Indian Phytopath. 64 (4) : 335-341 (2011)

RESEARCH ARTICLE

Efficacy of different modules for the management of major pests of tomato (*Lycopersicon esculentum*) and garden pea (*Pisum sativum*) in Himalayas

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ABSTRACT: Foliar and soil borne diseases are major impediments in profitable cultivation of garden pea and tomato in North West Himalayas. Therefore, three modules (IPM, Chemical and organic) were tested in hill ecosystem for pest management in garden pea and tomato. Out of 3 modules tested in tomato, maximum severity of early blight, buckeye rot and fruit borer was observed in organic module (>6.8%) followed by chemical (>4.4%) and IPM modules (>2.1%). Highest percent pest control on pooled mean basis was recorded by IPM module (> 82%) followed by chemical (> 33%) and organic module (> 55%) leading to significant yield enhancement (22.8% in organic, 67.5% in chemical and 105.3% in IPM modules) over their respective unprotected checks. The yield loss due to insect pests and diseases in organic, chemical module, organic unprotected check, chemical treated check and unprotected inorganic check compared to IPM module was 38.6%, 18.4%, 50.0%, 45.0% and 51.3% respectively. Benefit cost ratio ranged from 2.65 to 6.94 in the modules highest being IPM module (6.94). Amongst the 3 modules applied in garden pea, maximum incidence of pre-emergence rot, wilt, white rot, leaf blight, rust, ascochyta blight, powdery mildew, leaf miner and fruit borer were observed in organic module followed by IPM and chemical modules. Maximum percent pest control on pooled mean basis was in case of chemical module (>35%) followed by IPM (>27%) and organic module (>29%). All the modules led to significant yield enhancement (39%) in organic, 88.6% in chemical and 80.7% in IPM modules) over their respective unprotected checks. The yield loss due to pests in organic, IPM over chemical module was 32.4% and 4.2% respectively.

Key words: Foliar diseases, garden pea, modules, seed-borne diseases, tomato

Tomato (*Lycopersicon esculentum* Mill.) and garden pea (*Pisum sativum* L.) are cash vegetables cultivated at different altitudes of Himalayas. Both crops are remunerative to the hill farmers owing to fetching good price during off seasons. Many pests are attacking these crops and therefore, farmers are not able to tap potential yield. Amongst those important ones are pre-emergence rot (*Alternaria alternata*, *Pythium debaryanum*, *Rhizoctonia solani* and *Rhizopus stolonifer*), wilt (*Fusarium oxysporum* pv. *pisi*), powdery mildew (*Erysiphe pisi*), leaf blight (*Alternaria alternata*), white rot (*Sclerotinia sclerotiorum*), leaf miner (*Liriomyza trifolii*), fruit borer (*Helicoverpa armigera*) in garden pea and damping-off (*Pythium aphanidermatum, Rhizoctonia solani* and species of *Fusarium* but predominantly *Pythium aphanidermatum*), early blight (*Alternaria solani)*, buckeye rot (*Phytophthora nicotianae var. parasitica)*, fruit borer (*Helicoverpa armigera*) in tomato. Of late, all these pests have become major impediment to the cultivation of these crops taking a heavy toll on the crop. Though some biological and chemical components for pest management in these crops for the region have been identified (Hooda *et al.* 2006; Sushil *et al.,* 2007; Hooda *et al.,* 2008) yet there is need for development of ecologically sound, environmental friendly sustainable pest management modules for the hill region which can play pivotal role in intensive and organic farming systems of fragile hill ecosystem. Consequently such modules would certainly lead to reduction and judicious use of high risk chemicals. Therefore, the present study was conceived with the objective to test three modules (organic, chemical and IPM) for the pest management in tomato and garden pea under hill ecosystem.

