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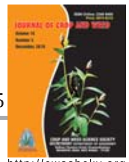

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# Productivity and profitability of legume based cropping systems grown under organic conditions in mid-hills of Himachal Pradesh

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## ABSTRACT

*Field experiment was conducted at Model Organic Farm of Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during kharif and rabi season of 2012-13 and 2013-14 on silty clay loam soil to study the productivity and profitability of legume based cropping systems grown under organic conditions. The cropping sequence mash – garlic resulted in higher soybean equivalent yield (SEY) and benefit: cost ratio, which was statistically at par with soybean – garlic and cowpea – garlic sequences in kharif legume – rabi vegetable based cropping system whereas in kharif vegetable – rabi legume based cropping system, okra – gram recorded higher okra equivalent yield (OEY). OEY was statistically at par with chilli – gram cropping sequence. Higher net returns and benefit: cost ratio was recorded in chilli – gram sequence.*

***Keywords***: Bioformulations, cropping sequence, okra, productivity, profitability and soybean

Production of more food for the ever growing population in the coming decades, while combating poverty and hunger at present, is a significant challenge to the developing nations. The demand for fruits and vegetables is increasing faster and is expected to increase by more than 100% from 2000 to 2030. As a result, area under horticultural crops has increased appreciably during past two decades. Crop diversification towards high-value crops can potentially increase farm incomes, especially in India, where demand for high-value food products has been increasing more quickly than that for staple crops. Diversification has been envisaged as a new strategy for enhancing and stabilizing productivity toward achieving the sustainable agricultural development (Prasad *et al*., 2013).

Legumes, with their suitability to different cropping pattern and their ability to fix nitrogen, may offer opportunities to sustain increased productivity (Jeyabal and Kuppuswamy, 2001). Legume-based crop rotation preserves organic matter, increases soil nitrogen (N), balances soil nutrients, improves soil physical properties and breaks soil-borne disease cycles. Inclusion of *kharif* legumes in cropping cycle has more advantage (Jawale *et al.,* 1998). Mid-hill regions of Himachal Pradesh have niche advantage of growing off-season vegetables in comparison to north Indian plains. Vegetables are coming up with a great pace in the farming system but growing vegetable under organic farming conditions is challenging because of high nutritive requirement, insect pest and disease problems. Pulses and vegetable crops are complementary in a cropping rotation. Inclusion of vegetables in existing cropping system can play a vital role in commercialization and thereby in maximizing system productivity, higher monetary returns and higher resource use efficiency. Therefore multiple cropping systems offer special advantages and reduce the probability of low income for small and marginal farmers (Rana *et al.,* 2011; Sharma *et al.,* 2009). To illustrate the nutrient dynamics in crop diversification involving legumes and vegetables, this study analyses the performance of different *kharif* legume – *rabi* vegetable and *kharif* vegetable – *rabi* legume rotations under organic farming in mid hill conditions which permit continuous and intensive cropping.

## MATERIALS AND METHODS

The experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2012–13 and 2013–14 at Model Organic Farm of Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur which has been maintained under complete organic farming conditions since April 2006. The experimental site is geographically located at 32°4' 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 factorial randomized block design having three replications comprising of nine sequences in *kharif* legume – *rabi* vegetable based cropping system *i.e.* soybean – onion, cowpea – onion, mash – onion, soybean – garlic, cowpea – garlic, mash – garlic, soybean – potato, cowpea – potato

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and mash – potato and nine sequences in *kharif* vegetable – *rabi* legume based cropping system *i.e.* okra – lentil, brinjal – lentil, chilli – lentil, okra – gram, brinjal – gram, chilli – gram, okra – pea, brinjal – pea and chilli – pea. The different varieties of various crops *i.e.* soybean 'Harit soya', onion 'Palam lohit', cowpea 'Lobia 1', mash 'Him mash 1', garlic 'GHC-1', potato 'Kufri jyoti', lentil 'Vipasha', gram 'Him chana 1', pea 'PB 89', okra 'P8', brinjal 'Arka keshav' and chilli 'Suraj mukhi' were raised in accordance with the recommended package of practices of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. Vermicompost @ 5 tonnes ha$^{-1}$ + 3 sprays of vermiwash were added in legumes and in pulses vermicompost @ 10 tonnes ha$^{-1}$ + 3 sprays of vermiwash were added. There was no severe attack of any insect-pest and disease; however general schedule spray of various bioformulations was used to manage insect-pest and diseases. The details of different bioformulations used during the cropping period are given in table 1. The different bioformulations included *Lantana* extract which is a solution containing 4 kg fresh *Lantana* leaves mixed in 12 l of cow urine in equal amount of water kept for 15 days fermentation, *Tamra lassi* was a solution containing 5 l fermented butter milk kept in a copper vessel for 15-20 days with proper stirring. *Panchgavya* was prepared by mixing 2 kg fresh cow dung, 3 l cow urine, 2 l milk, 2 l curd and 1 kg desi ghee and fermented for 10-15 days. These bioformulations were sprayed periodically at 15 days interval starting after one month of crop germination. For comparison purposes, yield of different crops in sequence was converted into soybean-equivalent yield (SEY) on price basis in case of *kharif* legume - *rabi* vegetable based cropping sequences and in case of *kharif* vegetable - *rabi* legume cropping sequences, yield of different crops in sequence was converted into okra-equivalent yield (OEY) 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. Important quality parameters (protein, carbohydrate, TSS etc.) were analysed for these pulses and vegetables. Samples of these crops grown under inorganic conditions were also analysed for comparative studies. Benefit: cost ratio to determine profitability of the system was worked out by dividing gross returns (Rs ha$^{-1}$) with cost of cultivation (Rs ha$^{-1}$).

