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Evaluation and validation of IPM technology for bell pepper (*Capsicum annuum* var. *frutescens* L.) through farmers' participatory approach in mid Garhwal hills of Uttarakhand

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ABSTRACT

Field experiments were conducted to evaluate the formulated IPM programme for the management of insect-pests and diseases in bell pepper (capsicum) in Jadipani village of Chamba block in Tehri Garhwal district (Uttarakhand). Comparative study indicated that IPM module was found to be very effective in terms of suppression of pest infestation and increase in yield over non-IPM. It was found that there was 61.30, 66.98 and 42.99 per cent control of white-grub, cut worm, thrips, respectively, in IPM practiced field as compared to non-IPM practice, respectively. Similarly, 72.27, 53.71 and 49.22 per cent control of damping-off, *Colletotrichum* leaf spot and *Phytophthora* fruit rot, respectively, was recorded in IPM practiced field. Analysis of cost benefit ratio of IPM practice revealed that there was 38.64 per cent increase in yield with net return of Rs. 51.87 thousand per hectare and a B:C ratio of 1.46 over farmers' practice. Over all study revealed that the capsicum production under IPM situation proved comparatively more economically viable in terms of suppression of pest which resulted in increase of yield.

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INTRODUCTION

Bell pepper or sweet pepper (*Capsicum annuum* var. *frutescens* L.), is the most popular, widely grown and highly remunerative vegetable all over the country. Its total acreage in India during 2013-14 was 29.72

thousand hectare with a production of 9.04 million tons (Anonymous, 2014). It is one of the major vegetable crops grown in mid hills of Uttarakhand. However, due to its tender and supple nature with condition to grow under high moisture and input regimes, it is more prone to pest attack. Several pests *viz.*, thrips (*Scirtothrips dorsalis*) (Krishna Kumar *et al.*, 1996), whitefly (*Bemisia tabaci*), aphids (*Myzus persicae*), broad mites (*Polyphatarsonemus latus*), fruit borer (*Helicoverpa armigera*), tobacco caterpillar (*Spodoptera litura*), white-grub (*Holotrichia longipennis*), cutworm (*Agrotis ypsilon*), *Phytophthora* leaf blight/fruit rot (*Phytophthora capsici*), virus mosaic complex, bacterial leaf blight (*Xanthomonas campestris* pv. *vesicatoria*) and disorder like sun scald hamper the growth and production of bell pepper. These are the major constraints in getting high bell pepper yields (Sorensen, 2005; Krishna Kumar and Srinivasan, 1994). Quicker control strategy and aim to get higher yields has led indiscriminate use of pesticides for suppression of pest problem. There are many tracking technologies that have shown promising results for management of individual pest problems as stated above but these have neither featured prominently by practicing together to evolve comprehensive management strategy such as IPM nor provide proportionate economic returns (Ahuja *et al*., 2012).

In light of above fact, attempts have been made to integrate the promising technologies into operational IPM programme for management of insect pest and diseases of capsicum in farmer's participatory mode and effectiveness of IPM programme was compared with farmers practices in terms of cast benefit ratio.

MATERIAL AND METHODS

Chopdiyal village (block Chamba) of Tehri Garhwal district, located 10 kms away from Chamba on Chamba – Mussoorie highway, was selected for present study on validation of IPM module against major insect-pests and diseases of capsicum. The area is well known as Chamba-Mussorrie vegetable belt where maximum vegetable surplus goes to state capital *i.e.* Dehradun. A total 15 farmers were selected for validation of IPM module. There were two treatments in each plot *i.e.* (a) IPM module practiced field (Table 1) (b) Conventional system *vis a vis* farmers' practice field (FP or non-IPM). The IPM module was formulated based on existing pest problem in relation to crop phenology and the available control measures against these pests. The synthesized module was sequentially applied in selected fields consecutively for three years *i.e.* 2008-09, 2009-10 and 2010-11. Implementation of IPM technology was initiated through organizing farmer's field schools. Therefore, the most important component in the first year of the project was training of the farmers for development of technical skills. All the growers in the locality were persuaded to