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MATERIALS AND METHODS

Tomato and garden pea field trials were conducted at experimental farm of the Institute located at Hawalbagh (Altitude-1250m amsl, Latitude-29^{0}36' N, Longitude-79^{0}40' E) during the period of 2006-08 using 'Vivek Matar 8' (an early moderately resistant variety of garden pea) and Manisha (a susceptible variety) of tomato. Based on the findings of earlier experiments on tomato and garden pea (Sushil *et al.,* 2006; Hooda *et al.,* 2007; Hooda *et al.,* 2008), 3 pest management modules *viz*; organic, chemical and IPM were developed for both of these crops (Table 1, 2, 3). The six treatments of different modules along with checks were: T_1, application of organic module; T_2, application of chemical module; T_3, application of IPM module; T_4, check (organic), T_5 check (seed treatment and seedling root dip in thiram solution @ 0.2% in tomato, and seed treatment with carbendazim @ 0.05% in garden pea); T_6 check (untreated). In tomato, transplanting was done in mid April during both the years. Seed and seedlings (in tomato only) were treated/ bioprimed with *T. harzianum* in organic and IPM modules whereas in chemical module the seeds were treated with thiram @ 0.2% in tomato and carbendazim @ 0.05% in garden pea. The tomato nursery was drenched with solution of *T. harzianum* @ 10g formulation (1x10^9 cfu/g)/ L of water

Table 1. Treatment schedule for organic module

Crop stage	Operation	Target pests
	Tomato	
A. Nursery		
Nursery sowing	Changed nursery site, raised beds (0.5 X 0.5 X 0.5 m^3) with mixing of FYM @ 20t/ha, seed treatment with *T. harzianum* (10^9cfu/g)@ 1.0%	Damping-off, early blight, buckeye rot and fruit borer
Drenching	Two times with *T. harzianum* @ 1.0% at 10 and 20 days after sowing (DAS)	
At transplanting	Seedling root dip in solution of *T. harzianum* @ 1.0% for 30 minutes	
B. Main crop		
0 DAT	One row of marigold (African tall) (25days old seedlings) around the plot	
25 DAT	Spray of azadirachtin @ 0.03%	
25 DAT	Staking of plants and removal of their basal leaves 9" from soil	
30 DAT	Release of *T. chilonis* @ 50,000 insects/ha/release	
35 DAT	Spray of *Melia azedarach* seed kernel extract @10%	
40 DAT	Release of *T. chilonis* @ 50,000 insects/ha/release	
45 DAT	Spray of azadirachtin @ 0.03%	
45 DAT	Release of *T. chilonis* @ 50,000 insects/ha	
50 DAT	Release of *T. chilonis* @ 50,000 insects/ha/release	
60 DAT	Spray of *Melia azedarach* seed kernel extract @10%	
60 DAT	Release of *T. chilonis* @ 50,000 insects/ha	
70 DAT	Spray of azadirachtin @ 0.03%	
	Garden pea	
0 DAS	Seed treatment with *Trichoderma viride* (2x10^9 cfu/g) @ 0.4% with mixing of FYM @ 20t/ha	Pre-emergence rot, leaf blight, wilt, white rot, rust, powdery mildew, aschochyta blight, leaf miner and fruit borer
80 DAS	Release of *T. chilonis* @ 50,000 insects/ha/release	
90 DAS	Release of *T. chilonis* @ 50,000 insects/ha/release	
100 DAS	Spray of azadirachtin @ 0.03%	
105 DAS	Release of *T. chilonis* @ 50,000 insects/ha/release	
110 DAS	Spray of *Melia azedarach* seed kernel extract @ 10%	
120 DAS	Spray of azadirachtin @ 0.03%	
120 DAS	Release of *T. chilonis* @ 50,000 insects/ha/release	
130 DAS	Spray of *Melia azedarach* seed kernel extract @ 10%	
140 DAS	Spray of azadirachtin @ 0.03%	

