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Agronomy

Crop Diversification for Increasing Productivity and Profitability under Mid-hill Sub-humid Conditions of Himachal Pradesh

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Abstract

Eight cropping sequences *viz.* maize – wheat, maize (green cob) + frenchbean (pole type) – pea – summer squash, maize + soybean – garlic, maize (green cob) – broccoli – potato, maize (green cob) + asparagus bean – radish – onion, maize (green cob) + mash – cauliflower – frenchbean, maize (green cob) + ricebean – cauliflower – buckwheat, maize (green cob) + asparagus bean – broccoli – radish were evaluated for their production potential and economic feasibility under mid hill conditions of Himachal Pradesh.After completion of the experiment maize (green cob) + asparagus bean – radish – onion and maize (green cob) + frenchbean (pole type) – pea – summer squash sequences resulted in significantly higher maize equivalent yield (36.9 and 35.0t ha^{-1}), production efficiency (119.4 and 112.5 kg ha^{-1} day^{-1}), net returns (₹ 223568.6 and ₹ 225468.9 ha^{-1}) and B:C ratio (1.5 and 1.5), respectively than other crop sequences.While, maize - wheat sequence was superior over all crop sequences in terms of carbohydrate yield and protein yield (3,556.7 and 590.5, respectively). Maize – broccoli – potato resulted in higher cost of cultivation than other crop sequences due to the labour intensive nature of potato crop.

Highlights

- Multiple cropping systems offer special advantages and reduce the probability of low income for small and marginal farmers.
- Maize (green cob) + asparagus bean – radish – onion and maize (green cob) + frenchbean (pole type) – pea – summer squash sequences recorded higher MGEY, production efficiency, net returns and B: C ratio over traditional maize – wheat system.

Keywords: Maize equivalent yield, cropping system, production efficiency, net returns, B:C ratio, carbohydrate yield, protein yield

Production of more food for the ever growing populations in the coming decades, while combating poverty and hunger at present, is a significant challenge to the developing nations. Thus intercropping principal food crops (e.g. cereals) to intensify resource use is considered a key factor in meeting this challenge, in technologies such as evergreen agriculture which is considered a robust approach to sustainable food security in the developing world (Garrity *et al.* 2010). There are projections that demand for food grains would increase from 234 million tonnes in 2009-10 to 345 million tonnes in 2030 (Anonymous 2009). Simultaneously, the demand for fruits and vegetables is increasing faster than foodgrains, 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. The limit has reached for bringing additional area under cultivation. Therefore, it is necessary to increase the production per unit area per unit time. The possible way to increase the production per unit area is the adoption of multiple cropping systems.

Mid - hill region has minimal proportion of cultivated land under irrigation, but has niche advantage of growing off-season vegetables in comparison to north Indian plains. Maize (Zea mays) is cultivated during rainy (kharif) season, covers a substantial area under rainfed as well as irrigated conditions, mainly for use of

its cobs as a cash crop. In winter, wheat (Triticum aestivum L.) is commonly grown after maize under rainfed situation as well as under irrigated conditions. Intercropping cereals with a multitude of crops, and including legumes in these systems is most common and researched due to the synergistic effects, with the objective of diversifying food production and household cash incomes (Rao and Mathuva 2000; Kimaro *et al.* 2009). Vegetables play an important role in small holder farming systems of this region. Apart from encouraging large scale cultivation of vegetables in general, technology also needs to be generated to include vegetables in the existing cropping systems. 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.

Material and Method

A field experiment was carried out in a continuing experiment, at Bhadiyarkhar farm of CSK HP Krishi Vishvavidyalaya, Palampur. Eight cropping systems *viz.* maize – wheat, maize (green cob) + frenchbean (pole type) – pea – summer squash, maize + soybean – garlic, maize (green cob) – broccoli – potato, maize (green cob) + asparagus bean – radish – onion, maize (green cob) + mash – cauliflower – frenchbean, maize (green cob) + ricebean – cauliflower – buckwheat, maize (green cob) + asparagus bean – broccoli – radish were evaluated in a randomized block design with four replications. The soil of the experiment site was silty-clay loam with pH 5.38, OC 0.99%, available N 305.1, P 78.5 and K 117.4 kg ha^{-1}. The crops were raised in accordance with the recommended package of practices (Anonymous 2007a, b and c) for the region. Yields were harvested from net plot. For comparison between cropping sequences, the yields of crops were converted into maize-grain equivalent yield (MGEY) on price basis (Rana *et al.* 2011).

