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Production potential and economics of different vegetable-based crop sequences

RN Prasad, SK Singh, RB Yadava, Vanitha SM* and J Singh

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Abstract

Crop diversification in the form of including different cereal and horticultural crops in the cropping sequence can provide farmers with better income realization & profitability, resource use efficiency and productivity. Hence, a field experiment was conducted to diversify and select suitable vegetable based cropping system/sequence in Indo-Gangetic plain of Eastern Uttar Pradesh. Adequate intercultural operations, soil amendment and soil treatment along with proper fertilizer management produced higher crop yields. The vegetable yield during rabi season in the system where wheat was replaced by vegetable after rice ranged from 92.35 q/ha (Pea) to 407.1 q/ha (tomato). Rice equivalent yield (REY) in the cropping sequence where two vegetable crops were taken was 177% (Rice-broccoli-cowpea) and 115% (rice-pea-okra) higher than the rice wheat cropping sequence. Under upper midland situation the highest gross return (Rs 463736/ha) was recorded under okra -tomato- cowpea sequence however, the highest net return of Rs 261802 /ha and benefit cost ratio 2.43 was obtained in maize pea-pumpkin cropping sequence. Under low midland situation the highest gross return (Rs 459505/ha) and net returns (Rs 249955/ha) and benefit cost ratio (2.20) was obtained in rice-broccoli-cowpea cropping sequence. Hence, it is suggested and recommended that intensive vegetable-based cropping patterns are suitable for small & medium farmers. Growing of three seasonal vegetables in a year and inclusion of vegetables into the rice-wheat cropping pattern could increase the cropping intensity and productivity and economic returns.

Keywords: Vegetable based crop sequence, diversification, Rice equivalent yield, low midland and upper midland

ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi-221305, UP

*Corresponding author, E-mail: vanitha.gkvk@gmail.com

Introduction

India is the second largest vegetable producer in the world, with an annual production of 184.40 m tonnes from an area of 10.26 mha (Horticulture statistics, 2018). Our requirement of vegetables has increased to about 220 million tonnes/annum to meet the nutritional requirement of an estimated 1200 million population. Cereals continue to constitute major portion of India's food basket and its production is essential for sustaining the livelihood of the poor people. However, as food crops, vegetables play an important role inachieving the nutritional security since these are rich source of vitamins, minerals and other phytochemicals. The dominant paddy – wheat cropping system of cultivation has led to serious economic, social and ecological problems such as deceleration in the productivity of ground water resources and decline in soil fertility and increase in environmental pollution. In the recent decades, agricultural diversification has increasingly been considered as a panacea for the severe problems that have afflicted agriculture. Diversified agriculture is profitable; it generates additional employment for rural masses and conserves natural resources. Crop diversification in the form of including different cereal and horticultural crops in the cropping sequence can provide farmers with better income realization & profitability, resource use efficiency and productivity. Therefore, a key step to the economic development of Indian farmer's will be to diversify their cereal based production system through inclusion of vegetable crops in cropping sequence. (Rishitha et al. 2017)

Vegetables are cash crops which can be grown easily, give higher productivity in a short time and fetches higher price in market compared to cereals along with year-round availability.The inclusion of vegetables in the major cropping systems will not only improve the availability of vegetable and help in achieving nutritional security drive but will also provide means to earn foreign exchange by exporting fresh vegetables and vegetable seeds.

Moreover, vegetable crops are suitable for production on small pieces of land and their inclusion in traditional cropping systems can improve the nutritional potential of the system. Under low land and low midland, rice is the default crop during kharif season due to its capability to grow and produce reasonable yield under water logged condition, where no other crops can be grown. Under upland and upper midland cereals and vegetable crops grow luxuriantly. There is need to diversify the traditionally grown less remunerative cropping system under midlands to more remunerative cropping systems. Since there is practically no information available on these aspects of vegetable based cropping systems, hence, a field experiment was conducted to diversify and select suitable vegetable based cropping system/ sequence for higher productivity, profitability and resource use efficiency under Indo-Gangetic plain of Eastern Uttar Pradesh

