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AGRONOMY

Yield sustainability and chemical fertilizer economy through IPNS in capsicum (*Capsicum Annum* L. Var. *grossum*) under dry temperate condition of Himachal Pradesh

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ABSTRACT

A field experiment to evaluate the effect of five organic sources of plant nutrients and three fertility levels on productivity and economics of tomato was conducted during *Kharif* seasons of 2006 and 2007 under dry temperate region of HAREC, Kukumseri (L&S), Himachal Pradesh. Among organic sources, application of FYM @ 5 t/ha has recorded the higher values for all yield attributes except No. of branches/plant and was followed by FYM @ 2.5 t/ha + *Azotobacter*. However both these treatments were significantly at par with each other in recording significantly more No. of branches/plant, higher yield and productivity. Significantly higher economic efficiency of Rs. 1567.6 was achieved with the application of FYM @ 2.5 t/ha + *Azotobacter* and was followed by FYM @ 5 t/ha (1567.6 Rs./ha/day). Increase in the level of NPK has significant influence on yield, productivity and economic efficiency. Significantly higher values of different yield attributes were recorded with the application of 150% NPK which was reflected in getting significantly higher capsicum yield (190.0 q/ha) and productivity (1.04 q/ha/day) with greater economic efficiency of 1766.7 Rs./ha/day.

Highlights

- Cultivation of sweet pepper in dry temperate area of Lahaul and Spiti (H.P.) is a new venture as an off-season crop.
- Being a newly introduced crop there is a need to develop agronomic practices particularly its nutrient requirement in integrated manner which will prove to be remunerative cash crop for the farmers of this region.

Keywords: Capsicum, FYM, PSB, Azotobacter, profitability, productivity

Sweet pepper (Capsicum annuum L. var. grossum) is commercially grown as a summer crop (April- June) in almost all parts of the country as well as in mid and low hill of Himachal Pradesh. The crop in these areas is almost over by the end of June. Whereas, in dry temperate conditions of Himachal Pradesh it is a new introduction and has an advantage of being an off season vegetable crop as the availability of its fruits is at such a time when there is no other source of its availability from other parts of India and Himachal Pradesh. However, farmers of this area grow pea as off season vegetable crop for table purpose and potato for seed purpose. But, in recent years with upcoming of diseases in pea and reduced market of seed potato the need has been felt for alternative high value cash crops in the region. Sweet pepper being a highly remunerative off season cash crop could prove to be a viable alternative. Sweet pepper is considered an excellent source of bioactive nutrients. Ascorbic acid (vitamin C), carotenoids and phenolic compounds are its main antioxidant constituents (Marin *et al.*, 2004). It has also other medicinal properties and hence recommended for the treatment of dropsy, colic, toothache and cholera (Bose *et al.*, 2003). The concentration of quality compounds in peppers and other vegetables depend on several factors including cultivar, agricultural practices and growing conditions (Lee and Kader 2000. Cultivation of sweet pepper in dry temperate areas is a new venture and being a newly introduced crop, there is a need to develop agronomic practices particularly its nutrient requirement in these areas. Nutrient balance and sub optimal use of nutrients to any crop may lead to depletion of nutrient reservoir of soils leading to multiple nutrient deficiencies. Injudicious use of high analysis fertilizers can further aggravate the secondary and micronutrient deficiencies causing a significant decline in crop productivity. Application of essential nutrient elements from a single source, be it chemical fertilizer, organic manure or biofertilizers can not meet the requirement of any crop. Rather nutrients have to be supplied from organic, inorganic and biofertilizer sources in an integrated manner and in balanced amounts, following appropriate management technology which is economically viable, socially acceptable and ecologically friendly (Grant *et al.*, 2008). Since, no such systematic study has so far been undertaken in high hills (Zone-IV), where the conditions were quite different than from lower zones of H.P., the present investigation was undertaken to study the influence of INM on production and economics of capsicum.

Materials and Methods

Experiment consisting of fifteen treatment combinations of five organic sources of plant nutrients *viz.* FYM @ 5 t/ha (Oven dry weight basis), *Azotobacter* (strain A-HP-1(Kangra)) (@200g/10 kg seed), Phosphate Solubilizing Bacteria (Indigenous strain from Kangra) (@200g/10 kg seed), FYM @ 2.5 t/ha + *Azotobacter* and FYM @ 2.5 t/ha + Phosphate Solubilizing Bacteria and three fertility levels *viz.* 50, 100 and 150 per cent of the recommended (90:75:55 kg/ha) NPK were laid out in Split-plot design with three replications. The nursery was raised under poly house conditions. Field experiment was conducted at Highland Agricultural Research and Extension Centre, Kukumseri (2772 m amsl), Lahaul and Spiti during *kharif* seasons of 2007 and 2008. The soil was sandy loam in texture and neutral in reaction (pH 6.9). The initial soil contained 2.4% organic carbon, available nitrogen 260 kg/ha, phosphorus 51.3 kg/ha and potassium 174 kg/ha, respectively. The Capsicum crop (var. California wonder) was transplanted on June 11 and May 15 during 2006 and 2007 respectively, using 45 x 30 cm spacing. The plot size was 1.5 X 1.8 = 2.7 m^2 during both the years of study. Half dose of N and full doses of P and K were applied at the time of sowing and remaining half after one month of transplanting. Weed control was done using pendimethalin @ 1.2 kg *a.i.*/ha within 48 hrs. of transplanting. Crop was irrigated as and when required using sprinkler system. The data of two years (2006 and 2007) were pooled. Plant height (cm) and No. of branches/plant were recorded before first picking. Number of fruits/plant, fruit weight (g), fruit weight/ plant (g), fruit diameter (cm^2) were recorded at the time of picking. Economics was calculated on the basis of prevalent market prices of inputs and outputs. Productivity and profitability was worked out by dividing the yield and net returns, respectively with the duration of crop in particular treatment.