Productivity (kg $ha^{-1}day^{-1}$) was obtained by dividing total production in terms of maize equivalent in sequence by the total duration of crop, the economic yields of various crops in different sequences was converted into equivalent values of proteins and carbohydrates (kg ha^{-1}) as per standards given in Table 1, so that comparison between different sequences could be undertaken in terms of these equivalents. Economics of the crop sequences was computed based upon the prevailing prices of inputs used and the output realised. The cost of cultivation of different crops individually and for crop sequences were calculated. The yields of different crops in various crop sequences were converted into gross returns in rupees. Further, net returns and. B: C ratio was also calculated as per the formulae given below:

$$\text{B: C ratio} = \frac{\text{Net returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

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

Results and Discussion

Production efficiency

Maize grain equivalent yield (MGEY)

Theresults revealed that MGEY increased with increase in cropping intensity. The maize + asparagus bean – radish – onion (36.9 t ha^{-1}) and maize (green cob) + frenchbean– pea – summer squash (35.0 t ha^{-1}) sequence were found superior in terms of MGEY, because of higher tonnage produce by summer squash, onion and radish crops and the remunerative price it fetched in the market. Next in order was maize (green cob) – broccoli – potato which remained at par with maize (green cob) + asparagus bean – broccoli – radish. This in turn was followed by maize + soybean – garlic. Maize (green cob) + ricebean – cauliflower – buckwheat and maize (green cob) + mash – cauliflower – frenchbean sequences did not differ among themselves. Maize – wheat sequence resulted in lowest MGEY. The increase in MGEY was mainly due to additional yield advantage of intercropping and vegetable crops in the crop sequences as well as higher market price of grain legumes and vegetable crops than that of maize – wheat similar results were reported by Rathika *et al.* (2014).

Production efficiency

Production efficiency almost followed similar trend as MGEY. Themaize (green cob) + frenchbean – pea – summer squash (119.4 kg ha^{-1} day^{-1}) sequence remaining at par with maize + asparagus bean – radish – onion (112.5 kg ha^{-1} day^{-1}) resulted in significantly higher productivity over other crop sequences, because of higher production and price of the produce *viz.* summer squash, pea, onion and radish. Similar results were obtained by Sharma *et al.* (2008) in a study of rice based crop sequences. However, maize – wheat resulted in lowest productivity.

Carbohydrate yield and protein yield

Themaize –wheat (3556.73 kg ha^{-1}) sequence gave significantly highest carbohydrate yield than rest of the

crop sequences which was due to high dry biomass (main product) produced by the wheat crop. It was followed by maize (Green cob) + ricebean – cauliflower – buckwheat (2275.64 kg ha^{-1}) sequence which yielded statistically more carbohydrate than all the remaining crop sequences. Protein yield followed similar trend as carbohydrate yield. The maize – wheat (590.52 kg ha^{-1}) sequence significantly out yielded all the other crop sequences in terms of protein yield. It was attributed to the higher dry biomass (main product) produce and higher protein content of maize and wheat than the vegetable crops. Maize + soybean – garlic (416.78 kg ha^{-1}) sequence also resulted in significantly higher protein yield than other crop sequences mainly because of high protein content of soybean kernels.

Profitability analysis

Cost of cultivation

The cost of cultivation increased with increase in number of crops in the system. Further, cost of cultivation was high in all vegetable involving crop sequences over maize – wheat sequence because of labour intensive nature of these crops as more labor is required in vegetable crop production. Maize (Green cob) – broccoli – potato (₹ 1,76,018 ha^{-1}) sequence proved to be most expensive in terms of total cost of cultivation. Inclusion of potato in the sequence increased the cost of cultivation, as it is a labour intensive crop. Yadav *et al.* (2000) also reported similar results. While, maize – wheat resulted in lowest cost of cultivation.

Gross returns

Maize + asparagus bean – radish – onion (₹ 3,79,148 ha^{-1}) sequence remaining at par with maize (Green cob) + frenchbean (P) – pea – summer squash (₹ 3,69,620 ha^{-1}) sequence proved significantly superior to rest of the crop sequences in respect of gross returns because radish and onion in T_5 sequence and pea and summer squash in T_2 sequence produced higher yields and fetched remunerative prices. Significantly lowest gross returns were obtained in maize – wheat sequence.