Table A : IPM module for the management of insect-pest and diseases in capsicum

Crop stage	Months	Management particle	Target pest/disease
Pre-sowing	April-May	Well prepared raised beds of 10-15 cm height were applied with value added vermicompost (*Trichoderma harzianum* @250g/q FYM/ vermi-compost) and were covered with transparent plastic sheet 3 weeks prior to sowing for the solarization of soil	White grubs soil borne pathogens damping-off
Sowing	June	Seed treatment with carbendazim 2g/kg seed.	For the management of soil borne diseases
Nursery stage	June-July	One spray of *Pseudomonas* formulation @ 10g/lit. water	Damping-off, Leaf spots etc.
Transplanting	July	Seeding-dip in the suspension of bioagent (*T. harzianum* and *P. fluorescence*) formulations.	Damping-off, root rot complex
Early growth stage	July-Aug	Application of Ridomil MZ @ 2.5g/1it. of water Application of neem based insecticide (neem oil) Azadirachtin 0.03% (300 PPM)	Damping-off, Cutworm, White grub
Late growth stage	Sept-Oct	Application of neem based insecticide (neem oil) Azadirachtin 0.03% (300 PPM) Application of copper fungicide i.e. copper oxychloride 50 WP @ 0.3%	Thrips, Fruit borer, Fruit rot
Harvesting stage	October	Collection and destruction of crop debris	Perpetuating pest

undertake sowing simultaneously to minimize the error that may occur due to difference in timing of the transplanting of the crop and ultimately may be reflected while estimating the yield between IPM trials and conventional practice. Crop was raised under similar agronomic schedule in both IPM and non-IPM fields. Management practices were applied as per month-wise IPM schedule for three consecutive crop seasons *i.e.* 2008-09, 2009-10 and 2010-11 (Table A).

The data on incidence of white-grub, cut worm, thrips, damping-off, *Colletotrichum* Leaf spot and *Phytophthora* fruit rot at weekly interval and yield (q/ha) in IPM and non-IPM fields were recorded. Overall efficacy and economics of IPM, in managing the insect-pests and diseases was worked out by mean disease incidence, grain yield, additional net income and cost benefit (C:B) ratio. Market price of capsicum (Rs. 20.00/kg) was considered for the purpose based on average of three years (2008-09, 2009-10 and 2010-11). For spraying and soil drenching of one hectare area, five mandays were considered. Labour and spray charges were taken into account to compute incremental net benefit cost ratio. Cost of labour @ 150 per manday and average market price of carbendazim (@ Rs. 590/kg), Ridomil MZ (@ Rs. 1440/kg), copper oxychloride (blitox 50) (@ Rs. 630/kg), Azadirachtin 0.03 per cent (@ Rs. 435/lit), vermi-compost/FYM (@ Rs. 2/kg) and BCA (@ Rs. 100/kg) were taken to assess the incremental cost benefit ratio using the formula.

C:B =Additional income over Non-IPM /Additional cost over Non-IPM

RESULTS AND DISCUSSION

IPM technology implementation was initiated through organizing farmer's field schools. Therefore, the most important component in the first year of the project was training of the farmers for development of technical skills. The organization of field schools resulted in the increased awareness of participants on importance of soil-borne insect-pests and diseases, recognition of symptoms, scouting for the damage due to white-grub, cut worm, thrips, damping-off, *Colletotrichum* Leaf spot and *Phytophthora* fruit rot and led to the transfer of IPM technologies to them for development of technical skills such as preparation of value added FYM or vermi-compost by adding *T. harzianum* and following seed and seedling treatment. This type of farmers' participatory trainings has had greater success in achieving IPM implementation (Way and Van Emden, 2000). In India also Farmer's Participatory Training has changed the attitude of farmers to adopt the IPM technology and have favourable attitude towards IPM in comparison untrained farmers (Krishnamurthy and Veerabhadraia, 1999).

