Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP5: 37-41

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(Special Issue- 5)
International Conference on
"Food Security through Agriculture & Allied Sciences"
(May 27-29, 2019)

Identification of suitable vegetable based cropping sequences in relation to economic yield and profitability

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Abstract
The present investigation was carried out for two years 2010-11 and 2011-12 at Horticultural Farm, BAU, Ranchi. The experiment was laid out in RBD with three replications that comprised of nine cropping sequences. The FYM added in vegetable crops was @ 20t/ha whereas, in cereal crops it was @ 5t/ha. The soil was poor in fertility with acidic in reaction (pH 5.56) and sandy loam in texture, low in organic carbon (3.70 g/kg), available N (238.34 kg/ha), B (0.43 ppm) and medium in available P (49.84 kg/ha), K (157.92 kg/ha), S (15.01 kg/ha) and Zn (1.06 ppm).The rice equivalent yield was obtained highest in sponge gourd-rice-broccoli (144.40 q/ha) sequence and was at par with ridge gourd-cowpea-Tomato (143.34 q/ha) and sponge gourd-brinjal-capsicum (124.89 q/ha) sequences. The gross return (Rs/ha), net return (Rs/ha) and benefit: cost ratio differed significantly in both the years of experimentation and also in pooled analysis. The highest net return and benefit cost ratio was obtained in sponge gourd-rice-broccoli sequence with 99427.00 Rs/ha and 3.26, respectively at the end of two years and was followed by ridge gourd-cowpea-tomato (86094.61 Rs/ha and 2.41, respectively) and sponge gourd-rice-potato (66491.16 Rs/ha and 2.46, respectively) sequences.

Keywords: Cropping sequences, rice equivalent yield, gross returns, net returns and benefit-cost ratio

Introduction
The state of Jharkhand offers ample opportunity for successful cultivation of a wide range of vegetables in different season of the year due to its mild climatic conditions. Judicious selection of crop combination held the key to profitability of vegetable production system. An effective and suitable vegetable cropping sequence with provision for round the year production as well as supplemental income can effectively address towards ensuring nutritional security to both the growers and the consumers. However, per capita consumption of vegetables in India is only 140 g and in Jharkhand it is 135 g against a minimum of about 300 g recommended by Indian Council of Medical Research and National Institute of nutrition, Hyderabad (Anonymous, 1979) [2]. In Jharkhand state, where mono-cultivation is the traditional farming system which is dominated by rice culture can be substituted by some more remunerative crops with the introduction of various lift irrigation projects. At the end of March, 2009, 7.31 lakh ha irrigation potential has been created by the completion of several minor and major irrigation projects (Annual Report, 2010-11) [3]. During 2008-09 vegetable production of the state was 3637.00 thousand metric tones with an area of 242.10 thousand hectare and productivity of 15.00 metric tones per hectare (Indian Horticulture Database 2009) [9]. The incorporation of vegetables in the existing cropping sequences is an effective option for improving profitability. Although production technologies for different vegetables have already been standardized under Jharkhand conditions, but work has not been yet done to identify suitable vegetable based cropping sequence and an effective vegetable crop combinations for providing regular income and nutritional support for marginal land holders.

Materials and Methods
The experiment was conducted in the Horticultural Farm of Birsa Agricultural University Ranchi during summer, kharif and rabi season of 2010-11 and 2011-12. The experimental plot was upland having well drained soil with fairly uniform topography. The field was well connected to irrigation system for timely irrigation.

The soil of the experimental site belongs to Red-Yellow soil, association group Alfisols representing the major soil group of Jharkhand plateau. During the experimentation the crops received total rainfall of 1425.4 mm in 2010-2011 and 2518.2 mm during 2011-12. The rainfall was higher in the month of September (689.10mm) in first year while in the month of June (714.3mm) in the second year. The maximum temperature varied between 38.8 to 21.8 °C and 35.8 to 21.2°C while the minimum temperature ranged between 24.7 to 4.5 °C and 22.4 to 5.8 °C during the cropping period of first and second year, respectively. The mean maximum and minimum relative humidity ranged from 89.20 to 75.10 percent in the first year whereas, it was 87.50 to 83.10 percent in the second year. With the advent of irrigation facilities in the state, farmers of the state have choice to go for double or triple cropping sequences in a year. Total 9 (nine) cropping sequences were taken to constitute treatments for different vegetable based cropping sequences *viz*; bottle gourd-rice-potato, ridge gourd-cowpea-tomato, watermelon-maize-garden pea, bottle gourd-french bean-cauliflower, sponge gourd-french bean-cauliflower, sponge gourd-brinjal-capsicum, cucumber-okra-wheat, sponge gourd-rice-broccoli, bottle gourd-chilli-radish and okra-maize-cabbage. To avoid mixing of soil, individual plot was thorough prepared in each season. Recommended doses of fertilizers were given to each crop under the cropping sequences. The FYM was given @ 20 t/ha for all vegetables and 5 t/ha for agronomical crops like rice, wheat and maize. Improved and popular varieties were selected for each crop. The planting distance and seed rate were maintained as per the recommendation.