Table 2. Treatment schedule for chemical module

Crop stage	Operation	Target pests
	Tomato	
A. Nursery		
Nursery sowing	Raised beds (0.5 X 0.5 X 0.5 m^3) with mixing of FYM @ 10t/ha, seed treatment with thiram @ 0.2%	Damping-off, early blight, buckeye rot and fruit borer
Drenching	Two times with thiram @ 0.2% at 10 and 20 days after sowing (DAS)	
Before transplanting	Seedling root dip in solution of thiram @ 0.2%	
B. Main crop		
25 DAT	Spray of mancozeb @ 0.25%	
35 DAT	Spray of mancozeb @ 0.25%	
35 DAT	Spray of indoxacarb @ 0.03%	
42 DAT	Spray of mancozeb @ 0.25%	
45 DAT	Spray of profenphos @ 0.1%	
50 DAT	Spray of mancozeb @ 0.25%	
55 DAT	Spray of endosulfan @ 0.07%	
60 DAT	Spray of mancozeb @ 0.25%	
65 DAT	Spray of indoxacarb @ 0.03%	
	Garden pea	
0 DAS	Seed treatment with carbendazim @ 0.05%	Pre-emergence rot, leaf blight, wilt, white rot, rust, powdery mildew, aschochyta blight, leaf miner and fruit borer
100 DAS	Spray of mancozeb @ 0.25%	
110 DAS	Spray of mancozeb @ 0.25%	
110 DAS	Spray of wettable sulfur @ 0.2%	
110 DAT	Spray of endosulfan @ 0.07%	
120 DAS	Spray of carbendazim @ 0.05%	
120 DAT	Spray of endosulfan @ 0.07%	
125 DAS	Spray of wettable sulfur @ 0.2%	
130 DAS	Spray of carbendazim @ 0.05%	
130 DAS	Spray of endosulfan @ 0.07%	

Table 3. Treatment schedule for IPM module

Crop stage	Operation	Target pests
	Tomato	
A. Nursery		
Nursery sowing	Changed nursery site, raised beds (0.5 X 0.5 X 0.5 m^3) with mixing of FYM @ 10t/ha, seed treatment with *T. harzianum* (10^9cfu/g)@ 1.0%	Damping-off, early blight, buckeye rot, leaf miner and fruit borer
Drenching	Two times with *T. harzianum* @ 1.0% at 10 and 20 days after sowing (DAS)	
At transplanting	Seedling root dip in solution of *T. harzianum* @ 1.0% for 30 minutes	
B. Main crop		
0 DAT	One row of marigold (African tall) (25days old seedlings) around the plot	
25 DAT	Spray of azadirachtin @ 0.03%	
25 DAT	Staking of plants and removal of their basal leaves 9" from soil	
35 DAT	Spray of mancozeb @ 0.25%	
35 DAT	Spray of *Melia azedarach* seed kernel extract @10%	
40 DAT	Spray of endosulfan @ 0.07%	
45 DAT	Release of *T. chilonis* @ 50,000 insects/ha/release	
45 DAT	Spray of azadirachtin @ 0.03%	
60 DAT	Release of *T. chilonis* @ 50,000 insects/ha/release	
55 DAT	Spray of mancozeb @ 0.25%	
60 DAT	Release of *T. chilonis* @ 50,000 insects/ha	
	Garden pea	
0 DAS	Seed treatment with *Trichoderma viride* (2x10^9 cfu/g) @ 0.4%	Pre-emergence rot, leaf blight, wilt, white rot, rust, powdery mildew, aschochyta blight, leaf miner and fruit borer
100 DAS	Spray of mancozeb @ 0.25%	
100 DAS	Release of *T. chilonis* @ 50,000 insects/ha/release	
100 DAS	Spray of azadirachtin @ 0.03%	
110 DAS	Spray of *Melia azedarach* seed kernel extract @10%	
115 DAS	Spray of endosulfan @ 0.07%	
120 DAS	Spray of carbendazim @ 0.05%	
120 DAS	Release of *T. chilonis* @ 50,000 insects/ha	
120 DAS	Spray of wettable sulfur @ 0.2%	
130 DAS	Spray of azadirachtin @ 0.03%	
130 DAS	Spray of mancozeb @ 0.25%	

