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Performance of Different Farming Practices in Legume based Cropping System under Mid-hills of H.P. Himalayas

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ABSTRACT

Background: Increasing demands of food, depleting land, degrading land resources and changing climate are some of the important factors driving the cropping systems of any agro-ecological zone in the world. Cropping systems have been traditionally structured to maximize crop yields. Now, there is a strong need to design cropping systems which take into consideration the emerging social, economical and ecological or environmental concerns. Legumes can provide opportunities for increased productivity to be sustained because of their adaptability to various cropping patterns and ability to fix nitrogen. Legume-based crop rotation helps to conserve organic matter, maximise soil nitrogen, balance soil nutrients, maintain soil physical properties and break soil-borne disease cycles. Moreover, with increasing fertilizer prices and emphasis of the government for doubling the farmer's income by reducing cost of cultivation, the current trend is to explore the possibility of supplementing chemical fertilizer with the organic ones, more particularly organic manures and bio-fertilizer of microbial origin. The current study is aimed to increase small and marginal farmer's income and to reduce cost of cultivation through legume based vegetable cropping systems and to find out best farming practices.

Methods: Field experiments were conducted at Organic Farm Holta, Department of Organic Agriculture and Natural farming, CSK HPKV, Palampur (H.P.) during *kharif* and *rabi* seasons of 2018-19 and 2019-20 on silty clay loam soil to study the performance of different farming practices in legume based cropping system under mid-hills of H.P. Himalayas. The experiment was laid out under Split plot design with three replications comprising of three sequences in legume vegetable-based cropping systems *i.e.*, "Soybean-Onion", "Okra-Pea" and "Mash-Garlic" under different farming practices *i.e.*, Organic farming, Natural farming, Inorganic and Integrated farming practices. For comparison of different crops soybean equivalent yield and pea equivalent yields were calculated in *kharif* and *rabi* seasons, respectively.

Result: In *kharif* seasons okra crop attained highest soybean equivalent yield followed by soybean and mash crop. In *rabi* seasons garlic crop attained highest pea grain equivalent yield followed by onion and pea crop. During both *kharif* seasons organic farming practices attained highest yield and was at par with integrated farming practices. Significantly highest yield was attained from integrated farming practices and was at par with organic farming practices in both rabi seasons. Highest net returns, net returns per rupee attained was in inorganic farming system. Highest cost of cultivation was found in organic farming practices.

Key words: Cropping system, Farming practices, Productivity, Profitability.

INTRODUCTION

Increasing demands of food, depleting land, degrading land resources and changing climate are some of the important factors driving the cropping systems of any agro-ecological zone in the world. Cropping systems have been traditionally structured to maximize crop yields. Now, there is a strong need to design cropping systems which take into consideration the emerging social, economical and ecological or environmental concerns. Legumes can provide opportunities for increased productivity to be sustained because of their adaptability to various cropping patterns and ability to fix nitrogen (Jeyabal and Kuppuswamy, 2001). Legume-based crop rotation helps to conserve organic matter, maximise soil nitrogen (N), balance soil nutrients, maintain soil physical properties and break soil-borne disease cycles in the soil. Moreover, with increasing fertilizer prices and emphasis of the government for doubling the farmers' income by reducing cost of cultivation, the current trend is to explore the possibility of supplementing chemical fertilizer with the organic ones, more particularly organic

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manures and bio-fertilizer of microbial origin. Legume and vegetable based multiple cropping systems have unique benefits and reduce the risk of low income for small and marginal farmers (Rana *et al.* 2011; Sharma *et al.* 2009).

Chemical fertilizers have the ability to fulfil the nutrient demand of these crops but the poor socio-economic conditions of small and marginal farmers restrict the use of chemical fertilizers. Moreover, continuous and indiscriminate use of high analysis chemical fertilizers has resulted in the degradation of environment ultimately leading to depleted soil productivity, crop productivity and sustainability (Chakraborti and Singh, 2004). In this changing scenario, strategic change in nutrient management through integrated input supply system has shown promise with combined application of different sources of plant nutrients (organic and inorganic) for sustainable crop production without degrading the natural resource base of the soil and that too on long term basis.