The cost of cultivation of different treatments was calculated on the basis of inputs used and their prevailing corresponding costs. Gross return (Rs ha^{-1}) were calculated on the basis of fruits/grain and plant part/straw yield and their existing price. These values were used to calculated net return (Rs ha^{-1}). Benefit: cost ratio was determined by dividing gross return with cost of cultivation. Rice equivalent yield under vegetable based cropping sequences was calculated by using following formula.

$$Rice \text{ equivalent yield } (q\,ha^{-1}) = \frac{\text{Yield of crop } (q\,ha^{-1}) \times \text{Price of crop } (Rs\,q^{-})}{\text{Price of rice } (Rs\,q^{-1})}$$

The significance of treatment differences were judged by F-test as outlined by Cochran and Cox (1957). To evaluate the significant of difference between two treatment means, critical difference (C.D.) at 5 percent level was worked out.

Results and Discussion

Economic produce of component crops in various sequences were converted in REY (q/ha) by considering economic fruit / grain yield and price of each crop to facilitate comparison of economic yield in terms of rice in different vegetable based cropping sequences. The significantly higher of 158.64 q/ha REY was obtained in ridge gourd-cowpea-tomato sequences in the first year of experiment and was found superior to all the treatment combinations. However, it was followed by sponge gourd-rice-broccoli and sponge gourd-brinjal-capsicum sequences with 123.45 and 114.62 q/ha REY, respectively. In the second year, sponge gourd-rice-broccoli sequences recorded significantly maximum of 165.34 q/ha REY and was also found superior to all the sequences under different cropping sequences. It was followed by sponge gourd-brinjal-capsicum and ridge gourd-cowpea-tomato sequences with 135.17 and 128.03q/ha yields, respectively.

Pooled data also differed significantly with respect to REY under different cropping sequences and maximum of 144.40 q/ha REY was found in sponge gourd-rice-broccoli sequence and was at par with ridge gourd-cowpea-tomato sequence with 143.34 q/ha whereas, significantly minimum of 87.90 q/ha REY was recorded in cucumber-okra-wheat sequence. Katyal *et al.* [11] revealed that inclusion of vegetables in the system distinctly gave better yields in terms of wheat equivalent yield and productivity.

In the first year, Ridge gourd-Cowpea-tomato sequence exhibited superiority over other sequences and produced highest (158.64 q/ha) rice equivalent yield than the rest of the sequences. Higher production potential of tomato along with good yield of cowpea & ridge gourd and better market prices were instrumental for attaining higher REY, it was followed by sponge gourd-rice-broccoli (123.45 q/ha). Ali Masood (1992) [1], Bangar *et al.* (2003) [4] and Dungrani *et al.* (2003) reported that highest rice equivalent yield was obtained with pulse crops as against summer fallow. In the second year, sponge gourd-rice-broccoli sequence was found superior (165.34 q/ha) in REY than the other sequences. However, in the second year decreasing trend were observed in almost all sequences with respect of yield attributing characters but due to higher market price and higher production of sponge gourd and broccoli along with good rice yield fetched better returns in these sequences. At the end of both year experimentation in pooled data, sponge gourd-rice-broccoli sequence recorded highest (144.40 q/ha) REY and was closely followed by ridge gourd-cowpea-tomato (143.34q/ha) sequence. Addition of leguminous crop (cowpea) with ridge gourd and tomato might be the reason for higher yield of the sequence which resulted in higher REY and are in agreement with earlier findings of Soni and Kaur (1984) [16], Bohra *et al.* (2007) [6] and Kumar *et al.* (2008) [12], Urkurkar *et al.* (2008) [18] and Kalpana, *et al.* (2009) [10] observed that inclusion of more than two crops in a year particularly vegetables lowered down the stability of the system in respect of yield and economics. Sharma, *et al.* (2004) [15], Saroch *et al.* (2005) [14] and Tripathi and Singh (2008) [17] reported that diversification of rice-wheat cropping sequences particularly with vegetables gave highest rice equivalent yield.