in organic and IPM modules, and thiram @ 2g/ L of water in chemical module at 10 and 20 days for protection against damping-off. During transplanting, seedling roots were dipped for 30 minutes in aqueous solutions of *Trichoderma harzianum* (local isolate) @ 10g formulation (1x10^9 cfu/g)/ L of water in organic and IPM module in contrast to chemical module wherein thiram @ 2g/ L of water was used for seedling root dip. The treated seedlings were transplanted in the main field. The crop was staked after 30 days of transplanting with bamboo sticks followed by removal of basal leaves up to 9" from the soil (SRBL) in organic and IPM modules only. Release of *T. chilonis* @ 50,000 insects/ ha and foliar sprays of organic and inorganic products and mechanical practices at different intervals were given as described in the tables 1, 2 & 3. Three checks (organic, chemical and untreated) were maintained for comparison of treatments. In garden pea, seed biopriming with *T. viride* (Strain BIL 198, Biotech International Ltd.) @ 4g formulation (2x10^9 cfu/g)/ kg of seed in organic and IPM modules and seed treatment with carbendazim @ 0.05% in chemical module was given and sown in mid November in both the years. Spray schedule was followed as mentioned in tables 1, 2 and 3. Checks similar to tomato were maintained for treatment comparison. The field trials were conducted in RBD with 4 replications in plots of 5x2 m^2 at 0.50m X 0.50m spacing in tomato and 0.30m x 0.05m in garden pea. FYM @ 10t/ha and NPK @ 100:50:50 kg/ha in tomato and 20:60:40 kg/ha in garden pea (except in organic module wherein 20 t/ha FYM was applied in both the trials) was commonly applied in the tomato nursery and main field. Recommended package of practices (VPKAS, 2002) required for cultivation of tomato and garden pea was followed in routine. Per cent severity of pests was recorded and transformed into arc sine for statistical analysis. The transformed data were subjected to analysis of variance (ANOVA) and means were compared by least significant difference (LSD) test at 5% significance level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Tomato: Early blight, buckeyes rot and fruit borer were the major pests encountered during both the years of trial. Unprotected inorganic checks recorded maximum pest severity (Table 4) and pooled mean severity of early blight, buckeye rot and fruit borer was 66.3%, 62.5% and 15.1% respectively. Out of 3 modules tested, maximum severity of early blight, buckeye rot and fruit borer was observed in organic module (>6.8%) followed by chemical module (>4.4%) and IPM module (>2.1%). Highest percent pest control on pooled mean basis was recorded by IPM module (> 82%) followed by chemical (> 33%) and organic module (> 55%). All the modules led to significant yield enhancement (22.8% in organic, 67.5% in chemical and 105.3% in IPM modules) over their respective unprotected checks (Table 6). The yield loss due to insect pests and diseases in organic, chemical module, organic unprotected check, chemical treated check and unprotected inorganic check compared to IPM module was 38.6%, 18.4%, 50.0%, 45.0% and 51.3% respectively. Benefit cost ratio ranged

