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Economic analysis of sweet pepper-garden pea cropping sequence as influenced by NPK and micronutrients through fertigation under polyhouse conditions

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Sweet pepper (*Capsicum annuum* L.) is one of the most important vegetable and has attained a status of high value crop in India. It is used both as salad and culinary purposes and is highly praised worldwide for its flavour, aroma and colour and is rich in vitamin A and C and has adequate levels of essential minerals like iron, copper, zinc, manganese and selenium. It is also an excellent source of antioxidants and anti-inflammatory, phytonutrients and carotenoids. Due to its versatile use and high nutritional value, it is cultivated in most parts of the world especially in temperate regions of Central and South America, Europe, tropical and subtropical areas of Asia mainly in India and China. In India, it is grown over an area of about 24 thousand hectares with a production of 326 thousand metric tonnes while in state of Jammu and Kashmir, it occupies an area of 1.05 thousand hectares with a production of 23.16 thousand tonnes (Horticultural Statistics 2018). Sweet pepper although mainly a tropical crop, requires moderate temperature for obtaining good growth, high yields and quality. Under open field conditions, due to erratic temperature and moisture, the growth, quality as well as yield of sweet pepper gets severely affected. Moreover, judicious use of chemical fertilizers with ideal cropping sequence is an effective alternative for increasing the productivity. Although, many cropping sequences are being practiced optimizing the cropping system but the inclusion of legumes in sequence lead to improvement in soil biochemical and physical properties. After the harvest of main crop sweet pepper (first crop), the second crop garden pea which is a legume can be a best option during *rabi* under protected conditions to utilize the structure and generate additional revenue and make available green pods during the early spring as offseason crop. Thus, a sweet pepper-garden pea cropping sequence seems to be a good option through fertigation of required nutrients for optimum nourishment with minimum nutrient losses and for achieving better yields with higher productivity.

The experiment was conducted under naturally ventilated polyhouse at Vegetable Experimental Farm, Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J&K, India. The soil of experimental site was well drained, deep and loamy comprising of 51.26% sand, 34.94% silt and 13.8% clay. The soil reaction was slightly alkaline with a pH of 7.8 and EC of 0.16dsm^{-1}with a bulk density of 1.33g cm^{-3}. Two genotypes of sweet pepper namely cv. Nishat-1 and hybrid Shalimar Capsicum Hybrid-2 (SCH-2) were simultaneously evaluated under Gothic type polyhouse during May to October. The residual crop garden pea was directly sown on third week of December on same experimental plots after harvesting of sweet pepper. The experimental plot was thoroughly ploughed and leveled and divided into two blocks, each block consisted of three sub blocks which in turn were divided into seven equal plots of size 1.50 × 1.25 m^2 totaling 21 plots per block. The experiment was laid out in randomized complete block design (RCBD) with three replications and seven treatments viz., T_1(control) i.e. soil application of N,P,K (100% recommended dose of fertilizers (RDF i.e. 120:90:30 NPK kgha^{-1} for cv.Nishat-1 and 150:120:60 NPK kgha^{-1}for hybrid SCH-2); T_2 (75 % RDF through fertigation) ; T_3(100 % RDF through fertigation); T_4 (125 % RDF through fertigation);T_5 (75 % RDF + 75% recommended dose of micronutrients (RDM i.e. 0.5% (5ml/l) of micronutrient mixture through fertigation); T_6 (100 % RDF + 100 % RDM through fertigation); T_7

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Table 1: Economic analysis of sweet pepper cv. Nishat-1-garden pea cropping sequence

Treatments	Plant growth (Ht. in cm)	Fruit yield (g plant^{-1})	Total Fixed cost of cropping sequence	Total variable cost of cropping sequence	Total cost of cultivation (TFC+TVC)	CEYha^{-1} (tonnes)	Gross return lakh Rs. ha^{-1}/(Gross returns in Rs./ 100m^2)	Net return lakh Rs. ha^{-1}/Net returns in Rs./100m^2)	B:C
T_1	72.07	344.40	27,40,28.23	75,81,8.16	34,984,6.4	31.68	9.50 (95,04.85)	6.00 (60,06.39)	1.72
T_2	83.57	713.20	27,40,28.23	75,20,9.56	34,92,37.8	53.57	16.07 (16,072.71)	12.58 (12,580.3)	3.60
T_3	90.86	783.50	27,40,28.23	76,88,7.81	35,09,16	64.18	19.25 (19,255.29)	15.74 (15,746.1)	4.49
T_4	97.62	604.90	27,40,28.23	78,563.58	35,25,91.8	55.63	16.68 (16,689.86)	13.16 (13,163.9)	3.73
T_5	102.01	1258.6	27,40,28.23	75,948.16	34,99,76.4	86.99	26.09 (26,098.71)	22.59 (22,598.9)	6.46
T_6	113.24	1157.7	27,40,28.23	77,888.58	35,19,16.8	86.83	26.04 (26,049.86)	22.53 (22,530.7)	6.40
T_7	118.82	1087.2	27,40,28.23	79,815.94	35,38,44.2	83.30	24.99 (24,990.86)	21.45 (21,452.4)	6.06

Table 2: Economic analysis of sweet pepper hybrid SCH-2-garden pea cropping sequence