Materials and Methods

The field experiment was conducted at ICAR-Indian Institute of vegetable Research (IIVR) Varanasi, under irrigated condition during the rainy, winter and summer season of 2017-2018 and 2018-2019 on silt loam soil having pH 7.5, EC 0.17 dS/ m, low organic carbon (0.34 %) medium available nitrogen (N) (210.2kg/ha), available phosphorus.(31.0 kg P_2O_5/ha) and potash (210.4 kg K_2O /ha). The experiment was laid out in a randomize block design with three replications. Treatments consisted of ten cropping sequences (CS) as given below, five each for low midland and upper midland situations, respectively.

CS_1 = Paddy –wheat; CS_2 =Paddy -wheat- coriander; CS_3 =Paddy–tomato-mung bean

CS_4 =Paddy -cauliflower-cowpea; CS_5 =Paddy -pea-okra; CS_6 =Maize- pea – pumpkin

CS_7 =Bottle gourd-wheat -amaranth; CS_8=Brinjal-cowpea; CS_9 =Okra-tomato-cowpea

CS_{10} =Cowpea-tomato-okra

Fertilizers were applied as per the recommendation for each crop. The sources of nitrogen (N), phosphorous (P_2O_5) and Potassium (K_2O) were urea, single super phosphate and muriate of potash. Uniform dose of Farmyard manure (FYM) at the rate of 200 q/ha was mixed in the soil before sowing/transplanting of vegetable crops. Irrigation was provided as and when required and timely plant protection measures were taken. To raise the crops, all standard intercultural operations and management practices were adopted as per the recommendations of the crop. The details of the crop management practices adopted for the cropping sequences have been presented in the Table 2. The plot size was 5 × 6 m for each treatment. The analysis report of soil samples collected before and after the completion of experimentation is presented in the Table 1. The organic carbon content was determined by Walkely and Black (1934) method, available N, P and K content of soil was determined by alkaline potassium permanganate method (Subbia and Asija 1956), Olsen method (Olsen et.al. 1954) and ammonium acetate method by Jackson (1973) respectively.

Data on yield of the all crops are presented on the basis of the produced recorded from the net plot. During both the years of experimentation, meteorological parameters were more or less same, and the crops were normal. The two-year's experimental data were pooled and subjected to statistical analysis as described by Gomez and Gomez (1984). The yields of crops were converted to Rice Equivalent Yield (REY) as suggested by Tomar and Tiwari (1990) on the basis of the existing market prices of the crops. The cost of cultivation was calculated by including costs incurred on all the input for each cropping sequence which includes the capital and labour cost. Gross returns were obtained by the product of price of rice and the REY obtained under different cropping sequence. BC ratio was calculated by the ratio of gross returns to the total cost of cultivation. Gross and net returns were computed using prevailing rates of produce and agro inputs. Minimum support price of rice of respective years was considered for calculation of REY

Results and Discussion

Yield of Vegetables: Average yield and economic performance of vegetable-based cropping systems during 2017-18 and 2018-19 are presented in Table 3 and 4. From the result, it was observed that during kharif season under low midland situation, the average rice yield varied between 49.22 to 50.30 q/ha. The vegetable yield of kharif season under upper midland ranged from 133.q/ha in cowpea to 292.85 q/ha (bottle gourd). During rabi season wheat yield varied from 40.19 to 40.70 q/ ha in the system where wheat was taken after rice. The vegetable yield during rabi season in the system where wheat was replaced by vegetable after rice ranged from 92.35 q/ha (Pea) to 407.1 q/ha (tomato). The vegetable crop yield during rabi season under upper midland situation ranged from 98.92 (pea) to 491.25 q/ha (Tomato) and the average wheat yield was 41.66 q/ha where preceding crops during kharif season were vegetables. During *zaid* season, the grain yield of moong was 10.32q/h and the vegetable yield was 20.08q /ha (coriander leaf) to 129.46q/ha in okra. However, under upper midland situation, the vegetable yield ranged between 123.89q/ha in amaranth to 294.96q/ha in pumpkin.