Perusal of the data (Tables) revealed that there was a significant decrease in incidence of insect-pests (white-grub, cut worm, thrips) and diseases (damping-off, *Colletotrichum* Leaf spot and *Phytophthora* fruit rot) with increase in yield in IPM package adopted field as compared to the non-IPM fields. During the study, white-grub infestation varied from 1.50 to 2.00 per cent with average of 2.21 per cent in IPM field which was significantly lower than non-IPM fields where infestation ranged from 3.91 to 6.78 per cent with average of 5.71 per cent. Similarly, cutworm and thrips infestation ranged from 2.22 to 2.74 per cent (average 2.49%) and 0.00 per cent to 7.67 per cent (average 7.54 %) while in non IPM practiced field (control) it was 6.28 per cent to 9.90 per cent (average 7.54 %) and 0.00 per cent to 11.24 per cent (average 6.28 %), respectively. On an average, the IPM program provided 61.30 per cent control of white-grub, 66.98 per cent control of cut worm, 42.99 per cent control of thrips, over non IPM practiced field

Table 1 : Effect of IPM module on the incidence of insect-pests in capsicum

Treatments	White grub					Cutworm					Thrips				
	2008 - 09	2009 -10	2010 -11	Pooled mean	Insect control (%)	2008 - 09	2009 -10	2010 -11	Pooled mean	Insect control (%)	2008 - 09	2009 -10	2010 -11	Pooled mean	Insect control (%)
IPM	1.50	3.12	2.00	2.21	61.30	2.50	2.22	2.74	2.49	66.98	0.00	3.09	7.67	3.58	42.99
NIPM	6.45	6.78	3.91	5.71	-	9.90	6.28	6.45	7.54	-	0.00	7.61	11.24	6.28	-
S.E.±	0.23	0.20	0.14	0.12		0.31	0.19	0.35	0.17		NS	0.23	0.40	0.16	-
C.D. (P=0.05)	0.69	0.60	0.41	0.35	-	0.93	0.59	1.05	0.50	-	NS	0.69	1.20	0.48	
CV	22.12	15.43	17.83	11.27		19.18	17.62	29.25	12.82		NS	16.45	16.22	12.34	

NS=Non-significant

(Table 1).

There was significant difference in incidence of diseases in IPM and Non IPM practiced field. In IPM practiced field, the incidence of damping-off, *Colletotrichum* leaf spot and *Phytophthora* fruit rot varied from 2.30 to 16.66 per cent (with average 7.49 %), 4.44 to 20.12 per cent (with average 9.72 %) and 3.73 to 28.33 per cent (with average 12.95), respectively. However, with farmers' conventional practices it was 7.20 to 53.33 per cent (average 27.01%), 7.40 to 47.78 per cent (average 21.00%) and 6.61 to 60.00 per cent (average 25.50%) incidence of damping-off, *Colletotrichum* leaf spot and *Phytophthora* fruit rot diseases, respectively. Thus in IPM practiced field, there was 72.27 per cent, 53.71 per cent and 49.22 per cent reduction of damping-off, *Colletotrichum* leaf spot, and *Phytophthora* fruit rot over non IPM practiced field. Present findings are in accordance with the work of Sardana *et al*. (2013) who reported beneficial effects of IPM technology for bell pepper which included application of FYM @ 20 tonnes/ha fortified with *Trichoderma* sp., seedling dip before transplanting in *Pseudomonas fluorescens*, need based sprays of neem for aphids in early stages of crop. Similarly, Singh *et al.* (2002) also reported that these pests can also be managed through integration of the seed treatment with carbendazim @ 2 g/kg seed, raising seedling in solarized beds. Earlier studies by Atwa *et al.* 2009; Dabbas *et al.* (2009); Mandal *et al.* (2009); Muthukumar *et al.* (2007); Pramanik and Chatterjee (2004); Hussain *et al.* (2003) and Mohapatra *et al.* (1995) have proven the effectiveness of these IPM components against several pests under limited scale field and laboratory conditions. At research farms efficacy of biocontrol agents such as of soil and seedling treatment with *T. harzianum* has been well documented against damping-off pathogens like *Pythium* sp. (Sivan *et al*., 1984 and Bhagat and Pan, 2008).