**Table 1: Bioformulations for insect-pest and disease management in *kharif* and *rabi* season**

| Bioformulations | Quantity | No. of spray |
|---|---|---|
| ***Kharif*** | | |
| *Lantana* extract | 10% | 3 |
| Neem oil | 3 ml l$^{-1}$ | 2 |
| *Tamra lassi* | 10% | 2 |
| ***Rabi*** | | |
| *Panchgavya* | 10% | 2 |
| Neem oil | 3 ml l$^{-1}$ | 1 |
| Nucleo polyhedrosis virus (NPV) hali | 3 ml l$^{-1}$ | 2 |
| *Bacillus thuringiensis* (Bt) | 2.5 g l$^{-1}$ | 1 |
| *Tamra lassi* | 10% | 2 |

## RESULTS AND DISCUSSION

### *Soybean equivalent yield*

Perusal of data (Table 2) revealed that SEY increased with increase in cropping intensity. Mash – garlic sequence was found superior in terms of SEY, because of higher tonnage produce by garlic and the remunerative price it fetched in the market. However, it was statistically at par with soybean – garlic and cowpea – garlic system. Inclusion of pulses in intensive agriculture is beneficial, as these improve the crop productivity. The increase in SEY was mainly due to additional yield advantage of vegetable crops in the crop sequences as well as higher market price of vegetable crops. Mash – garlic system produced 151.4% higher and soybean – garlic system produced 148.9% higher SEY as compared to cowpea – onion cropping system. These findings are in conformity with those of Rana *et al.* (2011) who also reported higher system productivity with inclusion of pulses and vegetables in the cropping systems. The lowest soybean equivalent yield was found in cowpea – onion system.

Mash – garlic resulted in higher net returns (Rs 327.9 ha$^{-1}$) and benefit: cost ratio (4.47) over rest of the crop sequences (Table 2). The minimum benefit: cost ratio was recorded under cowpea – onion cropping sequence

**Table 2: Effect of different *kharif* legume-*rabi* vegetables based cropping systems on soybean equivalent yield and economics of the system**

| Sequences | Yield (kg ha$^{-1}$) | | | Economics | |
|---|---|---|---|---|---|
| | ***Kharif*** | ***Rabi*** | **Soybean equivalent yield of system** | **Net returns (Rs ha$^{-1}$)** | **B: C ratio** |
| Soybean - Onion | 1510 | 6510 | 4770 | 117.1 | 1.59 |
| Cowpea - Onion | 1070 | 5840 | 3990 | 85.9 | 1.17 |
| Mash - Onion | 1010 | 6090 | 4550 | 108.6 | 1.49 |
| Soybean - Garlic | 1620 | 6650 | 9930 | 323.8 | 4.42 |
| Cowpea - Garlic | 1130 | 6900 | 9750 | 316.4 | 4.31 |
| Mash – Garlic | 1060 | 6750 | 10030 | 327.9 | 4.47 |
| Soybean - Potato | 1540 | 8170 | 4600 | 110.7 | 1.51 |
| Cowpea - Potato | 1060 | 8860 | 4380 | 101.8 | 1.38 |
| Mash – Potato | 1000 | 8730 | 4780 | 117.6 | 1.60 |
| **SEm (±)** | - | - | **186** | - | - |
| **LSD (0.05)** | - | - | **560** | - | - |

**Table 3: Effect of different *kharif* vegetable-*rabi* legume based cropping systems on the okra equivalent yield and economics of the system**

| Sequences | Yield (kg ha$^{-1}$) | | | Economics | |
|---|---|---|---|---|---|
| | ***Kharif*** | ***Rabi*** | **Okra equivalent yield of system** | **Net returns (Rs ha$^{-1}$)** | **B: C ratio** |
| Okra – Lentil | 7290 | 570 | 8980 | 106.1 | 1.44 |
| Brinjal - Lentil | 3170 | 720 | 5330 | 38.2 | 0.56 |
| Chilli - Lentil | 5120 | 650 | 9630 | 124.1 | 1.82 |
| Okra - Gram | 7660 | 1210 | 11300 | 152.5 | 2.08 |
| Brinjal - Gram | 2740 | 1210 | 6360 | 58.7 | 0.85 |
| Chilli - Gram | 4530 | 1490 | 11260 | 156.8 | 2.30 |
| Okra - Pea | 7670 | 1170 | 10020 | 126.9 | 1.73 |
| Brinjal - Pea | 2610 | 1200 | 5010 | 31.8 | 0.47 |
| Chilli - Pea | 4670 | 1140 | 9280 | 117.2 | 1.72 |
| **SEm (±)** | - | - | **226** | - | - |
| **LSD (0.05)** | - | - | **680** | - | - |