Organic farming is reported to have enhanced both microbial biomass and microbial activity by 20-30% and 30-100%, respectively (Stolze *et al.* 2000). The farmyard manure (FYM) is an important source of organic matter in India, however its availability in huge quantity is questionable and is not enough to realize its optimum production potential. Thus, there is a strong need to adopt integrated nutrient supply system by judicious combination of organic and inorganic fertilizers to improve soil health and crop productivity (Verma and Bhattacharya 1990). Application of bio-fertilizers which is environment friendly and low-cost input, with organic and inorganic fertilizers as part of an integrated nutrient management strategy play a significant role in plant nutrition. Zero budget natural farming is another farming practice suggested by Padam Shri Dr. Subhash Palekar (ZBNF). This is a new concept that aims to promote long-term sustainability. It substitutes organic farming's use of farmyard manure and compost with cover crops, green manure crops and *desi* cow preparations. With the help of these components, humus formation occurs within the fields which releases nutrients slowly, allowing plants to absorb them more effectively. So, this experiment was planned to study the relative performance of conventional and traditional farming practices in different cropping systems.

MATERIALS AND METHODS

The experiment was conducted during *kharif* and *rabi* seasons of 2018-19 and 2019-20 at Organic Farm Holta of Department of Organic Agriculture and Natural Farming, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental site is geographically located at 32°6′ N latitude and 76°3′ E longitudes at an elevation of about 1224 meters above mean sea level. The soil of the experimental field was silty clay loam in texture, acidic in reaction, low in available nitrogen, high in available phosphorus and medium in available potassium.

The experiment was laid out under split plot design with three replications comprising of three crop sequences in legume vegetable-based cropping system *i.e.,* "Soybean - Onion", "Okra - Peas" and "Mash -Garlic". The varieties of crop *i.e.,* Soybean 'Harit Soya', Okra 'Punjab -8', Mash 'UG 218', Onion 'Patna red', Peas 'Punjab 89' and Garlic 'GHC-1' were raised in different farming practices *i.e.*, Organic farming, Natural farming, Inorganic and Integrated farming.

In organic practices, seed treatment with *Jeevamrit* @10%, vermicompost @ 5 t ha^{-1} (Soybean, Mash), 10 t ha^{-1} (Okra, Onion, Peas, Garlic) + 3 sprays of vermiwash were followed and in natural farming practices, soil treatment with jeevamrit @10%, *ghanjeevamrit* 250 kg ha^{-1} and sieved FYM 250 kg ha^{-1} + spray of *jeevamrit* after 21 days interval were followed. Under inorganic farming practices, recommended dose of NPK was followed whereas in integrated farming practices, half dose of inorganic and half the dose of organic practices was followed. There was no severe attack of any insect-pest and disease. For comparative performance of different cropping sequences under different farming practices, yield of all crops was converted into soybean grain-equivalent yield (SGEY) in *kharif* and pea grain equivalent yield (PGEY) in *rabi* on price basis. Since data followed the homogeneity test, pooling was done over the seasons and mean data was used to calculate productivity and profitability of the system. Profitability of the system under the different farming practices was worked out in terms of net returns per rupee invested and was calculated by dividing net returns (Rs ha^{-1}) with cost of cultivation (Rs ha^{-1}). The data was statistically analyzed as per the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Soybean grain equivalent yield (SGEY)

In *kharif* season crops *i.e.*, soybean, okra, mash yields were converted into soybean grain equivalent yield on price basis. Significantly higher soybean grain equivalent yield (SGEY) was recorded under organic farming practices (17.23 q ha^{-1}) during both the years of *kharif* season and was statistically at par with integrated farming (50% inorganic + 50% organic) farming practices (17.03 q ha^{-1}). Lowest SGEY (12.70 q ha^{-1}) was observed in zero budget natural farming practices. The beneficial effect of organic manures on yield might be due to additional supply of plant nutrients as well as improvement in physical and biological properties of the soil (Datt *et al.* 2003). Amongst cropping system, SGEY was significantly higher (23.46 q ha^{-1}) in "Okra-Pea" followed by "Soybean-Onion" (14.23 q ha^{-1}) cropping system. Lowest SGEY was recorded under "Mash- Garlic" (9.78 q ha^{-1}) cropping system (Table 1).

Pea grain equivalent yield (PGEY)

In *rabi* season crops *i.e.*, onion, peas, garlic yields were converted into pea grain equivalent yield on price basis. Significant effect on pea grain equivalent yield (PGEY) was observed with interaction effect of inorganic, organic, integrated and zero budget natural farming practices. Significantly highest yield (107.32 q ha^{-1}) was recorded under integrated farming (50% inorganic + 50% organic) and followed by organic farming practice (103.97 q ha^{-1}). Lowest PGEY (81.49 q ha^{-1}) was observed in Zero budget natural farming practices during *rabi* season of both the years (Table 2). In cropping System, PGEY under "Mash-Garlic" system (167.79 q ha^{-1}) was significantly higher followed by "Soybean-Onion" (72.90 q ha^{-1}). "Okra-Pea" cropping system produced lowest PGEY (51.31 q ha^{-1}). Kumar *et al.* (2020) also reported that "mash-garlic" cropping system produced significantly highest yield. This may be due to higher garlic yield and remunerative price it fetched (Table 1).

