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Udit Kumar
Department of Horticulture, PG College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

BM Sinha
Department of Horticulture, PG College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

LM Yadav
Department of Horticulture, PG College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Correspondence
Udit Kumar
Department of Horticulture, PG College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

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Standardization of vegetable-based cropping sequence under naturally ventilated polyhouse in subtropical-sub-humid region of eastern India

Udit Kumar, BM Sinha and LM Yadav

Abstract
The field experiment was conducted during 2016-18 at Hi-Tech Horticulture Unit at RPCAU, Pusa, Samastipur. The experiment was conducted in naturally ventilated polyhouse to determine the best cropping sequence to ensure round-the-year production and profitability of vegetables. The experimental design was randomized complete block design with 6 cropping sequence treatments and 4 replications. The 6 cropping sequences were; CS1: Tomato – French bean – Cucumber CS2: Capsicum– Brinjal - Cucumber, CS3: Tomato – Okra– Cucumber, CS4: Broccoli – Carrot– Cucumber CS5: Tomato – Cowpea – Green onion, CS6: Cucumber – Tomato – Bitter gourd. Significantly highest production (1009.00 kg/100m2/year) and production efficiency (2.76 kg/100m2/year) were recorded in the CS2; Capsicum– Brinjal - Cucumber, which was at par with CS3; Tomato– Okra – Cucumber with total production of 975.98 kg/100m2/year and production efficiency 2.67 kg/100m2/year, whereas, CS5: Tomato– Cowpea– Green onion gave the lowest cumulative yield (804.99 kg/100m2/year) and production efficiency (2.65 kg/q/day). Capsicum– Brinjal - Cucumber sequence gave significantly highest net return (Rs. 11508.85 /100m2/year) over all other cropping sequences. Benefit: cost ratio was highest (3.53) in Capsicum– Brinjal - Cucumber (CS2) followed by tomato – French bean – bottle gourd (CS1), whereas minimum BCR (2.36) was recorded in Broccoli– Carrot– Cucumber sequence (CS4). Hence under naturally ventilated polyhouse condition Capsicum– Brinjal - Cucumber cropping sequence was adjudged the most productive and profitable, which deserves adoption by farmers of Sub tropical sub humid eastern part of India.

Keywords: cropping sequence, polyhouse, production potential, profitability

Introduction

The development of naturally ventilated polyhouse provide an excellent opportunity in agriculture by virtue of maintaining congenial growing environment to produce high quality vegetables and assured regular supply during off season. Its large-scale adoption could lead to enough production for both domestic as well as export market. Thus for increasing the production and profitability of vegetables farming, naturally ventilated polyhouse cultivation provides an option for better utilization of land in order to increase the vegetable production per unit area and time (Chandra *et al*. 2003) [1]. To harness the maximum benefits of the naturally ventilated polyhouse technology for increasing the vegetable production, the proper cropping sequences play an important role in utilizing the available space inside the naturally ventilated polyhouse in the best possible way (Sharma, 2016) [8]. In the era of market-driven production system, suitable cropping sequence of high value vegetables is the most important aspect to get more benefit per unit of area. However weather extremities limit the production potential and in turn profitability. Protected cultivation of vegetables is a vital tool to cultivate vegetables even during weather extremities. Moreover a viable cropping sequence will play significant role in making farming more profitable particularly for small and marginal farmers (Srivastava *et al*. 2002, Singh *et al*. 2017a; Singh *et al*. 2017b; Singh *et al*. 2017c; Singh *et al*. 2018; Tiwari *et al*. 2018; Tiwari *et al*. 2019a; Tiwari *et al*. 2019b; Kour *et al*. 2019; Singh *et al*. 2019) [19, 9-17]. Therefore, the present investigation was under taken to determine the best cropping sequence to ensure round-the-year production and profitability of vegetables.