Table 4. Efficacy of different modules for pest management in tomato

Treatments	Early blight (%)			Buckeye rot (%)			Fruit borer (%)		
	2007	2008 (% control)	Pooled mean	2007	2008 (% control)	Pooled mean	2007	2008 (% control)	Pooled mean
T1 (Organic module)	27.2 * (31.4)	28.5 (32.2)	27.9 (55.1)	11.8 (20.0)	14.4 (22.2)	13.1 (77.7)	7.3 (15.7)	6.3 (14.6)	6.8 (57.8)
T2 (Chemical module)	11.0 (19.4)	12.1 (20.3)	11.6 (82.5)	40.4 (39.5)	42.7 (40.8)	41.6 (33.4)	5.3 (13.3)	3.5 (10.8)	4.4 (70.9)
T3 (IPM module)	9.8 (18.2)	13.3 (21.3)	11.6 (82.5)	7.33 (15.7)	8.0 (16.4)	7.7 (87.7)	2.5 (9.1)	1.6 (7.3)	2.1 (86.1)
T4 (Unprotected organic check)	62.5 (52.2)	61.8 (51.8)	62.2	58.7 (50.0)	58.6 (49.9)	58.7	17.8 (24.9)	14.3 (22.2)	16.1
T5 (Protected check –ST with carbendazim)	59.9 (50.7)	58.0 (49.6)	59.0	53.7 (47.1)	54.4 (47.5)	54.1	15.3 (23.0)	12.6 (20.8)	14.0
T6 (Unprotected inorganic check)	66.4 (54.6)	66.1 (54.4)	66.3	62.8 (52.4)	62.1 (52.0)	62.5	16.2 (23.7)	13.9 (21.9)	15.1
CD (P = 0.05)	3.43	3.48	-	2.34	2.48	-	2.15	1.51	-

T_1: *Trichoderma harzianum* @ 1% ST, Drenching and root dip, Azadirachtin @ 0.03% spray / BSKE @ 10% spray, *Trichogramma chilonis* @ 50000 insects/ ha/ release, Staking & removal of leaves upto 9" from soil, one row of marigold around plot **(Organic Module);** T_2: Thiram @ 0.2% ST& Drenching the nursery and root dip, Indoxacarb @ 0.03%/ Profenofos @ 0.1%/ Endosulfan @ 0.07% spray, Mancozeb @ 0.25% spray **(Chemical Module);** T_3: *Trichoderma harzianum* @ 1% ST, Drenching and root dip, Azadirachtin @ 0.03% spray / BSKE @ 10% spray/ Indoxacarb @ 0.03%/ Profenofos @ 0.1%/ Endosulfan @ 0.07% spray, Mancozeb @ 0.25% spray, *Trichogramma chilonis* release@ 50000 insects/ ha/ release, Staking & removal of leaves upto 9" from soil, one row of marigold around plot **(IPM Module);** T_4: Control (**Organic**); T_5: Control (*Fungicidal*; ST with thiram @ 0.2%); T_6: Control (**Inorganic**)

* Figures in parentheses are angular transformed values

from 2.56 to 6.87 (Table 6) in different modules. Therefore, amongst the three modules tested, IPM was best by recording highest yield and benefit cost ratio of 6.87 through pest management in tomato.