In addition to reduction of insect pest and diseases, there was also significant increase in yield harvested in IPM as compared to non IPM practiced field. In IPM practiced field, there was 156.93 qha^{-1} yield while in non IPM practiced field it was 113.19 qha^{-1}. It shows 38.64 per cent increase of yield in IPM practiced field as compared to non IPM field due to following the IPM modules. Sardana *et al.* (2012) reported higher marketable yields of bell pepper in IPM trial based on healthy nursery raising, destruction and rouging out of borer damaged fruits and mosaic virus complex plants, respectively and using one or two biopesticides and chemicals.

Analysis of cost benefit ratio of IPM and non practice revealed that there was increase of yield in IPM adopted field (156.93qha^{-1}) as compared to non IPM practice thereby showing Rs. 51.87 thousand per hectare addition net return over non IPM practice. The B:C ratio

Table 2 : Effect of IPM module on the incidence of diseases in capsicum

Treatments	Damping-off					*Colletotrichum* Leaf spot					*Phytophthora* fruit rot				
	2008 - 09	2009 -10	2010 -11	Pooled mean	Disease control (%)	2008 - 09	2009 -10	2010 -11	Pooled mean	Disease control (%)	2008 - 09	2009 -10	2010 -11	Pooled mean	Disease control (%)
IPM	2.30	3.51	16.66	7.49	72.27	4.44	4.60	20.12	9.72	53.71	6.80	3.73	28.33	12.95	49.22
NIPM	7.20	20.50	53.33	27.01	-	7.40	7.82	47.78	21.00	-	9.90	6.61	60.00	25.50	-
S.E.±	0.27	0.26	0.34	0.15		0.46	0.18	0.31	0.19		0.21	0.22	0.68	0.27	
C.D. (P=0.05)	0.83	0.80	1.04	0.44		1.39	0.53	0.93	0.57		0.65	0.68	2.05	0.82	
CV	22.38	8.49	3.78	3.26		29.99	10.93	3.50	4.70		9.89	16.73	5.94	5.47	

Table 3 : Economic analysis of IPM in capsicum (2008-09, 2009-10 and 2010-11) at Tehri Garhwal

Treatments	Yield (q/ha)				Increase in yield (%)	Additional yield (q/ha)	Additional Income (Rs./ha)	Additional Cost (Rs./ha)	Net return (Rs./ha)	B:C ratio
	2008 - 09	2009 -10	2010 -11	Pooled mean						
IPM	149.92	156.26	164.60	156.93	38.64	43.74	87480.00	35603.00	51877.00	1.46
NIPM	119.60	113.40	106.57	113.19	-	-	-	-	-	-
S.E.±	1.77	2.39	1.19	1.08						
C.D. (P=0.05)	5.37	7.24	3.62	3.29	-	-	-	-	-	-
CV	5.09	6.85	3.41	3.11						

of IPM practice was 1.46 over Non-IPM field (Table 4). Birthal (2003) and Ahuja *et al.* (2011) have also reported IPM as more profitable than chemical pesticides.

The results established that IPM had the economic potential to substitute chemical pesticides without demanding any enhancement in cost of cultivation and ensured higher economic returns as well as higher head yield with added advantage of no adverse effects on environment, natural enemies and human health. Economics of IPM module revealed that IPM technology has the potential to protect the crop from insect-pests and diseases in more profitable manner as compared to farmer's practice *i.e.* use of toxic pesticides having adverse consequence on agro ecosystem. Moreover, IPM technology was found to be more eco-friendly, environmentally compatible and safe for human health as well as hill agro-ecosystem.

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