Results and Discussion

A. Productivity

(a) Effect of organic and bio-fertilizers

The pooled data of productivity parameters depicted in Table 1 revealed that the entire yield attributes

Table 1. Effect of organic/bio-fertilizers and NPK levels on yield attributes of capsicum (Pooled data of two years)

Treatment	Plant ht. (cm)	No. of branches/ plant	No. of fruits/Plant	Fruit weight plant (g)	Fruit weight (g)	Fruit dia. (cm)
Organic/bio-fertilizers						
FYM @ 5 t/ha	43.6	2.7	7.8	372.9	62.6	54.1
Azotobacter	41.9	2.7	7.4	348.7	58.4	44.9
PSB	37.6	2.5	6.5	304.4	55.6	41.4
FYM @ 2.5 t/ha + *Azotobacter*	43.7	2.8	7.3	354.3	61.5	52.3
FYM @ 2.5 t/ha +PSB	40.6	2.5	7.0	318.6	59.8	43.7
CD (P=0.05)	0.25	0.17	0.12	9.04	0.51	0.55
NPK-Levels						
50%	38.1	2.5	6.5	302.1	54.2	42.3
100%	41.8	2.6	7.3	345.7	59.3	47.6
150%	44.6	2.8	7.8	371.5	65.3	51.9
CD (P=0.05)	0.35	0.14	0.13	5.02	0.64	0.43

dia.-Diameter, FYM-Farm Yard Manure, PSB-Phosphate Solubilizing Bacteria, 100%-recommended dose

were significantly influenced with the application of organic and bio-fertilizers. Application of FYM @ 5 t/ha though remained statistically at par with FYM @ 2.5 t/ha + *Azotobacter* in case of plant height of capsicum but was found superior to all other treatments in case of other yield attributes and was followed by FYM @ 2.5 t/ha + *Azotobacter* corrected statement remained statistically at par with the application of *Azotobacter* when compared for number of fruits per plant and fruit weight per plant but significantly superior to *Azotobacter* with respect to observations on fruit weight and fruit diameter.

The influence of FYM @ 5 t/ha and FYM @ 2.5 t/ha + *Azotobacter* on yield contributing characters has been reflected on the yield and productivity of capsicum (Tab 1 and 2). Application of FYM @ 2.5 t/ha + *Azotobacter* resulted in significantly higher yield of capsicum (175.2 q/ha). This treatment remained statistically at par with FYM @ 5 t/ha but significantly superior to all other treatments under study. Similarly, productivity was significantly higher with the application of FYM @ 2.5 t/ha + *Azotobacter* and FYM @ 5 t/ha (0.96 and 0.95 q/ha/day, respectively). These two treatments were followed by the treatment having *Azotobacter* which remained significantly superior to all other treatments for higher yield and productivity. With the application of FYM @ 2.5 t/ha along with *Azotobacter* could increase the yield up to 5.86% over *Azotobacter* alone. The beneficial effect of combined use of organic manure (FYM) and biofertilizer (*Azotobacter*) on yield attributes of capsicum could be attributed to the fact that after proper decomposition and mineralization, FYM improves soil physical and biological environment, supply available nutrients directly to the plant. In addition, *Azotobacter* N_2 fixation. synthesize and secrete considerable amounts of biologically active substances like B vitamins, biotin, phytohormones, produce antifungal compounds to fight against many plant pathogens, defense enzyme and siderophores (Kowsar *et al.*, 2014). The cumulative effect of improvement in vegetative growth and yield attributes owing to combined use of organic manure (FYM) and biofertilizer particularly *Azotobacter* resulted in additional improvement in fruit yield of capsicum.