Rice Equivalent Yield (REY): Total productivity of different cropping sequences was determined by Rice Equivalent Yield (REY) calculated from the yield of component crops. From the two years result of vegetable based cropping sequence, it was found that under low midland situation the average highest REY (257.81q/ha) was recorded from the cropping sequence of rice-broccoli-cowpea and lowest (137.29q/ha) was found from the cropping sequence of rice-wheat-coriander (green leaf). The REY in rice-wheat sequence was only 93.0q/ha. Rice equivalent yield (REY) in the cropping sequence where two vegetable crops were taken was 177% (Rice-broccoli-cowpea) and 115% (rice- pea-okra) higher than the rice wheat cropping sequence. Even inclusion of one vegetable crop such as coriander (Rice- wheat -coriander) or tomato in Rice-tomato-moong bean increased the productivity of the system by 48 and 98 percent, respectively over rice-wheat system. The percent contribution of vegetable crop in the total productivity of cropping system varied from 32.85 (of coriander) in rice-wheat-coriander sequence to 50.35 (of tomato) in rice-tomato-moong cropping sequence under low midland situation. The present study is closely related to the research findings of Ram et al. (2012) Mandal *et al.,* (2015) which stated that inclusion of one vegetable crop in three or four crops-based cropping patterns sharply increase the rice equivalent yield of cropping pattern. Under upper midland situation the highest total productivity in terms of REY was recorded in okra-tomato-cowpea sequence (260.21q/ha) which was at par to Cowpea-Tomato-Okra (251.16q/ha), brinjal-cowpea (249.61q/ha) and maize- pea – pumpkin (249.85q/ha). The lowest system productivity was recorded in bottle gourd-wheat-amaranth sequence (194.61 q REY/ha) probably due to lower yield of wheat crop.

Economic Analysis: Economic analysis was done on the basis of prevailing market price of the commodities. Economics of system productivity of vegetable-based cropping sequences is given in table 4. It was revealed that the gross return varied from one cropping pattern to another cropping pattern due to inclusion of vegetable crop. Under low midland situation the highest gross return (Rs 459505/ha) and net returns (Rs 249955/ha) and benefit cost ratio (2.20) was obtained in rice-broccoli-cowpea cropping sequence probably due to inclusion of high value vegetable (Cauliflower) and also higher yield obtained in this sequence. This was closely followed by rice -pea-okra cropping system with gross return of Rs 356912, net return of Rs 164762 and B:C ratio of 1.86. Under upper midland situation the highest gross return (Rs 463736/ha) was recorded under okra -tomato- cowpea sequence however, the highest net return of Rs 261802 /ha and benefit cost ratio 2.43 was obtained in maize pea-pumpkin cropping sequence probably due to lower cost of cultivation and better market price of the crops included in the sequence. In okra -tomato- cowpea sequence in spite of higher yield and gross return, the net return and B:C ratio is lower due to higher cost of cultivation of the cropping sequence. Profitability of bottle gourd-wheat –amaranth cropping sequences are also higher compared to others as given by the returns to rupee invested (BC ratio) which is consistently high in both the years. This was followed by Brinjal-cowpea cropping sequence with the BC ratio of 2.11. Vegetables being capital and labour intensive incurred higher cost of cultivation as compared to cereal crops in different cropping sequences (Table 4). Tomar and Tiwari (1990), Ram *et al.* (2012) and Mondal et al. (2015) also reported that three crop-based cropping sequence is agronomically feasible and economically profitable with inclusion of vegetables, compared to existing farmers cropping pattern of rice-wheat system.

Soil Fertility Amendment: In the vegetable-based cropping patterns soil organic carbon, available P and available K increased after two-years cycle (Table 1).

