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Studies on doubling farmers' income in 'Lahaul valley'-high altitude cold desert region of Himachal Pradesh

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Abstract

Diversifying farming has been adopted as one of multi-pronged strategies by many Indian states to double farmers' income by 2022. A field experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Highland Agricultural Research and Extension Centre, Kukumseri (32°44'55" N, 76° 41' 23" E and 2672 m altitude above mean sea level) during summer/*kharif* 2013 to study the productivity and comparative profitability of different commonly grown off-season (April to September) vegetable crops in dry temperate zone (Lahaul valley) of Himachal Pradesh. It was carried out with the objective of maximizing the profitability of tribal farmers by suggesting them to divert more of acreage under more remunerative vegetables crops. Productivity of cabbage (380.9 q/ha) was more than that of cauliflower (308.4 q/ha) but was found economically less remunerative because of its lower prevailing price, hence cauliflower was the most profitable vegetable among the cole crops. Pea crop in the valley occupies 50 per cent of the cultivated area. Peas recorded less value of net returns/ha and benefit cost ratio (Rs 1,21,436; 2.9) than cabbage (Rs 3,27,815; 6.1), tomato (Rs 4,01,205; 5.9), cauliflower (Rs 5,06,333; 7.9) and summer squash/*zucchini* (Rs 5,33,008; 8.4). Under open field conditions, low temperature at the time of tomato harvest requires special attention for proper fruit-colour development i.e. to keep the fruits wrapped and packed/ in polyhouse. French bean, broccoli and capsicum were less profitable than peas. As compared to peas, *zucchini* was more profitable by 338.9 %, cauliflower by 316.9 %, tomato by 230.4 %, and cabbage by 169.9%. Thus, farmers of Lahaul valley should divert more of their land in cultivating summer squash, cauliflower and tomato to double their income.

Key words: Cabbage, cauliflower, cold desert, double income, Lahaul, productivity, profitability, *zucchini*

Diversifying farming has been adopted as one of multi-pronged strategies by many states to double farmers' income by 2022 to realize the national goal as advised by Hon'ble Prime Minister of India. The role of off-season vegetables in farmers' income is of paramount importance. Hills are bestowed with congenial agro-climatic conditions and have enormous potential for off-season vegetable production like green peas, beans, cauliflower, cabbage, tomato, broccoli, capsicum etc. particularly in the tribal areas of Himachal Pradesh which has low temperatures favoring cultivation of off-season quality vegetables in summers/*kharif* season. Net returns from these vegetables are very attractive as these are not grown in plains at that time. This profit is many folds compared to traditional cereal crops. The produce of hills is known for their freshness, flavor, sweetness, texture and crispness, shelf life etc. Vegetables occupy 75233 hectares of area in the state with productivity of 213 q/ha which is higher than the national average (Anonymous, 2015-16). Lahaul and Spiti district of Himachal Pradesh falls in cold desert

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zone where diversification has been emphasized to upgrade the socio-economic conditions of the tribal farmers (Tewari and Kapoor, 2013). FAO (2020) has emphasized the cultivation of fruits and vegetables for increasing the livelihood of farmers. In Lahaul and Spiti, only one cropping season (April to September, cropping intensity 106%) is available in a year as in winters the area remains snow bound and temperature dips down much below the freezing point. History of cropping patterns of this valley reveals that acreage under the traditional crops like wheat '*Triticum* spp.', barley '*Hordeum vulgare*', rajmash '*Phaseolus vulgaris*' etc. was appreciably replaced by introduction of seed potato in mid 1960s. Later, commercial off-season garden pea (in mid 1980s) snatched the acreage and occupied half of cultivated area in the Lahaul valley. In recent past, the cultivation of many vegetables has been taken up. Therefore, present investigation was undertaken to select the more remunerative vegetables for Lahaul valley to help doubling income of tribal farmers.