Garden pea: Pre-emergence rot, wilt, leaf blight, white rot, rust, ascochyta blight, powdery mildew, leaf miner, fruit borer were the major pests on garden pea, though, rust and ascochyta blight did not appear in 2007-08. All the modules applied in the present study resulted in significant improvement of germination (> 76%) except in bioagent treated IPM module in 2006-07; over their respective checks (64.5% in unprotected organic & 68.2% in unprotected inorganic). Overall, maximum increase in germination (16.7%) was recorded in chemical module followed by IPM (13%) and organic module (18.4%). The maximum pest severity was observed in unprotected checks and pooled mean severity of pre-emergence rot, wilt, white rot, leaf blight, rust, ascochyta blight, powdery mildew, leaf miner and fruit borer was 31.9%, 11.5%, 25.1%, 35.7%, 17.7%, 5.3%, 51.7%, 16.9% and 10.7% respectively. Amongst the 3 modules applied, maximum incidence of pre-emergence rot, wilt, white rot, leaf blight, rust, ascochyta blight, powdery mildew, leaf miner and fruit borer were observed in organic module followed by IPM and chemical modules (Table 5). Maximum pest control on pooled mean basis was in case of chemical module (>35%) followed by IPM (>27%) and organic module (>29%). All the modules led to significant yield enhancement (39%) in organic, 88.6% in chemical and 80.7% in IPM modules) over their respective unprotected checks. The yield loss due to pests in organic, IPM, organic unprotected check, chemical treated check and unprotected inorganic compared to chemical module was 32.4%, 4.2%, 51.4%, 40.2% and 47.0% respectively. Though, chemical module seemed to be best in recording highest yield increase but could not be found economically profitable since it recorded less benefit cost ratio (5.72) than the IPM module (5.94) (Table 6). The organic module recorded B: C ratio of 3.34 (Table 6). Thus, overall increase in yield of pea against 9 pests in 2006-07 and 7 in 2007-08 was due to economic pest management. Higher emergence and plant vigour as a result of growth promotion in the biological and IPM modules might have also contributed to the good yield obtained as reported by various workers (Kumar, 2001; Verma and Dohroo, 2002; Howell, 2003; Sharma, 2003; and Hooda *et al*., 2006). The application of azadirachtin, locally available *Batein* (*Melia azedarach*) seed kernel extract, Bt, azadirachtin, endosulfan and *T. chilonis* were effective in lowering the intensity of leaf miner and pod/ fruit borers as reported in earlier studies on vegetables (Sushil *et al*., 2006; Singh and Banyal, 2007). Sharma *et al.* (2004 and 2006) found IDM module better than chemical and biological ones in chilli and cauliflower respectively in contrast to the findings of the present study on garden pea. This might be due to the fact that IPM module in the present study was formulated with sole use of bioagent (*T. viride*) as seed treatment to avoid pesticide pollution in the soil whereas Sharma *et al.* (2004 and 2006) gave seed treatment and seedling dip with bioagent + fungicide (captan and carbendazim respectively) which will always be more efficacious than that of sole bioagent particular in one year of application. Moreover, bioagents take few years in proliferating/ establishing in the soil and to be at par with synthetic fungicides. As with all synthetic chemicals, deplete the soils of beneficial non-target microbial population in contrast to the bioagents which promote the microbial population when continuously used in the soil (Nedunchezhiyan *et al*., 2010). So in the present

Table 5a. Efficacy of different modules for pest management in garden pea

Treatments	Germination (%)			Pre-emergence rot (%)			Wilt (%)			White rot (%)		
	2006-07	2007-08	Pooled mean (% increase)	2006-07	2007-08	Pooled mean (% control)	2006-07	2007-08	Pooled mean (% control)	2006-07	2007-08	Pooled mean (% control)
T1 (Organic)	73.5 (59.0)**	79.2 (62.9)	76.4 18.4)	26.0 (30.6)	20.8 (27.1)	23.4 (34.1)	9.9 (18.3)	7.8 (16.1)	8.9 (38.6)	13.7 (21.7)	11.9 (20.0)	12.8 (48.2)
T2 (Chemical)	78.1 (62.1)	81.1 (64.3)	79.6 (16.7)	22.0 (27.9)	18.9 (25.7)	20.5 (35.7)	6.6 (14.7)	5.5 (13.6)	6.1 (47.0)	7.8 (16.1)	7.0 (15.3)	7.4 (70.5)
T3 (IPM)	75.6 (60.4)	78.5 (62.5)	77.1 (13.0)	24.5 (29.6)	21.5 (27.5)	23.0 (27.9)	7.8 (16.2)	7.1 (15.4)	7.5 (34.8)	12.2 (20.3)	9.2 (17.6)	10.7 (57.4)
T4 (Unprotected organic check)	67.4 (55.2)	61.6 (51.7)	64.5	32.6 (34.8)	38.4 (38.3)	35.5	14.7 (22.6)	14.2 (22.0)	14.5	27.5 (31.6)	21.8 (27.8)	24.7
T5 (Protected check–ST with carbendazim)	76.6 (61.1)	80.4 (63.7)	78.5	23.4 (28.9)	19.6 (26.3)	21.5	8.1 (16.5)	8.0 (16.4)	8.1	23.3 (28.8)	19.4 (26.1)	21.4
T6 (Unprotected inorganic check)	72.4 (58.3)	63.9 (53.1)	68.2	27.7 (31.7)	36.1 (36.9)	31.9	11.2 (19.5)	11.8 (20.0)	11.5	28.5 (32.2)	21.7 (27.7)	25.1
CD (P = 0.05)	2.66	4.65	-	2.41	4.65	-	2.47	2.68	-	2.66	1.97	-