Table 1: Initial and final soil properties of the experimental field during 2017-18 and 2018-19

	Land type	Soil texture class	pH	EC (ds/m)	OC%	Available N	Available P_2O_5	Available K_2O
Initial		Silt loam	7.50	0.17	0.34	210.20	31.00	210.40
Final								
Paddy-wheat	LML	Silt loam	7.46	0.18	0.37	214.00	35.50	215.00
Paddy-wheat-coriander	LML	Silt loam	7.45	0.19	0.38	230.60	38.80	220.50
Paddy-tomato-mungbean	LML	Silt loam	7.48	0.17	0.36	235.00	37.60	220.00
Paddy-cauliflower-cowpea	LML	Silt loam	7.46	0.16	0.38	238.00	37.40	225.20
Paddy-pea-okra	UML	Silt loam	7.48	0.17	0.38	237.00	37.00	226.00
Maize-pea-pumpkin	UML	Silt loam	7.48	0.17	0.36	234.80	38.90	228.30
Bottle gourd-wheat-amaranth	LML	Silt loam	7.45	0.19	0.36	228.70	38.80	214.40
Brinjal-cowpea	UML	Silt loam	7.44	0.16	0.36	240.50	38.60	228.70
Okra-tomato-cowepa	UML	Silt loam	7.45	0.19	0.37	234.80	36.60	227.20
Cowpea-tomato-okra	UML	Silt loam	7.48	0.19	0.38	232.60	34.70	218.70
CD			NS	NS	NS	18.42	3.17	12.54

Table 2: Crop management practices in the experimental plot under different cropping systems

Parameters	CP1		CP2			CP3			CP4		
Crop	Paddy	Wheat	Paddy	Wheat	Coriander	Paddy	Tomato	Mung bean	Paddy	Cauliflower	Cowpea
Variety	HUR-3032	HD-2967	HUR-3032	HD-2967	Ganga	HUR-3032	Kashi Aman	HUM-16	HUR-3032	Maduri	Kashi Nidhi
Planting/Sowing date	July, 16-20	Nov, 20-25	July, 16-20	Nov, 20-25	May, 5-8	July, 16-20	Oct, 20-25	April, 10-15	July, 16-20	Nov,9-15	March, 5-10
Spacing (cm)	20 X 20	22.5 X 5	20 X 20	22.5 X 5	30 X 10	20 X 20	60 X50	60 X 20	20 X 20	50 X 45	60 X 20
Fertilizer dose (N-P-K ka/ha)	120:60:60	120:60:60	120:60:60	120:60:60	60:30:30	120:60:60	150:80:60	30:50:50	120:60:60	120:60:60	40:60:60
Field duration (days)	110	148	110	152	47	110	126	56	110	75	62
0Harvesting dates	October 25-28	April, 20-25	October 25-28	April, 20-25	June,20-22	October 15-20	March, 5-15	June, 10-20	October 25-28	January, 15-20	June, 10-15
Parameters	CS5			CS6			CS7				
Crop	Bottle gourd	Wheat	Amaranth	Maize	Pea	Pumpkin	Brinjal	Cowpea			
Variety	Kashi Ganga	HD-2967	Kashi Suhavani	Naveen	Kashi Udai	Kashi Harit	Kashi sandesh	Kashi Nidhi			
Planting/ Sowing date	July, 20-25	Nov, 20-25	April, 15-20	July, 8-12	Oct-30 to Nov-5	Mar, 12-16	Aug, 8-25	March 12-18			
Spacing	250 X 60	22.5 X 5	20 X 15	60 X 20	22.5 X 7.5	250 X 50	60 X 75	60 X 20			
Fertilizer dose (N-P-K kg/ha)	50:35:30	120:60:60	80:40:40	100:50:50	30:60:60	60:30:30	100:50:50	40:60:60			
Field duration (days)	81	145	70	80	77	68	187	65			
Harvesting dates	Oct, 10-20	April, 10-15	June, 25-28	Sept 28-30	Jan,15 -25	May, 20-25	March, 5-8	May, 15-18			
Parameters	CS8			CS9			CS10				
Crop	Okra	Tomato	Cowpea	Paddy	Pea	Okra	Cowpea	Tomato	Okra		
Variety	Kashi Kranti	Kashi Aman	Kashi Nidhi	HUR-3032	Kashi Mukti	Kashi Kranti	Kashi Nidhi	Kashi Aman	Kashi Kranti		
Planting date	July, 8-13	Oct, 15-20	March,12-15	July, 16-20	Nov, 15- 20	March, 8-12	July, 16-20	October, 15-20	March, 10-15		
Spacing	60 X 20	60 X 50	60 X 20	20 X 20	22.5 X 7.5	60 X 20	60 X 20	60 X 50	60 X 20		
Fertilizer dose (N-P-K ka/ha)	100:50:50	150:80:60	40:60:60	120:60:60	30:60:60	100:50:50	40:60:60	150:80:60	100:50:50		
Field duration (days)	65	126	63	110	90	65	62	126	65		
Harvesting dates	September, 16-20	March, 5-8	May, 16-20	October, 25-28	Feb, 15-18	May,12-18	September,18-22	Feb.25-28	May, 15-20		

