% NPK + 50% FYM) in the year 2018 and 2019, respectively, however, benefit cost ratio of 2.09 and 2.21 in 2018 and 2019 season, respectively was recorded highest in treatment T_4 (NPK).

Economics of garden pea

The results demonstrated that the higher net return of Rs 195736 and 199928 ha^{-1}were obtained from treatment T6 (50% NPK + 50% FYM) in the year 2018-19 and 2019-20, respectively (Table 6). Further, maximum benefit cost ratio of 2.34 and 2.39 was recorded with application of T_4 (NPK)and least net profit was found in T_3. The high profitability in T6 after incurring Rs. 93247 ha^{-1} towards cost of cultivation during both the years, respectively.

Improvement in yield due to combined application of inorganic fertilizer and organic manure could also be attributed to control release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth and yield. These results are in accordance with Verma *et al*. (2017) and Tyagi and Singh (2019).

The better produce quality observed in the current study was a result of higher availability of phosphorus which is a constituent of ADP, ATP and other high energy compounds which are responsible for improving quality of produce (Koshalendra *et al*. 1992). Also, application of organics might have increased sugar phosphates polysaccharides as phosphorus is one of the important constituents for enhancing TSS content. Similar findings have also been documented by Sharma and Rana (1993) who reported increased TSS in pea seed with the application of NPK.

The increased protein content in pea and black gram can be explained on the basis of the findings of Tisdale *et al*. (1995) wherein the amount of protein produced was resultant of the N supplied to the crop. On the other hand, added organics play an important role in synthesis of protein by enhancing the availability of N and S through mineralization, which help in formation of sulphur containing amino acids. Similar findings have been reported by Kumar *et al*. (2012). Gopinath *et al*. (2009) also recorded higher benefit cost ratio in bell pepper with the addition of inorganic fertilizers in combination with organics. These results are in agreement with those of Sharma *et al*. (2011) and Dey *et al*. (2012).

Table 6. Effect of different farming practices on economics of garden pea

Treatment	Cost	2018			2019		
	(Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	89500	248917	159417	1.78	251517	162017	1.81
T_2	85100	239025	153925	1.81	241292	156192	1.84
T_3	102675	256742	154067	1.50	259700	157025	1.53
T_4	83368	278742	195373	2.34	282992	199623	2.39
T_5	108368	298333	189965	1.75	302708	194340	1.79
T_6	93247	288983	195736	2.10	293175	199928	2.14
T_7	90132	267842	177710	1.97	271850	181718	2.02
T_8	77675	191383	113708	1.46	187300	109625	1.41
CD (P=0.05)	-	-	6506.38	0.08	-	7558.61	0.08

T_1- Soil application of *Jeevamrit* at 15 days interval, T_2- Soil application of *Jeevamrit* at 30 days interval,T_3- FYM alone, T_4- NPK alone (Soil test based fertilizer application), T_5- Recommended NPK + FYM (Soil test based fertilizer application), T_6- Integrated (50% NPK + 50% FYM), T_7- Farmers' Practice (40% of RDF),T_8- Absolute control

Conclusion

Based on two years study, it may be concluded that the treatment T5 (NPK + FYM) registered the maximum yield and quality of both crops. The economic analysis of black gram and garden pea showed that highest B:C ratio was under treatment T_4 (NPK alone). Treatment T_5 (NPK+ FYM) was not as economically viable as NPK alone i.e. T_4 because of high expense of FYM as compared to synthetic NPK. Hence, treatment T_5 can be suggested as a cost effective nutrient module for getting higher yield and quality for cultivation of black gram and garden pea crop on sustainable basis.

Conflict of Interest: The authors declare that there is no conflict of interest.

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