Materials and Methods

A field experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Highland Agricultural Research and Extension Centre, Kukumseri (32°44' 55" N, 76°41' 23" E and 2672 m altitude above mean sea level during summer/*kharif* 2013 through 2016 to study the productivity and comparative profitability of different commonly grown off-season (April to September) vegetable crops in dry temperate zone (Lahaul valley) of Himachal Pradesh i.e. cold desert area. It was carried out with the objective of maximizing the profitability of tribal farmers by suggesting them to divert more of acreage under more remunerative vegetables crops. The soil of the experimental site was medium in available N (437 kg /ha), available P (26 kg/ha) and organic carbon (14 g/kg) and high in available potash (320 kg/ha). The soil was sufficient in Ca (3.20 meq/100 g), Mg (1.55 meq/100 g), Fe (23.72 mg/kg), Mn (10.08 mg/kg), Cu (1.96 mg/kg) and Zn (2.02 mg/kg and medium in S (22 kg/ha). Soil pH was below neutral point (6.7) and had EC 123 ds/m. The different vegetables (Table 1) *viz*., capsicum (*Capsicum annuum*), french bean (*Phaseolus vulgaris*), peas (*Pisum sativum*), broccoli (*Brassica oleracea* var *italica*), red cabbage (*B.oleracea* var *capitata*), tomato (*Solanum lycopersicum*), cauliflower (*B. oleracea* var. *botrytis*), cabbage (*B. oleracea* var. *capitata*) and *zucchini* (summer squash *'Cucurbita pepo'*) were tested in randomized block design with three replications.

Crops were grown with recommended package of practices. Frequent irrigations through sprinklers were applied to crops, as the water retentively of these skeletal soils is low. The minimum temperature during the cropping period ranged from 5.7 to14.4, 2.8 to 13.0, 3.2 to 13.5, 3.5 to 14.2 °C, maximum temperature ranged from 15.4 to 24.0, 16.0 to 24.1,

Table 1. Cultivars/hybrids of vegetable crops tested

Crop	2013	2104	2015	2016
Cauliflower	*Madhuri*	*Madhuri*	*Maharani*	*Maharani*
Cabbage	*Varun*	*Varun*	*Varun*	-
Red cabbage	*Hybrid*	*Hybrid*	-	*Hybrid*
Broccoli	*Hybrid*	*Palam Samridhi*	*Palam Samridhi*	*Palam Samridhi*
Pea	*Azad Pea-1*	*Azad Pea-1*	*Azad Pea-1*	-
French bean	*Contender*	*Contender*	*Palam Mridula*	*Palam Mridula*
Tomato	*Avtar*	*Avtar*	*Avtar*	*Avtar*
Tomato	*Hem Sohna*	*Hem Sohna*	-	-
Capsicum	*California Wonder*	*California wonder*	-	-
Summer squash	-	*F1 Himani*	*F1 Himani*	*F1 Himani*

16.8 to 24.7, 19.9 to 25.1 °C and monthly rainfall 209.4 189.0, 356.3 and 201.3 mm was received during 2013, 2014, 2015 and 2016, respectively (Table 2).

Economic analyses viz., cost of cultivation, gross and net returns, benefit : cost (B:C) ratio was carried out by taking into account the prevailing costs of inputs and market prices of the produce each year. Cost of cultivation included the costs incurred on seed, field preparation, sowing/transplanting, fertilizes, hoeing, pesticides, irrigation, plucking/harvest etc. Prevailing price for the years 2013 to 2015 for tomato and broccoli was Rs. 15/-; for summer squash, tomato cv. Roma, cabbage and red cabbage was Rs. 10/-, and for cauliflower, pea, french bean was Rs 20/- and that of capsicum Rs. 25/- per kilogram. During 2016, price of summer squash was Rs. 10/-; tomato Rs. 25/-; red cabbage Rs. 12.50/-kg, and cauliflower Rs. 15/-.

Results and Discussion

Cabbage and cauliflower

The data on productivity, gross returns, cost of cultivation, net returns and benefit cost ratio year-wise (2013, 2014, 2015 and 2016) have been given in Table 3. The productivity of cabbage (416.2, 437.8, 288.6 q/ha) was more compared to cauliflower (288.8, 271.1, 248.0 q/ha) in all the years (2013, 2014 and 2015) of study but on account of its lower prevailing price, it recorded lower gross returns *vis* a *vis* net returns (Rs 5,20,262, 4,84,800, 4,38,600/ha) than cauliflower. Hence, the values of benefit cost ratio were also more in cauliflower (9.1, 8.4 and 7.6) compared to Cabbage (6.8, 7.2, and 4.4).