Materials and methods

The field experiment was conducted during 2016-18 at Hi-Tech Horticulture Unit, (25.98^0 N latitude and 85.68^0 E longitudes with an altitude of 52.0 m above MSL) of RPCAU, Pusa, Samastipur. The experiment was conducted in naturally ventilated polyhouse (Quonset-shape, orientation North-South, UV stabilized film was used as glazing material) made of GI pipes in an area of 500 m2. The maximum temperature was reported during May - June (average 36.6 °C) and minimum temperature during December-January (average 7.9 °C), respectively. During summer (May - August) side curtain was raised for cross ventilation of fresh air and to maintain polyhouse ambient temperature. There was no top ventilation in polyhouse because of Quonset shape. The soil of the experimental field is deep and comes under the soil order *Entisols*. It is loamy sand in texture, whitish-brown in color and alkaline in reaction due to presence of excess (23.62 %) free $CaCO_3$ in surface soil. At the time of field preparation surface soil samples (0-0.15m) were taken and processed for the analysis of the initial soil properties in laboratory. The pH of the experimental field was 7.94 to 8.12, EC 0.46 to 0.53 dSm^{-1}, CEC (c mol (p+) kg^{-1}) 11.26 to 13.14 and organic carbon was 0.36%. The N statuses of the experimental field were low (184 to 206 kg ha^{-1}), low in available P (18.40 to 20.14 kg ha^{-1}) and medium in available K status (143.2 to 157.4 kg ha^{-1}). The experimental design was randomized complete block design with 6 cropping sequence treatments and 4 replications. The 6 cropping sequences were; CS1: Tomato (*Solanum lycopersicum* L.) – Frenchbean (*Phaseolus vulgaris* L.) – Cucumber (*Cucumis sativus* L.) CS2: Capsicum (*Capsicum annum* L.) – Brinjal (*Solanum melongena* L) - Cucumber (*Cucumis sativus* L.), CS3: Tomato (*Solanum lycopersicum* L.) – Okra (*Abelmoschus esculentus*) – Cucumber (*Cucumis sativus* L.), CS4: Broccoli (*Brassica oleracea* var. *italic* L.) – Carrot (*Dacus carota* L)– Cucumber(*Cucumis sativus* L.) CS5: Tomato (*Solanum lycopersicum* L.) – Cowpea (*Vigna unguiculata* (L.) Walp) – Green onion (*Allium cepa* L.), CS6: Cucumber (*Cucumis sativus* L.) – Tomato (*Solanum lycopersicum* L.) – Bitter gourd (*Momordica charantia* L.). Varieties selected for experimentation were Himsona (tomato), Bhima Super (green onion), Pant Sankar Lauki-1 (bottle gourd), Indra (capsicum), Swarna Lata (French bean), Pusa Kesar (carrot), Swarna Yamini (bitter gourd), Everest (broccoli) and Tasty (cucumber). Recommended fertilizers doses were given to each crop as per schedule. The seedlings for the experimentation were raised inside polyhouse. The first crop of the cropping sequence was transplanted during September. Recommended package of practices were followed for raising the crops.

Result and Discussions

Crop yield and production efficiency of cropping sequences in polyhouse (Table 1) showed significant difference. Tomato, cucumber, brinjal and green onion were the major determinants for yield, whereas French bean and cowpea had the minimum yield potential. Under polyhouse, the significantly highest production (1009.00 kg/100m2/year) and production efficiency (2.76 kg/100m2/year) were recorded in the CS2; Capsicum– Brinjal - Cucumber, which was at par with CS3; Tomato– Okra – Cucumber with total production of 975.98 kg/100m2/year and production efficiency 2.67 kg/100m2/year, whereas, CS5: Tomato– Cowpea– Green onion gave the lowest cumulative yield (804.99 kg/100m2/year) and production efficiency (2.21 kg/100m2/year). The findings on enhanced production under protected condition are in agreement with Singh *et al*. (2011) [18] Cheema *et al*. (2004) [2] and Kumar and Chandra (2014) [6] who recorded higher yield of vegetables under protected condition. The highest production efficiency in CS2; Capsicum– Brinjal - Cucumber sequence followed by CS3; Tomato– Okra – Cucumber were mainly due to high tonnage of Capsicum, Brinjal and cucumber in CS2 and Tomato, Okra and Cucumber whereas, low yield potential of cowpea, resulted lowest production efficiency in CS5: Tomato– Cowpea– Green onion sequence (Table 1). Kishore *et al.* 2014 [3] also reported that under protected condition, tomato - pea- carrot - cucumber gave the maximum production, production efficiency.