Net returns

The net returns of maize + legume – vegetable – vegetable was considerably higher than maize – wheat sequence. Themaize + asparagus bean – radish – onion (₹ 2,25,469 ha^{-1}) sequence remaining at par with maize (Green cob) + frenchbean (P) – pea – summer squash (₹ 2,23,569 ha^{-1}) sequence gave significantly higher net returns which was due to the higher gross returns besides high cost of cultivation. Inclusion of vegetable crops like beans, radish, okra, onion and cowpea in these cropping systems besides, increasing the system productivity, fetched higher market price thereby, increasing the net returns. Rana *et al.* (2010); Rana *et al.* (2011); Sharma *et al.* (2008) and Jat *et al.* (2012) also reported that inclusion of vegetable crops in cereal - based crop sequences improved the net returns.

B: C ratio

Results reveal that maize (Green cob) + frenchbean (P) – pea - summer squash (1.5) sequence remaining at par with maize + asparagus bean – radish – onion (1.5) sequence resulted in significantly higher B: C ratio over rest of the crop sequences. Most of the tested crop sequences were found remunerative over the existing maize - wheat sequence except maize (Green cob) + mash – cauliflower – frenchbean (0.2) which recorded lowest B: C ratio. Earlier studies also indicated that multiple cropping systems offer special advantages and reduce the probability of low income for small and marginal farmers (Rana *et al.* 2010, Rana *et al.* 2011 and Sharma 2009).

Table 1. Carbohydrate and protein content in economic part of different crops

Crop	Moisture Content (%)	Carbohydrate (%)	Protein (%)
Maize	14.9	66.2	11.1
Wheat	12.8	71.2	11.8
Buckwheat	11.3	65.1	10.3
Frenchbean	91.4	4.5	1.7
Soybean	8.1	20.9	42.2
Mash	10.9	59.6	24.0
Rice bean	10.2	65.0	19.80
Asparagus bean	13.4	8.35	2.8
Pea	72.0	15.9	7.2
Potato	74.7	22.6	1.6
Garlic	62.0	29.8	6.3
Onion	86.8	11.5	6.3
Broccoli	89.30	6.64	2.8
Cauliflower	90.8	4.0	2.6
Radish	94.9	3.4	0.7
Summer squash	92.6	5.3	1.4

Gopalan *et al.* 1980 and Manay and Shadaksharaswamy (1987).

Conclusion

Crop diversification has been recognized as an effective strategy for achieving the objectives of food security,

Table 2. Maize grain equivalent yield (t/ha), production efficiency, carbohydrate yield, protein yield and economics of different cropping systems

	Cropping Systems	MGEY (t ha^{-1})	Production efficiency (kg ha^{-1} day^{-1})	Carbohydrate yield (kg ha^{-1})	Protein yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1	Maize-wheat	5.7	20.0	3556.73	590.52	72,765	94,170	21,404	0.3
T_2	Maize (GC) + French bean - pea-Summer squash	35.0	119.4	1052.56	203.19	1,46,051	3,69,620	2,23,569	1.5
T_3	Maize + soybean – garlic	21.1	62.3	1245.15	416.78	99,712	2,19,652	1,19,940	1.2
T_4	Maize (Green cob) – Broccoli – potato	28.7	92.9	1555.55	216.31	1,76,018	2,96,214	1,20,195	0.7
T_5	Maize + asparagus bean – radish –onion	36.9	112.5	883.56	250.01	1,53,679	3,79,148	2,25,469	1.5
T_6	Maize (Green cob) + mash – cauliflower – French bean	14.5	40.5	812.70	167.82	1,53,369	1,58,813	5,444	0.0
T_7	Maize (Green cob) + rice bean – cauliflower – buckwheat	15.3	43.9	2275.64	378.36	1,12,676	1,62,828	50,152	0.4
T_8	Maize (Green cob) + asparagus bean – broccoli – radish	26.4	89.3	518.36	97.06	1,58,190	2,75,045	1,16,854	0.7
	CD (P=0.05)	3.3	24.4	581.52	100.34	—	32,440	32,340	0.2

nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge *et al.* 2003). Despite the fact that maize – wheat crop sequence resulted in higher carbohydrate yield, protein yield and energy equivalents it is advised to include vegetable crops in the sequence because besides increased production, nutritional standard of people has also to be taken care of. Vegetables play a vital role on food front as they are cheapest-sources of natural foods and can admirably supplement the main cereals of the country. While, for higher net income farmers of mid hills with sufficient resources can successfully adopt maize (Green cob) + frenchbean – pea – summer squash followed by maize + asparagus bean – radish – onion.