Table 5b. Efficacy of different modules for pest management in garden pea

Treatments	Powdery mildew (%)*			Rust (%) (% control)	*Ascochyta blight (%) (% control)	Leaf blight (%)			Leaf miner (%)			Fruit borer (%)		
	2006-07	2007-08	Pooled mean (% control)	2007-08	2007-08	2006-07	2007-08	Pooled mean (% control)	2006-07	2007-08	Pooled mean (% control)	2006-07	2007-08	Pooled mean (% control)
T1 (Organic)	19.4 (26.1)	16.7 (24.0)	18.1 (66.2)	11.9(20.1) (29.6)***	3.1 (9.9) (36.7)	25.0 (29.9)	23.5 (28.9)	24.3 (35.4)	5.6 (13.7)	8.1 (16.5)	6.9 (62.9)	3.2 (10.3)	3.2 (10.3)	3.2 (63.2)
T2 (Chemical)	3.7 (11.0)	3.0 (9.8)	3.4 (93.4)	4.0 (11.4) (77.4)	1.9 (7.9) (64.2)	9.8 (18.1)	8.6 (17.3)	9.2 (74.2)	4.3 (11.5)	6.3 (14.5)	5.3 (68.6)	2.3 (8.6)	3.1 (9.9)	2.7 (74.8)
T3 (IPM)	4.6 (12.2)	3.4 (10.5)	4.0 (92.3)	6.1 (13.9) (65.5)	2.3 (8.7) (56.6)	11.4 (19.7)	10.7 (18.9)	11.1 (68.9)	3.7 (10.4)	4.1 (11.7)	3.9 (76.9)	2.1 (8.3)	2.3 (8.6)	2.2 (79.4)
T4 (Unprotected organic check)	59.8 (50.7)	47.3 (43.4)	53.6	16.9 (24.2)	4.9 (12.8)	40.3 (39.4)	34.8 (36.1)	37.6	14.5 (21.2)	22.6 (28.4)	18.6	9.0 (17.5)	8.3 (16.1)	8.7
T5 (Protected check–ST with carbendazim)	46.9 (43.0)	43.5 (41.3)	45.2	17.0 (24.3)	4.4 (12.0)	33.3 (35.2)	30.0 (33.2)	31.7	15.1 (22.9)	19.7 (26.4)	17.4	11.7 (20.0)	12.7(20.6)	12.2
T6 (Unprotected inorganic check)	55.5 (48.1)	47.9 (43.8)	51.7	17.7 (24.8)	5.3 (13.3)	37.8 (37.9)	33.5 (35.3)	35.7	14.6 (21.5)	19.2 (26.0)	16.9	10.7 (19.1)	10.7 (19.1)	10.7
CD (P = 0.05)	2.44	1.10	-	2.27	1.09	1.19	2.39	-	2.13	2.67	-	1.31	1.32	-

*Rust and ascochyta blight did not appear in 2007-08; **Figures in parentheses are angular transformed values; ***Disease control (%)

T_1**:** *Trichoderma viride* @ 0.4% seed treatment (ST), Azadirachtin @ 0.03% spray/ Batein seed kernel extract (BSKE) @ 10% spray, *T. chilonis* release @ 50, 000 insects/ha/release (**Organic Module**); T_2**:** Carbendazim @ 0.05% ST, Mancozeb @ 0.25% spray, Carbendazim @ 0.05% spray, Wettable sulfur @ 0.2%, Endosulfan @ 0.07% spray (**Chemical Module**); T_3**:** *T. viride* @ 0.4% ST, Mancozeb @ 0.25% spray, Carbendazim @ 0.05% spray, Azadirachtin @ 0.03%, Wettable sulfur @ 0.2%, *T. chilonis* release @ 50,000 insects/ha/release, Endosulfan @ 0.07% (**IPM Module**); T_4: Control (**Organic**); T_5**:** Control (*Fungicidal*; ST with carbendazim @ 0.05%); T_6**:** Control (**Inorganic**)