Treatments	Plant growth (cm)	Fruit yield (g plant^{-1})	Total Fixed cost of cropping sequence	Total variable cost of cropping sequence	Total cost of cultivation (TFC+TVC)	CEY ha^{-1} (tonnes)	Gross return lakh Rs. ha^{-1} (Gross returns in Rs./ 100m^2)	Net return lakh Rs. ha^{-1}/Net returns in Rs./100m^2)	B:C
T_1	74.78	429.60	27,40,28.23	79,049.88	35,30,78.1	40.82	12.24 (12,246.0)	8.71 (8,715.21)	2.46
T_2	85.75	787.40	27,40,28.23	78,441.28	35,24,69.5	62.37	18.71 (18,712.29)	15.18 (15,187.59)	4.30
T_3	94.33	930.80	27,40,28.23	80,119.53	35,41,47.8	77.46	23.23 (23,238.86)	19.69 (19,697.38)	5.56
T_4	99.41	729.00	27,40,28.23	81,795.3	35,58,23.5	67.34	20.20 (20,204.14)	16.64 (16,645.91)	4.67
T_5	104.70	1482.3	27,40,28.23	79,179.88	35,32,08.1	100.96	30.28 (30,288.86)	26.75 (26,756.78)	7.57
T_6	115.00	1315.9	27,40,28.23	81,120.3	35,51,48.5	100.20	30.06 (30,069.00)	26.51 (26,517.51)	7.46
T_7	121.00	1087.8	27,40,28.23	83,047.66	35,70,75.9	91.78	27.53 (27,534.43)	23.96 (23,963.67)	6.71

(125 % RDF + 125 % RDM through fertigation). These seven treatments were taken separately for both the cultivars. Fertigation was carried out using water soluble fertilizers *viz*., Urea, SSP and MOP and micronutrient mixture (Agromin consisting of Cu, Mn, B, Zn, Mo) as per treatments. First dose was given after one month of transplanting, second dose after fifteen days of first dose and third and other remaining doses at an interval of ten days. To test the significance of treatments and calculating critical difference (CD), the experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984). Levels of significance used for 'F' and 't' tests were p=0.05 as given by Fisher (1970). Capsicum equivalent yield was found to make comparison between the two crops based on economic returns and was given by the formula as: CEY= Yield of main crop (capsicum) + Yield of second crop (garden pea) * Sale Price of garden pea/Sale price of capsicum. The economics of different cultural practices, inputs and returns for sweet pepper and garden pea under each treatment combination was worked out to find the most effective and economical treatment.

Water and nutrients are vital resource inputs and have now become scarce and costly. Their uniform application through drip irrigation system is therefore necessary for optimizing their requirements particularly for high value crops like sweet pepper and garden pea for harvesting best quality and yields especially when they are grown under protected conditions. Perusal of final economic analysis of sweet pepper-garden pea cropping sequence revealed that capsicum equivalent yield (CEY ha^{-1}) per hectare was the highest (86.99 and 100.96 t ha^{-1}) with fertigation treatment T_5 (75 % RDF + 75% recommended dose of micronutrients (RDM i.e. 0.5% (5ml/l) of micronutrient mixture through fertigation) followed by treatment T_6 (86.83 and 100.23 t ha^{-1}) while it was the lowest in treatment T_1 (31.68 and 40.82 t ha^{-1}). The maximum gross return of Rs. 26,098.71/100 m^2, 26.09 lakh ha^{-1} and 30,288.86/100m^2, 30.29 lakh ha^{-1} yr^{-1}was obtained from the treatment T_5 (75% RDF+ 75% RDM) with highest net returns of Rs. 22,598.90/100 m^2, 22.59 lakh ha^{-1} and Rs. 26,756.78/100 m^2, 26.75 lakh ha^{-1} yr^{-1} in sweet pepper cultivar/hybrid-garden pea cropping sequence. Maximum B:C ratio of 6.46 and 7.57 for every rupee spent was also recorded with treatment T_5 in sweet pepper cultivar/hybrid-garden pea cropping sequence respectively. Maximum net returns under treatment $T_5$was due to the adequate supply of water and nutrients to the plants that maintained the nutrient balance at optimum levels eliminating stress to the plants throughout the growth period while inadequate amount of available nutrients during crop growth as in control T_1 probably hampering various physiological processes resulting in lower absolute growth rate (mg dry matter produced/unit time) and crop yields. The soil applied nutrients are not sufficient to meet the later stage demands due to reduction in their quantity by way of leaching or fixing of nutrients in the soil.In treatments T_6 and T_7 the higher nutrient doses especially N have resulted in more vegetative growth which ultimately reduces the economic yield. Badra and Yazied (2007) working with tomato also showed similar results where application of excessive rates negatively affected the yield and its components. Brahma *et al.* (2010) and Karuthamani *et al.* (2018) indicated enhanced vegetative growth parameters with incremental increase in nitrogen application. Also, Sabli (2012) showed through his experimentation on bell pepper that excessive irrigation and fertigation caused several ill effects on the growing environment that markedly affects plant yield, fruit quality and further added to the cost of production. Higher availability of both macro and microelements at regular intervals in root zone of fertigated treatments having synergetic effect probably also improved the availability of native as well as applied nutrients. Thus, better synchronization of nutrient supply as per nutrient demand is very important for efficient use of fertilizers. The increased nutrient uptake might have stimulated various physiological processes in plant leading to increased growth and yield attributing characteristics and subsequent cumulative effect resulting in enhanced productivity thereby leading to higher profits as exhibited by plants in treatment T_5. Similar such results were also reported by Choudhary et al. (2011) in fenugreek-pearl millet cropping sequence.

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