Table 3: Crop yield (q/ha) under different vegetable based cropping system

Cropping Sequence	2017-18			2018-19			Mean		
	Kharif	Rabi	Zaid	Kharif	Rabi	Zaid	Kharif	Rabi	Zaid
Low midland									
Paddy –wheat	48.62	40.20	-	51.40	41.20	-	50.01	40.70	0.00
Paddy -wheat- coriander	47.50	39.87	20.23	52.00	40.50	19.95	49.75	40.19	20.09
Paddy–tomato-mung bean	49.20	327.60	10.40	49.24	486.60	10.24	49.22	407.10	10.32
Paddy -broccoli-cowpea	49.00	145.63	128.58	51.60	150.58	127.53	50.30	148.11	128.06
Paddy -pea-okra	48.52	89.50	128.68	51.20	95.20	130.24	49.86	92.35	129.46
Upper midland									
Maize- pea – pumpkin	140.65	95.50	291.64	158.54	102.34	298.28	149.60	98.92	294.96
Bottle gourd-wheat-amaranth	270.46	41.51	125.41	315.23	41.80	122.36	292.85	41.66	123.89
Brinjal- cowpea	-	465.48	124.82		470.08	125.21	0.00	467.78	125.02
Okra-tomato-cowpea	132.41	458.65	131.47	133.61	485.67	128.62	133.01	472.16	130.05
Cowpea-tomato-okra	131.20	487.38	130.58	134.80	495.12	132.25	133.00	491.25	131.42

Table 4: Economics of different vegetable based cropping systems

Cropping Sequence	REY (q/ha) Pooled (2017-18 and 2018-19)				Economics Pooled (2017-18 and 2018-19)			
	Kharif	Rabi	Zaid	Total	Cost of cultivation (Rs. /ha)	Gross returns (Rs. /ha)	Net returns (Rs. /ha)	BC Ratio
Low midland								
Paddy –wheat	50.01	42.98	0.00	92.99	100400	165832	65432	1.65
Paddy -wheat- coriander	49.75	42.44	45.10	137.29	165400	244772	79372	1.48
Paddy–tomato-mung bean	49.22	91.06	40.55	180.83	224450	322813	98363	1.44
Paddy -broccoli-cowpea	50.30	99.71	107.80	257.81	209550	459505	249955	2.20
Paddy -pea-okra	49.86	77.70	72.64	200.20	192150	356912	164762	1.86
Upper midland								
Maize- pea – pumpkin	83.86	83.22	82.75	249.83	183650	445452	261802	2.43
Bottle gourd-wheat -amaranth	98.47	43.99	52.15	194.61	159200	347038	187838	2.18
Brinjal- cowpea	0.00	144.37	105.23	249.61	211050	444801	233751	2.11
Okra-tomato-cowpea	44.78	105.93	109.49	260.21	243100	463736	220636	1.91
Cowpea-tomato-okra	67.16	110.26	73.74	251.16	243100	447617	204517	1.84
CD (P=0.05)	20.2	29.5	21.4	53.4				