In the first year, among all the sequences, sponge gourd-brinjal-capsicum had maximum (59996.60 Rs/ha) cost of cultivation and minimum (42110.90 Rs/ha) was in sponge gourd-rice-broccoli sequence and in the second year sponge gourd-brinjal-capsicum sequence was again highest (65827.90 Rs/ha) in cost of cultivation whereas, lowest was calculated in bitter gourd-rice-potato sequence.

Gross return in different cropping sequences was comparatively higher in almost all sequences except few during 2011-12 as compared to 2010-11. Gross return (Rs/ha) in different cropping sequence differed significantly in both the years and also in pooled data. In first year, the maximum (156668.30 Rs/ha) gross return was obtained in ridge gourd-cowpea-tomato and was followed by sponge gourd-rice-broccoli with 126240.00 Rs/ha. Whereas, in the second year it was sponge gourd-rice-broccoli sequence which obtained highest (164573.10 Rs/ha) gross return and was followed by ridge gourd-cowpea-tomato (138274.00 Rs/ha) sequence.

The net return (Rs/ha) of different vegetable based cropping sequences was differed significantly in both the years and also in pooled analysis. The significantly higher (97831.20 Rs/ha) net return was obtained in ridge gourd-cowpea-tomato and

was followed by sponge gourd-rice-broccoli (84129.10 Rs/ha) in the first year of experiment whereas, in the second year significantly higher (114724.80 Rs/ha) net return value was observed in sponge gourd-rice-broccoli sequence and was followed by bitter gourd-rice-potato (84396.60 Rs/ha) sequence. Tripathi (2008) [17] and Kalpana *et al.* (2009) [10] observed that diversification or intensification of rice- wheat system once in three years especially with vegetables improved the net returns.

Benefit cost ratio of different cropping sequences differed significantly in both the years and also in pooled analysis. In the first year, the significantly higher (2.99) benefit cost ratio was obtained in sponge gourd-rice-broccoli sequence and was followed by ridge gourd-cowpea-tomato (2.66) sequence. In the second year, sponge gourd-rice-broccoli obtained significantly maximum (3.53) benefit cost ratio and was followed by bitter gourd-rice-potato (3.26) sequence. Backer *et al.* (1995) [5], Yadav *et al.* (2000) [19], Kumar *et al.* (2001) [13] and Sharma *et al.* (2004) [15] recorded maximum benefit-cost ratio with rice based cropping sequences and with other vegetable crops combination.

It was observed from different cropping sequences that net profit of some cropping sequences performed better in the year 2010-11 whereas, others in 2011-12 (Table 1 and figure 1). This variation could be attributed due to differences in yield and selling prices during both the years. Among all the cropping sequences, sponge gourd-rice-broccoli sequence proved its distinct superiority over rest of the sequences and was followed by ridge gourd-cowpea-tomato. This was mainly due to higher production potential associated with minimum cost of cultivation and higher selling price. During crop growth period, variation in weather condition was observed in both the years which affected their production potential and market demand that resulted in up and down in market price.

It was further observed that benefit: cost ratio of different sequences was slightly higher in 2011-12 as compared to 2010-12. This might be due to higher market rate of the produce though the yield obtained during second year was less than the first year. During second year, early break of monsoon led to lower production potential but its higher demand in the market increased their market value. Among different sequences, sponge gourd-rice-broccoli increased the production potential and higher net return of the sequence gave higher benefit: cost ratio than rest of the sequences. This sequence was followed by bitter gourd-rice-potato and ridge gourd-cowpea-tomato sequences.

From the above studies it can be concluded that sponge gourd-rice-broccoli, ridge gourd-cowpea-tomato and bitter gourd-rice-potato sequences are three options which can maximize production, maintain good soil health along with higher benefit-cost ratio under different vegetable based cropping sequences. Therefore, these sequences can be considered suitable for farmer's recommendation.