Economics

Cost of cultivation (Rs ha^{-1})

During both the years, highest cost of cultivation (Rs 1,39248) was recorded in "Mash- Garlic" cropping system under organic farming practices followed by "Mash- Garlic" cropping system (Rs 1,21834) in integrated farming practices. Similar findings were reported by Rana *et al.* (2014) with the application of vermicompost which increases the cost of cultivation. Cost of cultivation was least (Rs 71348) in "Soybean-Onion" cropping system under inorganic farming practices (Table 2).

Gross returns (Rs ha^{-1})

Highest gross returns (Rs 483868) were obtained with integrated nutrient management in "Mash- Garlic" cropping system during both the years (Table 3). This may be due to the fact that combination of organic manures and chemical fertilizers resulted in significantly higher yield that in return resulted into higher gross returns. Similar findings through conjunctive use of organic manures and chemical fertilizers have also been made by Ferdous *et al.* (2017), Jat *et al.* (2017) and Bharthy *et al.* (2017). Lowest value was recorded in "Okra-Peas" cropping system under zero budget natural farming practices. This may be due to less availability of nutrients in the soil.

Table 1: Effect of farming system and cropping system on yield (q ha^{-1}).

Treatments	Soybean grain equivalent yield (q ha^{-1})		Pea grain equivalent yield (q ha^{-1})	
	Kharif 2018	*Kharif* 2019	*Rabi* 2018-19	*Rabi* 2019-20
Farming practices (M)				
Organic (M_1)	16.27	17.23	103.97	97.73
Zero budget natural farming (M_2)	12.70	13.72	84.20	81.49
Inorganic (M_3)	14.58	15.54	93.85	91.41
Integrated (M_4)	16.17	17.03	107.32	100.31
LSD (P=0.005)	0.54	0.56	4.67	2.78
Cropping systems (S)				
Soybean-Onion (S_1)	14.23	14.81	72.90	73.30
Okra-Peas (S_2)	20.78	23.46	51.31	52.52
Mash-Garlic (S_3)	9.78	9.36	167.79	152.38
LSD (P=0.005)	0.30	0.51	3.56	3.69

Table 2: Effect of farming practices and cropping system on cost of cultivation (Rs ha^{-1}).

Treatment		Cost of cultivation (Rs ha^{-1})					
		2018-2019		2019-2020		(*Kharif* +	(*Kharif* +
Farming practice	Cropping system	*Kharif* 2018	*Kharif* 2019	*Rabi* 2018-2019	*Rabi* 2019-2020	*Rabi*) 2018-2019	*Rabi*) 2019-2020
Organic farming	Soybean - Onion	44350	46050	64438	66738	108788	112788
	Okra - Pea	61688	63768	49538	51638	111225	115405
	Mash - garlic	47038	49098	87850	90150	134888	139248
ZBNF	Soybean - Onion	41200	43060	46100	48560	87300	91620
	Okra - Pea	43600	45860	46200	48460	89800	94320
	Mash - garlic	44200	46460	69700	72160	113900	118620
Inorganic farming	Soybean - Onion	31688	33268	39660	41840	71348	75108
	Okra - Pea	34553	36533	37752	39732	72306	76266
	Mash - garlic	34688	36668	63260	65440	97948	102108
Integrated farming	Soybean - Onion	38719	40419	52655	54955	91374	95374
	Okra - Pea	48602	50682	44251	46351	92853	97033
	Mash - garlic	41219	43279	76255	78555	117474	121834

Table 3: Effect of farming practices and cropping system on gross returns (Rs ha^{-1}).

Treatment		Gross returns (Rs ha^{-1})					
		2018-2019		2019-2020		2018-2019	2019-2020
Farming practice	Cropping system	*Kharif* 2018	*Kharif* 2019	*Rabi* 2018-2019	*Rabi* 2019-2020	(*Kharif* + *Rabi*)	(*Kharif* + *Rabi*)
Organic farming	Soybean - Onion	84358	101634	148949	189226	233307	290860
	Okra - Pea	108898	150571	111943	142612	220841	293183
	Mash - Garlic	59782	67346	367037	405441	426819	472787
ZBNF	Soybean - Onion	65412	82676	138264	167834	203676	250510
	Okra - Pea	87402	119175	99919	126337	187321	245512
	Mash - Garlic	44945	52722	270523	320621	315468	373343
Inorganic farming	Soybean - Onion	72938	93406	144214	182177	217152	275582
	Okra - Pea	105156	138163	101434	128921	206590	267083
	Mash - Garlic	48529	56482	344036	353049	392565	409531
Integrated farming	Soybean - Onion	80414	97316	152970	195015	233384	292332
	Okra - Pea	114630	155759	109435	139961	224065	295719
	Mash - Garlic	56116	62425	385486	421443	441602	483868

Table 4: Effect of farming practices and cropping system on net returns (Rs ha^{-1}).