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References

Anonymous, 2007a. Package of Practices for Kharif Crops. Directorate of Extension Education, HPKV, Palampur.

Anonymous, 2007b. Package of Practices for Rabi Crops. Directorate of Extension Education, HPKV, Palampur.

Anonymous, 2007c. Package of Practices for Vegetable Crops. Directorate of Extension Education, HPKV, Palampur.

Anonymous, 2009. Economic Survey of India. Ministry of Finance, Government of India, New Delhi, India.

Garrity, D.P., Akinnifesi, F.K., Ajayi, O.C., Weldesemayat, S.G., Mowo, J.G., Kalinganire, A., Larwanou, M. and Bayala, J. 2010. Evergreen Agriculture: a robust approach to sustainable food security in Africa. *Food Security* **2**: 197-214.

Gopalan, C., Ramasastri, B.V. and Balasubramanian, S.C. 1980. Nutritive value of Indian Foods. National Institute of Nutrition. Indian Council of Medical Research, Hyderabad.

Hegde, D.M., Prakash Tiwari, S. and Rai, M. 2003. Crop diversification in Indian Agriculture. Agricultural Situation in India. August: 351-354

Jat, R.A., Dungrani, R.A., Arvadia, M.K. and Sahrawat, K.L. 2012. Diversification of rice (*Oryza sativa* L.)-based cropping systems for higher productivity, resource-use efficiency and economic returns in south Gujarat, India. *Archives of Agronomy and Soil Science* **58**: 561-572.

Kimaro, A.A., Timmer, V.R., Chamshama, S.A.O., Ngaga, Y.N. and Kimaro, D.A. 2009. Competition between maize and pigeon pea in semi-arid Tanzania: Effect on yields and nutrition of crops. *Agriculture, Ecosystems and Environment* **134**: 115-125.

Manay, N.S. and Shadaksharaswamy, M. 1987. Food facts and principles. Wiley Easter Limited.

Rana, S.S., Sharma, H.L., Subehia, S.K., Negi, S.C. and Sharma, S.K. 2011. Promising cropping systems for mid hill agro climatic conditions of Himachal Pradesh. *Himachal Journal of Agricultural Research* **37**: 138-148

Rana, S.S., Sharma, J.J., Sharma, H.L., Sharma, S.K. and Sharma, S.K. 2010. Production potential and economic feasibility of rice-based cropping sequences under mid hills of Himachal Pradesh. *Himachal Journal of Agricultural Research* **36**: 7-12.

Rao, M.R. and Mathuva, M.N. 2000. Legumes for improving maize yields and income in semi-arid Kenya. *Agriculture, Ecosystems and Environment* **78**: 123-137.

Rathika, S., Velayudham, K., Thavaprakaash, N. and Ramesh, T. 2014. Biological Efficiency of Legume Intercrops in Baby Corn (*Zea Mays* L.). *International Journal of Agriculture, Environment and Biotechnology* **73**: 627-633.

Sharma, S.K., Rana, S.S., Sharma, S., Subehia, S.K., Sharma, J.J. and Sharma, H.L. 2008. Production potential and economic feasibility of rice-based cropping sequences on cultivator's fields under sub-mountain low-hills of Himachal Pradesh. *Himachal Journal of Agricultural Research* **34**: 5-9.

Sharma, S.K., Rana, S.S., Subehia, S.K., Sharma, H.L., Sharma, J.J. and Sanjay, K. Sharma, 2009. Evaluation of rice based cropping sequences on cultivators' fields in Una district of Himachal Pradesh. *Himachal Journal of Agricultural Research* **35**: 171-175.

Yadav, D.S., Singh, R.M., Kumar, A. and Achal, R. 2000. Diversification of traditional cropping system for sustainable production. *Indian Journal of Agronomy* **45**: 37-40.