Table 2. Effect of organic/bio-fertilizers and NPK levels on yield and productivity of capsicum

Treatment	Yield (q/ha)			Productivity (q/ha/day)		
	2006	2007	Pooled	2006	2007	Pooled
Organic/bio-fertilizers						
FYM @ 5 t/ha	170.69	177.27	173.98	0.94	0.97	0.95
Azotobacter	161.75	169.28	165.52	0.89	0.93	0.91
PSB	154.64	160.49	157.57	0.85	0.88	0.86
FYM @ 2.5 t/ha + *Azotobacter*	171.43	178.92	175.18	0.94	0.98	0.96
FYM @ 2.5 t/ha +PSB	165.92	168.02	166.97	0.91	0.92	0.92
CD (P=0.05)	6.37	5.95	3.10	0.03	0.03	0.02
NPK-Levels						
50%	128.57	135.24	131.91	0.70	0.74	0.72
100%	178.76	184.50	181.63	0.98	1.01	0.99
150%	187.33	192.65	189.99	1.03	1.06	1.04
CD (P=0.05)	4.94	4.61	3.66	0.03	0.03	0.02

dia.-Diameter, FYM-Farm Yard Manure, PSB-Phosphate Solubilizing Bacteria, 100%-recommended dose

Table 3. Effect of organic/bio-fertilizers and NPK levels on profitability of capsicum (pooled data of two years)

Treatment	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio (Rs.)	Economic efficiency (Rs./ha/day)		
				2006	2007	Pooled
Organic/bio-fertilizers						
FYM @ 5t/ha	347966	286086	5.62	1545.25	1589.94	1567.6
Azotobacter	330997	277417	6.16	1478.61	1651.57	1520.1
PSB	315127	261547	5.87	1401.10	1465.17	1433.1
FYM @ 2.5t/ha+*Azotobacter*	350351	294646	6.27	1576.92	1652.09	1614.5
FYM @ 2.5t/ha+PSB	333941	278236	5.98	1516.46	1532.71	1524.6
CD (P=0.05)	6208	6205	0.11	69.88	65.17	34.03
NPK-Levels						
50%	263815	209187	4.84	1113.76	1178.69	1146.2
100%	363233	307144	6.49	1655.50	1710.46	1683.0
150%	379981	322429	6.61	1741.74	1791.73	1766.7
CD (P=0.05)	7323	7324	0.13	54.13	50.48	40.13

dia.-Diameter, FYM-Farm Yard Manure, PSB-Phosphate Solubilizing Bacteria, 100%-recommended dose

(b) Effect of NPK levels

Capsicum crop responded up to 150% NPK application. All the contributing characters *viz.* plant height, number of branches per plant, number of fruits per plant, fruit weight per plant, fruit weight and fruit diameter were significantly higher with the application of 150% NPK (Table 1). Application of recommended NPK followed it and was found significantly superior to 50% NPK. Similarly, the yield and productivity followed the same trend as that for yield attributes. Significantly highest yield (190.0 q/ha) was observed with 150% NPK levels followed by 100% NPK (181.6 q/ha) (Tab 1&2). Doikova *et al.*, (1984) also reported that increasing levels of N,P and K increased both the vegetative growth and fruit yield of capsicum and highest fruit yield was obtained with the highest level of NPK used. Productivity was also significantly highest with 150% NPK (1.04 q/ha/day).

The improvement in yield attributes and yield with increasing doses of NPK may be ascribed to the fact that these nutrients being important constituents of nucleotides, protein, chlorophyll and enzymes, involve in various metabolic processes, which have direct impact on vegetative and reproductive phases of plants. These results are in conformity with those of Shivaprasad *et al.*, (2010) with 150% NPK and Patil and Birader (2002) with 200% NPK for recording highest yield over others levels of inorganic fertilization in chilli.

B. Profitability

(a) Effect of organic and bio-fertilizers

Application of FYM @ 2.5 t/ha + Azotobacter being at par with FYM @ 5t/ha has recorded significantly higher gross returns of Rs. and value 350351 and 347966/ha, respectively. However, treatment receiving FYM 2.5t/ha along with *Azotobacter* has recorded significantly highest values of net returns and economic efficiency than all other treatments and was at par with *Azotobacter* alone for higher B:C ratio (Table 3).

(b) Effect of NPK levels

Increasing the dose of NPK from 100 to 150% significantly increased the gross returns, net returns, economic efficiency and B: C ratio. Gross returns of Rs. and value 379981/ha and net returns of Rs. 322429/ha were obtained with the application of 150% NPK, which were 4.61 and 4.98% higher compared to 100% NPK levels. This was due to significantly higher production of produce. Similarly, economic efficiency of Rs. 1766.7/ha/day was obtained with 150% NPK doses which was 4.97% higher compared to 100% NPK doses. In case of B: C ratio, 150% NPK remained statistically at par with 100% but both were significantly superior than 50% NPK (Table 3). Similar results were reported by Mishra *et al.*, (2004) at Karnataka in tomato and Rana *et al.*, (2009) in pea at high hill dry temperate conditions of H.P.

Conclusion

Under dry temperate conditions of Himachal Pradesh, application of FYM @ 2.5 t/ha + *Azotobacter* and 50% higher NPK than recommended level (*i.e.* 150% NPK) as organic and inorganic sources, respectively resulted in attaining significantly higher yield, productivity with higher economic efficiency in Capsicum.

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