Treatment		Net returns (Rs ha^{-1})					
		2018-2019		2019-2020		2018-2019	2019-2020
Farming practice	Cropping system	*Kharif* 2018	*Kharif* 2019	*Rabi* 2018-2019	*Rabi* 2019-2020	(*Kharif* + *Rabi*)	(*Kharif* + *Rabi*)
Organic farming	Soybean - Onion	40008	55584	84512	122488	124520	178072
	Okra - Pea	47210	86804	62405	90974	109615	177778
	Mash - Garlic	12745	18248	279187	315291	291932	333539
ZBNF	Soybean - Onion	24212	39616	92164	119274	116376	158890
	Okra - Pea	43802	73315	53719	77877	97521	151192
	Mash - Garlic	745	6262	200823	248461	201568	254723
Inorganic farming	Soybean - Onion	41250	60138	104554	140336	145804	200474
	Okra - Pea	70603	101629	63681	89188	134284	190817
	Mash - Garlic	13842	19815	280776	287608	294618	307423
Integrated farming	Soybean - Onion	41695	56897	100315	140060	142010	196957
	Okra - Pea	66028	105077	65184	93609	131212	198686
	Mash - Garlic	14897	19147	309231	342888	324128	362035

Table 5: Effect of farming practices and cropping system on net returns per rs invested.

Treatment		Net returns per rs invested					
		2018-2019		2019-2020		2018-2019	2019-2020
Farming practice	Cropping system	*Kharif* 2018	*Kharif* 2019	*Rabi* 2018-2019	*Rabi* 2019-2020	(*Kharif* + *Rabi*)	(*Kharif* + *Rabi*)
Organic farming	Soybean - Onion	0.90	1.21	1.31	1.84	1.14	1.58
	Okra - Pea	0.77	1.36	1.26	1.76	0.99	1.54
	Mash - Garlic	0.27	0.37	3.18	3.50	2.16	2.40
ZBNF	Soybean - Onion	0.59	0.92	2.00	2.46	1.33	1.73
	Okra - Pea	1.00	1.60	1.16	1.61	1.09	1.60
	Mash - Garlic	0.02	0.13	2.88	3.44	1.77	2.15
Inorganic farming	Soybean - Onion	1.30	1.81	2.64	3.35	2.04	2.67
	Okra - Pea	2.04	2.78	1.69	2.24	1.86	2.50
	Mash - Garlic	0.40	0.54	4.44	4.39	2.77	3.01
Integrated farming	Soybean - Onion	1.08	1.41	1.91	2.55	1.55	2.07
	Okra - Pea	1.36	2.07	1.47	2.02	1.41	2.05
	Mash - Garlic	0.36	0.44	4.06	4.36	2.76	2.97

Net returns (Rs ha^{-1})

The data on net returns (Table 4) revealed that in both the years, highest net returns (Rs 3,62035) were obtained in "Mash-Garlic" cropping system under integrated farming practices and least (Rs 97521) under zero budget natural farming practices. This may be due to low-cost inputs and high yield of crop. Kumar *et al.* (2020) also reported that "Mash-Garlic" produced significantly highest net returns as compared to other cropping systems.

Net returns per rupees invested

In 2018-2019, net returns per rupee invested was highest (2.77) in "Mash-Garlic" cropping system under inorganic farming practices (Table 5). In 2019-20, highest net returns per Rupee invested was recorded in "Mash-Garlic" cropping system (3.01) under inorganic farming practices. Joshi and Billore (2004) also reported that irrespective of the cropping system, 100% RDF recorded significantly highest net returns per rupees invested amongst different farming practices. Lowest (0.99 Rs) net returns per Rs invested was obtained in "Okra-Pea" cropping system under organic farming practices (Table 5). This may be due to high cost of vermicompost, resulting in increased cost of cultivation without much increase in net returns.

CONCLUSION

Integrated nutrient management practices *i.e.*, use of 50% chemicals + use of 50% organic is more helpful in giving more returns and was at par with organic farming practices as compared to other farming practices. Based on the the findings of present investigation it was concluded that for higher monetary returns farmers of mid hills, Himachal Pradesh with sufficient resources can successfully adopt integrated nutrient management practices with "Mash-garlic" cropping system followed by "Okra-peas" cropping system.

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