Cauliflower 'Madhuri' (288.8 q/ha) was observed to be the most profitable among the vegetable crops during 2013 with gross returns of Rs. 5,77,666/ha, net returns of Rs. 5,20,266/ha and 9.1 B:C ratio. It recorded Rs. 1,57,241/ha more net profit compared to cabbage "Varun' and Rs. 1,47,816/ha net more than tomato 'Hem Sohna'.

Broccoli

Among cole crops grown during 2013, 2014 and 2015, broccoli recorded average productivity of 84.29 q/ha with net returns of 85,885/ha and 1.2 benefit cost ratio and was found to be less remunerative compared to cauliflower 'Madhuri/Maharani', cabbage 'varun' and red cabbage F_1.

Red cabbage

Red cabbage recorded lower values of productivity (186.6 and 214.8 q/ha during 2013 and 2014) compared to green cabbage 'Varun' (416.2 and 437.8 q/ha) and hence recorded less gross returns (Rs 1,83,636 and 214800), net returns (Rs 1,30,486 and 1,61,675) and benefit cost ratio (2.4 and 3.0) and hence dropped during subsequent years.

French bean

French bean 'contender' produced 80.8 and 56.8 q/ha in 2013 and 2014, respectively, and 43.8 q/ha by its cultivar 'Palam Mridula' in 2015 with net profitability level of Rs 1,19,163, 71,250 and 45,250 in the years recording B:C ratio of 1.1 to 2.8.

Tomato

Successful cultivation of tomato was done in open

Table 2. Weather data during the cropping period

Month/Year	Mean Min. Temp. (°C)				Mean Max. Temp. (°C)				Total Rainfall (mm)			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
May	6.10	5.20	5.10	6.00	15.4	16.5	17.2	19.9	79.7	77.0	103.1	48.3
June	10.9	8.70	8.00	10.4	24.0	21.1	19.6	25.5	42.2	32.0	39.2	18.1
July	14.4	13.0	13.5	14.2	24.0	24.1	24.7	26.4	15.5	51.5	33.0	27.4
August	13.8	12.4	12.6	13.5	22.2	24.2	22.6	23.6	44.5	10.0	45.7	97.3
September	9.70	8.30	6.90	9.50	21.4	20.5	20.9	25.1	23.0	16.5	88.0	10.2
October	5.70	2.80	3.20	3.50	17.2	16.0	16.8	21.1	4.50	2.00	47.3	0.00
Range	5.7 - 14.4	2.8 - 13.0	3.2- 13.5	3.5- 14.2	15.4- 24.0	16.0- 24.1	16.8- 24.7	19.9- 25.1	209.4	189	356.3	201.3

Table 3. Productivity and economics of vegetable cultivation in Lahaul valley

Treatment	Yield (q/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha	Net returns (Rs/ha)	B:C ratio (Rs/Rs)
		2013			
Cauliflower *'Madhuri'*	288.8	577666	57400	520266	9.1
Cabbage *'Varun'*	416.2	416150	53125	363025	6.8
Red cabbage *'Hybrid'*	186.6	183636	53150	130486	2.4
Broccoli *'Hybrid'*	112.9	169360	57400	111960	1.9
Pea *'Azad Pea 1'*	92.40	230958	42350	188608	4.4
French been *'Contender'*	80.80	161513	42350	119163	2.8
Tomato *'Avtar'*	263.9	395320	59500	335820	5.6
Tomato *'Hem Sohna'*	288.0	431950	59500	372450	6.2
Tomato *'Roma'*	282.2	282206	48000	234206	4.8
Capsicum *'California Wonder'*	55.40	205108	59500	145608	2.4
		2014			
Cauliflower *'Madhuri'*	271.1	542200	57400	484800	8.4
Cabbage *'Varun'*	437.8	437800	53125	384675	7.2
Red Cabbage *'Hybrid'*	214.8	214800	53125	161675	3.0
Broccoli *'Palam Samridhi'*	98.60	147900	57400	90500	1.6
Pea *'Azad Pea 1'*	71.80	143600	42350	101250	2.4
French bean *'Contender'*	56.80	113600	42350	71250	1.7
Tomato *'Avtar'*	272.6	408900	59500	349400	5.9
Tomato *'Hem Sohna'*	277.3	415950	59500	356450	6.0
Capsicum *'California Wonder'*	44.30	110750	59500	51250	0.9
Summer squash *'F1 Himani'*	561.7	561700	53000	508700	9.6
		2015			
Cauliflower *'Maharani'*	248.0	496000	57400	438600	7.6
Cabbage *'Varun'*	288.6	288600	53125	235475	4.4
Broccoli *'Palam Samridhi'*	41.73	62595	57400	5195	0.1
French bean *'Palam Mridula'*	43.80	87600	42350	45250	1.1
Pea *'Azad Pea 1'*	58.40	116800	42350	74450	1.8
Tomato *'Avtar'*	232.6	348900	59500	289400	4.9
Summer squash *'F1 Himani'*	476.6	476600	53000	423600	8.0