Table 1: Rice equivalent yield (q/ha) of different cropping sequences.

Treatments	2010-11 (q/ha)	2011-12 (q/ha)	Pooled (q/ha)
T_1 - Bitter gourd–Rice–Potato	88.62	116.39	102.51
T_2 - Ridge gourd–Cowpea–Tomato	158.64	128.03	143.34
T_3 - Watermelon–Maize–Pea	95.91	100.60	98.25
T_4 - Bottle gourd–French bean–Cauliflower	98.45	97.66	98.06
T_5 - Sponge gourd–Brinjal–Capsicum	114.62	135.17	124.89
T_6 - Cucumber–Okra–Wheat	93.09	82.71	87.90
T_7 - Sponge gourd–Rice–Broccoli	123.45	165.34	144.40
T_8 - Bottle gourd–Chilli–Radish	113.54	125.35	119.45
T_9 - Okra–Maize–Cabbage	75.35	109.72	92.53
SEm ±	3.63	5.49	3.59
CD at P=0.05%	10.96	16.61	10.87
CV%	5.88	8.07	5.54

Table 2: Economics of different cropping sequences during 2010-11 and 2011-12.

Treatments	Cost of cultivation(Rs/ha)		Gross return(Rs/ha)			Net return(Rs/ha)			B:C ratio		
	2010-11	2011-12	2010-11	2011-12	Pooled	2010-11	2011-12	pooled	2010-11	2011-12	Pooled
T_1 - Bitter gourd–Rice–Potato	42464.63	45987.16	91050.00	127383.92	109216.96	48585.67	84396.64	66491.16	2.14	2.76	2.46
T_2 - Ridge gourd–Cowpea–Tomato	58837.17	63915.94	156668.33	138274.00	147471.16	97831.16	74358.06	86094.61	2.66	2.16	2.41
T_3 - Watermelon–Maize–Pea	53795.79	57978.61	87398.00	108647.00	98022.50	64608.69	50668.44	57638.56	1.62	1.87	1.75
T_4 - Bottle gourd–French bean–Cauliflower	59002.67	63567.62	100286.33	105478.33	102882.33	41283.70	41910.72	41597.21	1.69	1.66	1.68
T_5 - Sponge gourd–Brinjal–Capsicum	59996.00	65827.92	102100.33	139646.34	120873.33	40777.00	77151.74	58964.37	1.70	2.15	1.93
T_6 - Cucumber–Okra–Wheat	44786.88	47587.41	93120.00	84365.33	88742.67	48366.46	30226.63	39296.54	2.08	1.77	1.93
T_7 - Sponge gourd–Rice–Broccoli	42110.92	46514.98	126240.00	164573.10	145406.55	84129.11	114724.81	99426.96	2.99	3.53	3.26
T_8 - Bottle gourd–Chilli–Radish	50946.00	54758.07	109565.17	101011.00	105288.09	58284.17	33662.25	45973.21	2.15	2.57	2.36
T_9 - Okra–Maize–Cabbage	56500.79	60715.87	85666.67	128470.33	107068.50	29165.88	67751.46	48458.67	1.52	2.12	1.82
SEm ±			8025.00	4263.25	5033.78	2147.10	2919.79	2188.98	0.09	0.07	0.08
CD at P=0.05%			24266.40	12891.27	15416.35	6492.50	8828.91	6619.06	0.29	0.23	0.25
CV%			13.14	6.05	7.59	6.52	7.92	6.27	8.00	5.72	6.66

Table 3: Effect of cropping sequences on yield (q/ha) in summer, kharif and rabi season during 2009-10 and 2010-11.