Available N also increased to some extent. Due to intensive cropping with vegetables, substantial amount of well decomposed organic manure was applied before every vegetable in the cropping sequences. Crop residues of some crops or vegetables such as cowpea, cauliflower, bottle gourd, pea, pumpkin, amaranth etc. were also incorporated in the soil. For these reasons there was no depletion of soil nutrients in the subsequent years and there was some improvement in soil organic carbon and available nutrients (Table 1). This suggests that, soil fertility can be maintained by proper fertilizer management in intensive crop cultivation. Furthermore, adequate intercultural operations, soil amendment and soil treatment along with proper fertilizer management produced higher crop yield. Similar results have been obtained by Pasha et al. (2018) also.

Conclusion

From the above results, it can be suggested that intensive vegetable-based cropping patterns are suitable for small and medium farmers. Growing of three seasonal vegetables in a year and inclusion of vegetables into the rice-wheat cropping pattern could increase the cropping intensity and productivity and economic returns.

सारांश

सब्जी एवं अनाज फसलों को सम्मिलित कर फसल पद्धतियों का विविधिकरण किया जा सकता है जिससे किसानों को अधिक आय प्राप्त हो सकती है एवं उत्पादन तथा संसाधनों की उपयोग दक्षता में वष्द्धि की जा सकती है। इन्हीं बातों को ध्यान में रखकर भा.कृ.अनु.प.–भारतीय सब्जी अनुसंधान संस्थान, वाराणसी (उत्तर प्रदेश) के शोध परिक्षेत्र पर वर्ष 2018–19 एवं 2019–20 के दौरान एक शोध किया गया जिसका मूल उद्देश्य सब्जियों द्वारा फसल पद्धतियों का विविधिकरण कर गंगा के मैदानी क्षेत्रों (पूर्वी उत्तर प्रदेश) के लिए अधिक उत्पादन एवं आय प्रदान करने वाली सब्जी आधारित फसल पद्धतियों का चुनाव करना था। प्रयोग में यह पाया गया कि धान–गेंहूँ फसल पद्धतियों में धान के बाद गेंहूँ की जगह सब्जी फसलों की खेती करने पर मटर 92.35 कुन्तल/हे. से टमाटर 407.1 कुन्तल/हे. के बीच उत्पादन प्राप्त हुआ। जिन फसल पद्धतियों में दो सब्जी फसलों को सम्मिलित किया गया था उनमें धान–गेंहूँ फसल पद्धति की तुलना में धान समतुल्य उत्पादन में 177 (धान–गोभी–लोबिया) से 115 (धान–मटर–भिंडी) प्रतिशत की वृद्धि प्राप्त की गयी। अधिकतम कुल आमदनी 4,63,802 रूपये/हे. भिंडी–टमाटर–लोबिया फसल चक्र में प्राप्त की गयी। हालांकि अधिकतम शुद्ध लाभ (2,61,802 रूपये) एवं लागतःलाभ अनुपात (1:2.43) मक्का–मटर–कुम्हड़ा फसल चक्र में प्राप्त किया गया जबकि निम्न मध्यम ऊँचाई वाले खेतों में अधिकतम कुल आमदनी (4,59,505 रूपये/हे.), शुद्ध लाभ (2,49,955 रूपये/हे.) तथा लागतः लाभ अनुपात (1:2.43) मक्का–मटर– कुम्हड़ा फसल चक्र में प्राप्त किया गया जबकि निम्न माध्यम लागतःलाभ अनुपात (1:2.20) धान–गोभी–लोबिया फसल प्रणाली में प्राप्त की गयी। शोध से प्राप्त इन परिणामों के आधार पर यह संस्तुत किया जा सकता है कि सघन सब्जी आधारित फसल पद्धतियाँ छोटे एवं मझोले किसानों के लिए उपयुक्त है। एक वर्ष में 3 सब्जी फसलों की खेती अथवा धान–गेंहूँ फसल पद्धति में सब्जियों को सम्मिलित करने पर सस्य सघनता, उत्पादकता तथा आर्थिक लाभ को बढ़ाया जा सकता है।

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