Capsicum– Brinjal - Cucumber sequence gave significantly highest net return (Rs. 11508.85 /100m2/year)) over all other cropping sequences (Table 2). It was followed by CS3; Tomato– Okra – Cucumber sequence which gave Rs. 8207.76 /100m2/year net returns. The lowest net returns Rs. 6405.85 per hectare were obtained in Tomato– Cowpea– Green onion sequence. Benefit: cost ratio an important indicator of profitability with respect to production cost. Benefit : cost ratio was highest (3.53) in Capsicum– Brinjal - Cucumber (CS2) followed by tomato – French bean – bottle gourd (CS1), whereas minimum BCR (2.36) was recorded in Broccoli– Carrot– Cucumber sequence (CS4), however B: C ratio showed variation with respect to total production and production efficiency.

Results clearly indicated the variation in the cost of cultivation with crop and Cropping sequence with tomato or capsicum increased the cost of cultivation due to seed cost, while in other cases cost of cultivation was relatively less. When day-wise profitability was worked out, it was observed that this parameter followed the trends of BCR with the highest (Rs 31.53/ 100 m2/day) in Capsicum– Brinjal - Cucumber (CS2) and lowest (Rs 17.55/100 m2/day) in Tomato– Cowpea– Green onion sequence (CS5). The highest return showed variation with year due to the difference in market price, yield and cost of cultivation. Date clearly indicated significant influence of cropping sequence on profitability (Table 2). Kumar *et al*. (2009b) evaluated the cropping sequences of vegetables inside polyhouse in the hills of north-western Himalayan region and reported that capsicum – tomato – spinach sequence gave the highest net return and BCR; however, maximum production efficiency was found in squash - french bean – tomato – spinach sequence. Parvej *et al*. (2010) [7] reported high number of flowers, fruit size, fruit weight and fruit yield/plant of tomato inside polyhouse. Similarly Singh *et al*. (2011) [18], obtained higher return of sweet pepper under polyhouse with minimal problem of bacterial wilt and blossom end rot.

Table 1: Yield and production efficiency of vegetable-based cropping sequence under naturally ventilated polyhouse (poled data of 2016-17 and 2017-18)

Cropping sequence	Mean yield (kg/100 m2)			Total production (kg/100m^2/year)	Production efficiency (kg/100m^2/day)
CS1	Tomato (380.24)	French bean (101.49)	Bottle gourd (438.47)	920.20	2.52
CS2	Capsicum (198.04)	Brinjal (358.65)	Cucumber (452.31)	1009.00	2.76
CS3	Tomato (361.26)	Okra (154.27)	Cucumber (460.45)	975.98	2.67
CS4	Broccoli (316.07)	Carrot (251.26)	Cauliflower (296.98)	864.31	2.37
CS5	Tomato (364.14)	Cowpea (125.64)	Green onion (315.21)	804.99	2.21
CS6	Cucumber (328.98)	Tomato (276.87)	Bitter gourd (287.45)	893.30	2.44
CD (0.05)	6.48	8.36	9.41	32.12	0.17

Table 2: Economics of vegetables based cropping sequences under naturally ventilated polyhouse (poled data of poled data of 2016-17 and 2017-18)

Cropping sequence	Cost of cultivation (Rs /100m2/year)	Gross return* (Rs/100m2/year)	Net return (Rs /100m2/year)	B:C ratio	Profitability (Rs/100m2/day)
CS1	2354.47	9962.48	7608.01	3.23	20.84
CS2	3259.25	14768.1	11508.85	3.53	31.53
CS3	2874.56	11082.32	8207.76	2.86	22.49
CS4	3045.87	10223.45	7177.58	2.36	19.66
CS5	2121.05	8526.9	6405.85	3.02	17.55
CS6	2587.26	10541.64	7954.38	3.07	21.79
	84.67	102.35	943.24	0.31	1.92

*Local market price (`Rs/q) tomato` 1200, French bean 1000` Bottle gourd- 1000, capsicum` 3000, cucumber 1000, bitter gourd` 1000, carrot` 1000, broccoli` 2000, Brinjal 1200, Okra- 1000, Cauliflower-1500, Cowpea-800, Green oion-1000

Conclusion

Under naturally ventilated polyhouse condition, Capsicum–Brinjal - Cucumber gave the maximum production (1009.00 kg/100m^2/year), production efficiency (2.76 kg/100m^2/year), net return (Rs 11508.85 /100m^2), BCR (3.53) and profitability (Rs 31.53/100m^2/day). Capsicum, brinjal and cucumber were major determinants for production and profitability. Hence Capsicum– Brinjal- Cucumber cropping sequence was adjudged the most productive and profitable, which deserves adoption by farmers of Sub tropical sub humid eastern part of India.

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