(1.17). Inclusion of vegetable crops like onion, garlic and potato in these cropping sequence besides increasing the system productivity, fetched higher market price thereby, increasing the net returns.

***Okra equivalent yield***

Among all the cropping sequences, the sequences with okra crop in *kharif* season were the highest producer of OEY followed by those with chilli crop and the lowest production of OEY was recorded in cropping sequences with brinjal crop in the *kharif* season (Table 3). OEY was significantly higher in okra – gram cropping system followed by chilli – gram and okra – pea cropping system which were statistically at par with each other. The lowest OEY of the system was found in brinjal – pea system. Okra – gram system had 125.6% higher equivalent yield followed by chilli – gram system (124.8%) in comparison to brinjal - pea system. Saroch *et al.*, (2005) reported that multiple cropping systems with legumes offer special advantage to farmers in mid hills.

Economic analysis of various vegetable-based cropping systems under organic cultivation revealed that maximum net returns and benefit: cost ratio was found in chilli – gram system (Rs 156.8 ha$^{-1}$ and 2.30, respectively) followed by okra – gram system (Rs 152.5 ha$^{-1}$ and 2.08, respectively). Higher net returns and benefit: cost ratio with chilli – gram cropping system was mainly due to higher production potential and good market price which were instrumental for attaining higher OEY.

***Quality parameters***

It is evident from table 4 that protein content of organically grown legumes and vegetables was slightly higher in comparison to inorganically grown counterparts. The values for carbohydrates were comparatively higher in inorganically grown legumes and vegetables except peas, potato and chilli having more carbohydrates under organic condition with per cent difference of +7.89, +26.81 and +20.21. TSS content in onion and garlic was higher towards organic condition with per cent difference of +14.70 and +3.70. Ascorbic acid in brinjal was more in organic condition with per cent difference of +24.89 in comparison to inorganic condition.

**Table 4: Quality parameters of different crops grown organically and inorganically**

| Crop | Organic | Inorganic | Per cent difference |
|---|---|---|---|
| **Soybean** | | | |
| Protein (%) | 37.54 | 35.38 | +5.75 |
| Carbohydrate (%) | 35.00 | 36.79 | -5.11 |
| **Cowpea** | | | |
| Protein (%) | 26.31 | 24.10 | +8.40 |
| Carbohydrate (%) | 53.11 | 54.50 | -2.62 |
| **Mash** | | | |
| Protein (%) | 18.88 | 15.65 | +17.11 |
| Carbohydrate (%) | 64.02 | 67.18 | -4.93 |
| **Lentil** | | | |
| Carbohydrate (%) | 60.25 | 60.47 | -0.36 |
| **Gram** | | | |
| Protein (%) | 22.88 | 18.85 | +17.61 |
| Carbohydrate (%) | 62.90 | 66.74 | -6.10 |
| **Pea** | | | |
| Protein (%) | 21.94 | 18.30 | +16.59 |
| Carbohydrate (%) | 67.83 | 62.48 | +7.89 |
| **Onion** | | | |
| TSS (Brix) | 14.90 | 12.71 | +14.70 |
| Carbohydrate (%) | 67.65 | 70.91 | -4.82 |
| **Garlic** | | | |
| TSS (Brix) | 40.04 | 38.56 | +3.70 |
| **Potato** | | | |
| Protein (%) | 2.93 | 2.90 | +1.02 |
| Carbohydrate (%) | 19.58 | 14.33 | +26.81 |
| **Okra** | | | |
| Protein (%) | 13.49 | 13.29 | +1.48 |
| Carbohydrate (%) | 64.60 | 64.62 | -0.03 |
| **Brinjal** | | | |
| Ascorbic acid (mg $100^{-1}$ g) | 16.15 | 12.13 | +24.89 |
| Carbohydrate (%) | 71.82 | 72.49 | -0.93 |
| **Chilli** | | | |
| Protein (%) | 2.98 | 2.90 | +2.68 |
| Carbohydrate (%) | 3.76 | 3.00 | +20.21 |

Based on findings of present investigation, it was concluded that for higher net income, farmers of mid hills with sufficient resources can successfully adopt mash – garlic followed by soybean – garlic sequence and okra – gram followed by chilli – gram sequence under organic conditions.

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