Treatments	Summer season			Kharif season			Rabi season		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T_1 – Bitter guard – Rice – Potato	125.83	119.97	123.07	39.82	35.17	37.50	200.39	188.33	194.36
T_2 – Ridge guard – Cowpea – Tomato	121.00	121.01	121.01	168.55	150.33	159.44	265.00	245.17	255.09
T_3 – Watermelon – Maize – Pea	435.00	350.00	392.51	149.49	134.97	142.23	75.03	65.33	70.19
T_4 – Bottle guard – French bean - Cauliflower	288.17	200.01	243.74	95.00	82.44	88.76	200.00	155.00	177.50
T_5 – Sponge guard – Brinjal – Capsicum	208.17	195.37	201.96	220.33	199.67	210.00	95.17	90.00	92.59
T_6 – Cucumber – Okra – Wheat	224.83	150.34	181.63	125.00	99.63	112.30	41.86	48.67	45.27
T_7 – Sponge guard – Rice – Broccoli	180.00	152.01	166.06	40.47	37.83	39.15	150.00	137.03	143.58
T_8 – Bottle guard – Chilli – Radish	224.83	185.16	205.00	90.33	81.00	85.67	195.67	167.67	181.65
T_9 – Okra – Maize – Cabbage	110.33	99.72	136.46	130.00	123.33	146.69	199.67	230.00	218.84
Sem ± 1%	11.46	12.74	15.44	5.67	8.67	7.99	6.83	4.67	5.06
CD at P=0.05%	34.64	38.30	46.66	17.11	26.01	24.17	20.66	22.58	15.29
CV%	9.31	12.62	13.58	8.33	14.31	12.19	7.49	8.77	5.74

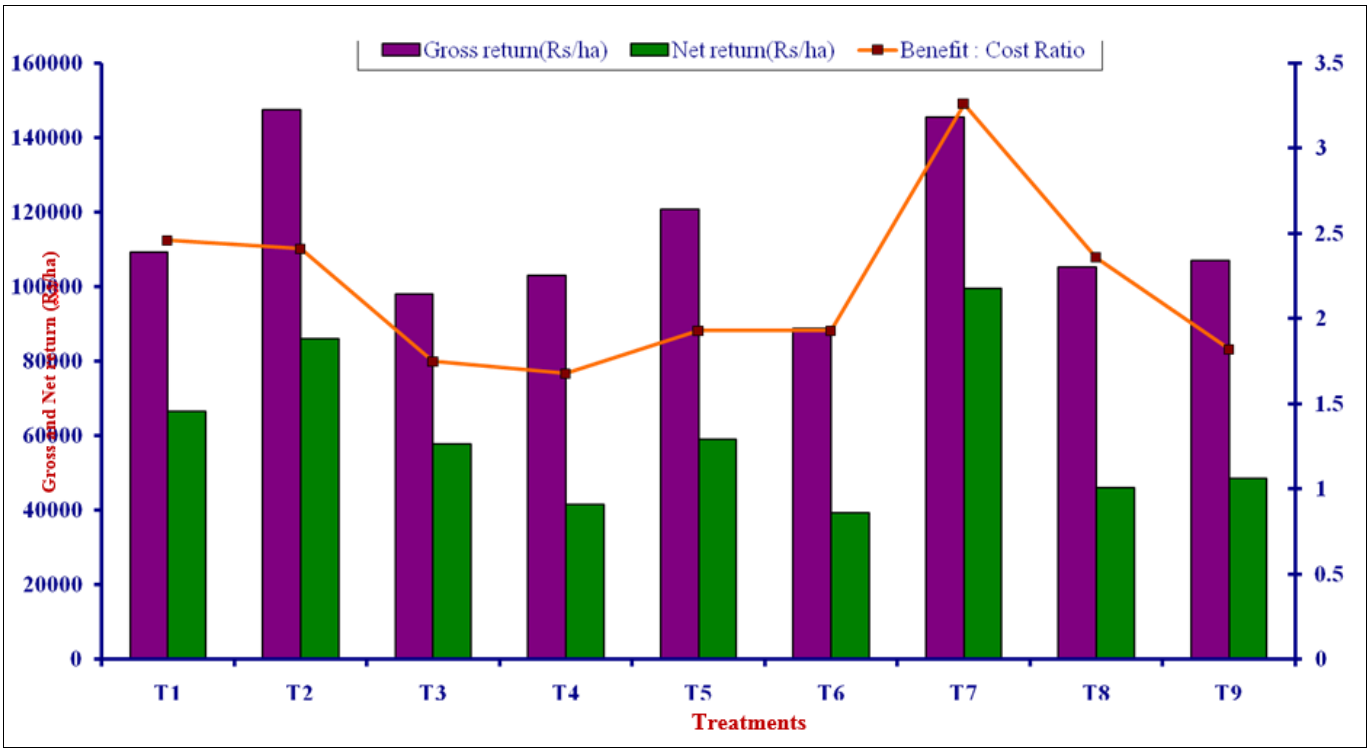

Fig 1: Economics of different cropping sequences during 2010-11 and 2011-12.

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