Price (2013 to 2015) of tomato and broccoli Rs. 15/-, tomato cv. Roma, summer squash, cabbage and red cabbage Rs. 10/-, cauliflower, pea, french bean 20/- and capsicum Rs. 25/- per kg

		2016			
Cauliflower *'Maharani'*	426.0	638965	57400	581565	6.65
Red Cabbage *'Hybrid'*	322.7	403339	53125	350214	4.00
Tomato *'Avtar'*	283.1	707836	59500	648336	7.24
Summer squash *'F1 Himani'*	714.7	714723	48000	666723	7.58

Price of summer squash Rs. 10/-, tomato Rs. 25/-, red cabbage Rs. 12.50/-, cauliflower Rs. 15/-per kg

field conditions. In 2013, the productivity of three genotypes of tomato ranged from 263.9 to 288.0 q/ha. Among three genotypes 'Hem Sohna' (Rs 4,31,950/ha, 3,72,450/ha, 6.2 benefit: cost) and 'Avtar (Rs 3,95,320, 3,35,820 and 5.6 B:C), recorded more values of gross returns, net returns and B:C ratio than Roma (Rs. 2,82,206, 2,34,206 and 4.8) as the later fetched low price. Therefore, Roma was dropped in subsequent years. Benefit cost ratio of 5.9 and 6.0 were recorded with Avtar and Hem Sohna, respectively, during 2014. It is mentioned here that tomato crop though can be grown in open field conditions but if the planting is delayed, special post harvest efforts are required to get the proper maturity/colour of this fruits as the temperature in end of September or October dips down and unplucked fruits may start withering on the plants itself due to cold injury. To avoid that, plucked tomato fruits can be kept wrapped/ packed in polyhouse or in warmer room for proper colour development. So, tomato grown in open fields can compete well with cauliflower.

Capsicum

Successful cultivation of capsicum 'California Wonder' (55.4 q/ha) was done in open field conditions rercording productivity of 55.4 and 44.3 q/ha in 2013 and 2014, respectively, fetching net returns of Rs 1,45,608 and 51, 250/ha and benefit cost ratio of 2.4 and 0.9. Capsicum was observed to be less remunerative compared to peas, tomato, red cabbage, green cabbage, tomato and cauliflower and hence precluded after two years of study.

Pea

Pea 'Azad Pea 1' grown during 2013, 2014 and 2015 recorded average productivity of 73.8 q/ha with net profit of Rs 121436/ha and 2.1 B:C ratio but was observed to be less remunerative than the red cabbage, green cabbage, tomato, cauliflower and summer squash. Pea was found to be more profitable than French bean and broccoli during 2013, 2014 and 2015. It was more profitable than capsicum grown during 2013 and 2014.

***Zucchini* (Summer squash)**

Summer squash was included in 2014 as its cultivation is less labor intensive. With productivity level of 561.7 q/ha, though it fetches less price than cauliflower i.e. Rs. 10/kg, but it surpassed the profitability per hectare than cauliflower by Rs 23,900/ha. Benefit cost ratio was also more with (9.6 vs. 8.4) summer squash. Similarly, summer squash recorded more net returns by Rs 85,158/ha than cauliflower during 2016. However, in 2015, it recorded less returns compared with cauliflower as its productivity was 476.6 q/ha. Benefit cost ratio recorded higher values with summer squash (7.58 to 9.6) compared to cauliflower (6.65 to 8.4) in all the three years under testing. Among all the crops under study, highest values of gross (Rs 5,61,700 and 7,14,723/ha) and net returns (Rs 5,08,700 and 6,66,723/ha) were recorded by Summer squash both in 2014 and 2016. The values of benefit cost ratio (7.58 to 9.6) were also highest with summer squash. However, it is emphasized that early planting of summer squash may benefit the crop by avoiding low temperature injury at end of season. Singh *et al* (2015) reported productivity of 613.5 q/ha of Summer squash accruing net returns of Rs. 4,52,897/ha.