Table 6. Economic analysis of different pest management modules in tomato and garden pea

Treatment module	Yield (q/ha)			Yield increase over respective Unprotected checks (%)	Avoidable yield loss over IPM module (%)	Additional yield over respective checks (q/ha)	Additional cost (Rs)	Additional income (Rs)	B : C ratio
	2007	2008	Pooled mean						
Tomato									
T1 (Organic)	255.5	273.4	264.5	22.8	38.6	49.1	23942.00	61375.00	2.56
T2 (Chemical)	354.2	348.4	351.3	67.5	18.4	141.6	20753.00	141600.00	6.82
T3 (IPM)	424.3	436.8	430.6	105.3	-	220.9	32168.00	220900.00	6.87
T4 (Unprotected org. check)	208.7	222.1	215.4	-	50.0	-	-	-	-
T5 (Protected check– ST &SD with thiram)	229.7	243.8	236.8	-	45.0	-	-	-	-
T6 (Unprotected inorg. check)	209.8	209.6	209.7	-	51.3	-	-	-	-
CD (P = 0.05)	41.19	33.44	-	-	-	-	-	-	-

Treatment module	Yield (q/ha)			Yield increase over respective Unprotected checks (%)	Avoidable yield loss over chemical module (%)	Additional yield over respective checks (q/ha)	Additional cost (Rs)	Additional income (Rs)	B : C ratio
	2006-07	2007-08	Pooled mean						
Garden pea									
T1 (Organic)	69.0	85.5	77.3	39.0	32.4	21.7	12685.00	42315.00	3.34
T2 (Chemical)	113.7	114.8	114.3	88.6	-	53.7	14089.00	80550.00	5.72
T3 (IPM)	111.0	108.0	109.5	80.7	4.2	48.9	12356.00	73350.00	5.94
T4 (Unprotected org.check)	49.3	61.8	55.6	-	51.4	-	-	-	-
T5 (Protected check– ST with carbendazim @ 0.05%)	66.5	70.1	68.3	12.7	40.2	7.7	-	-	-
T6 (Unprotected inorg. check)	56.5	64.7	60.6	-	47.0	-	-	-	-
CD (P = 0.05)	7.43	4.16		-	-	-	-	-	-

Pea price @ Rs 1500/q; org. pea @ 1950/q (25% higher premium price over inorganic pea)

Tomato price (off season) @ Rs. 1000/q; org tomato @ 1250/q (25% higher premium price over inorganic pea)

investigation IPM with bioagent ST will be equal or better than the fungicides when continuously applied in organic conditions. Therefore, amendment of organic matter in the soil should be a regular feature since it serves as substrate for the multiplication of many bioagents. In case of IPM in tomato, IDM study corroborate the findings of Sharma *et al.* (2004 and 2006) simply because sprays of pesticides without staking and removal of leaves remain ineffective due to lodging of tomato plant and touching the wet saturated soil thus contracting *Phytopphthora* infection. That is why chemical sprays are not so much effective in checking buckeye rot as in case of staked plants. Enhanced yield (21-49%) as a consequence of bioagents and other natural products in oraganic and IPM modules has also been obtained by earlier workers (Verma and Dohroo, 2002; Sharma, 2003; Hooda *et al.*, 2006 and Karthikeyan *et al.* 2010).

ACKNOWLEDGEMENTS

Thanks are due to Sh. J.S. Bisht, Sh. G.S. Bankoti and Keshar Singh for their technical assistance during the investigation.

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Received for publication: December 24, 2010
Accepted for publication: November 18, 2011