Mean Productivity and Profitability

Mean of productivity (q/ha), net return (Rs/ha) and B:C (invested) ratio have been given in Table 4. Capsicum produced 49.85, french bean 60.47, peas

Table 4. Mean Productivity and profitability of vegetable crops

Crop	Productivity (q/ha)	Net returns (Rs/ha)	B:C Ratio (Rs/Rs)	Net Profit over Peas (Rs/ha)	Increase in net returns over Peas(%)
Cauliflower	308.47	506333	7.9	384897	316.9
Cabbage	380.87	327815	6.1	206379	169.9
Red cabbage	240.37	214125	2.1	92689	76.3
Broccoli	84.29	85885	1.2	-35551	-29.3
Pea	73.87	121436	2.9	0	0
French bean	60.47	78554	1.9	-42882	-35.3
Capsicum	49.85	101230	1.8	-20206	-16.6
Tomato	267.15	401205	5.9	279769	230.4
Summer squash	584.33	533008	8.4	411572	338.9

73.87, broccoli 84.29, red cabbage 240.37, tomato 267.15, cauliflower 308.47, cabbage 380.47 and zucchini (summer squash) 584.33 q/ha mean productivity.

Profitability (net returns per hectare) in ascending order was observed as french bean (Rs 78,554/ha), broccoli (Rs 85,885/ha), capsicum (Rs 1,01,230/ha), peas (Rs 1,21,436/ha), red cabbage (Rs 2,14,125/ha), cabbage (Rs 3,27,815/ha), tomato (Rs 4,01,205/ha), cauliflower (Rs 5,06,333/ha) and summer squash (Rs 5,33,008/ha). French bean, broccoli and capsicum were less profitable than peas. Benefit: cost ratio followed the ascending order as broccoli (1.2), capsicum (1.8), french bean (1.9), red cabbage (2.1), peas (2.9), tomato (5.9), cabbage (6.1), cauliflower (7.9), and *zucchini* (8.4). Thus, garden peas which occupies major acreage (50 per cent of net cultivated area) in the valley is more profitable than french bean, broccoli and capsicum by accruing Rs 42,882, 35,551 and 20,206/ha more net returns, respectively, but less remunerative than red cabbage, green cabbage, tomato, cauliflower and summer squash. Cauliflower, tomato, cabbage and red cabbage recorded more net profit by Rs 3,84,897 (316.9 %), 2,79,769 (230.4%), 2,06,379 (169.9 %) and 92,697 (76.3%)/ha, respectively, which implies that farmers should replace pea acreage with summer squash to double their income.

Productivity of cabbage (380.9 q/ha) is more than that of cauliflower (308.4 q/ha) but economically less remunerative because of its lower prevailing price, hence cauliflower is the most profitable vegetable among the cole crops than commonly grown other vegetables in the valley.

Summer squash has emerged as an alternate to cauliflower and farmers of Lahaul valley may divert more of acreage under this crop with net gains of Rs. 5,33,008/ha. Summer squash recorded 338.9% more i.e. Rs 4,11,572/ha more net profit over peas. The respective increase in net profit by cauliflower, tomato, cabbage and red cabbage over garden peas was Rs 3,84,897 (316.9%), 2,79,769 (230.4%), 2,06,379 (169.9%) and 92,689 (76.3%), respectively. Thus, cultivation of summer squash, cauliflower, tomato and cabbage will lead to the doubling the income of farmers by replacing the pea acreage. On an average, summer squash recorded Rs 26,675/ha (6.93%) more net profit than cauliflower as well as more benfit: cost ratio (8.4 vs. 7.9), thus, a better alternative than even cauliflower.

Thus, farmers of Lahaul should divert more of their land in cultivating summer squash, cauliflower and tomato which will help double their farm income.

Conflict of interest: The authors have no conflict of interest in this research paper.

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