



Comparing integrated pest management modules to the farmers' practice for pest management in cabbage (*Brassica oleracea*) crop

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ABSTRACT

Field experiment was conducted during 2013–14, on cabbage (*Brassica oleracea*), variety Pusa Mukta, for testing thirteen IPM modules against farmers' practices to identify suitable location specific module. The most productive IPM module was identified as combination of Beta-cyfluthrin, Azadirachtin and Dichlorovos with intercropping of Indian mustard incorporating pheromones traps, with lure (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate as well using other important IPM components for seed treatment to harvest which resulted in the highest yield (19.38 tonnes/ha) and net return (48 500 ₹/0.5 ha) in comparison to farmers' plot that delivered 16.93 tonnes/ha yield (42 346 ₹/0.5 ha).

Key words: Cabbage, Integrated pest management, Pest management

The district Faridabad, located at the south-east of Haryana, is a major vegetable producing area as 70% of the total geographical area is under cultivation (DOA 2011) and the farmers are dependent upon synthetic pesticides for the problem of pest management in vegetables resulting in high pesticide residue in the product causing increase of level of toxicity, which through food chain creates health problems (Cesnik *et al.* 2009, Islam *et al.* 2009). The percentage of pesticide contamination in vegetables was found to be highest in Haryana state (56.2%) while the samples above Maximum Residue Limits (MRL) were 4.5 percent which was also highest in India (Bhushan 2013). Amongst pesticides used, cypermethrin (62%) and captan (74%) were discovered as the most popular and effective insecticide and fungicide respectively (Tyagi *et al.* 2015). The only solution is integrated pest management, the safe pest management solution which relies on the application of the pesticides below the Economic Threshold levels (ETL), (Bajwa 2002) However, IPM practitioners were found to be negligible in villages of North India, as identified through detailed interaction programmes (Bhardwaj 2015). Thus the scenario summarized the inevitability of IPM popularization programmes to disseminate IPM techniques in the area. For this purpose, a series of IPM validation trials were conducted at farmers' fields against parallel comparison to farmers' synthetic management.

Cabbage is attacked by a number of pests and the yield loss by major pests of cabbage, viz. diamond black moth

(DBM) (*Plutella xylostella*), cabbage caterpillar (*Peiris brassicae*) and cabbage leaf webber (*Crociodolomia binotalis*) were found to be by 77.4-99.1%, 69.2% and 48.5-51.6% respectively (Shivalingaswamy *et al.* 2002). To minimize the losses while maintaining the quality of produce, various IPM components, location and time specific, are effective which need to be validated in the form of a successful module to be adopted by cole crop growers for residue free production. For the purpose, the present study was conducted to validate and identify the most suitable location specific IPM module by the trails against farmers' conservative pest management practice.

MATERIALS AND METHODS

District Faridabad lies at 28° 25' 16" N latitude and 77°18' 28" E longitude at an average elevation of 198 m. Badarpur Said and Jasana, cole crop producing villages, situated at a distance of 50 km away from ICAR-Indian Agricultural Research Institute (IARI), New Delhi were selected for conducting the present study on popularization of IPM module for cabbage.

Before commencement of implementation of IPM programme, a series of interactions with farmers were held and respondents were selected on the basis of random sampling technique and interviewed using pretested interview schedule and their consents was taken. Due to the increasing demand of organic food, farmers were also keen to adopt such modules. The variables like educational level, operational size of land holding, experience in vegetable growing, cropping system, cabbage cultivation practices, extension services availed, source of seeds, knowledge of pests, assessment of losses due to the pest, natural enemies and their role in pest regulation, type of equipments used,

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pest control advice as well as mass media exposure were taken for analysis.

The research was initiated during rainy season at farmer's field in the village from the year 2013 to 2014. Cabbage variety Pusa Mukta was transplanted in first week of October with the crop geometry maintained to plot size restricted to 5.15m × 4.75m (24.5 sq m) while the spacing was 30 and 45 cm between plant to plant and row to row, respectively at 15 cm height and prepared in a well drained area so that excess water could be drained in case of heavy rains. An average of 0.50 kg/ha seed was used for sowing. The N:P:K @120: 60: 80 kg (per ha basis), was applied undertaking three hoeings at 20 days post sowing at an interval of 15-20 days. These beds were solarized by covering with transparent polythene sheet of 250 gauge thickness for 15-20 days for protection against soil borne pathogens after treating with 2.5 kg talc based formulation of *Trichoderma harzianum* (Howell 2003, Sharma *et al.* 2012).

Seeds of cabbage variety Pusa Mukta, developed by IARI, were treated with paste prepared by mixing 5g talc formulation of *T. harzianum* (108 conidia/g) in 10-15 ml of water. The *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 8-10 g/kg seed with neem cake @100 g/m² were treated in hot water at 52°C for 30 minutes followed by soaking in Streptocycline @100 ppm for the damping off and bacterial rot pathogens (Rai 2012) and Carbofuran 3% CG @ 20000 g/acre for nematodes (Di Sanzo 1973). Seedlings were ready for transplanting after 4-5 weeks and sown in the last fortnight of October.

All the growers in the locality were instructed to raise nursery and undertake transplanting simultaneously to minimize the error that could occur due to difference in timing of the sowing of the crop and ultimately may be reflected while estimating the curd yield between IPM trials and conventional practice. Farmers selected under IPM practice and the conventional practices were the early transplanters. Crop was raised under similar agronomic schedule in both IPM and non IPM fields. The experiment used paired treatment comparisons to compare the IPM system with the conventional system (Farmers' field).

Evaluation of various components of IPM approach was based on the field results per ha by confirming the effectiveness of module to achieve control and prevent flare up of pest incidence. The application of reduced risk pesticides was limited to late stage of the crop growth based on timely monitoring and scouting and action threshold based on the percentage of plants infected with major pest, viz. DBM, cabbage caterpillar, cabbage leaf webber, and tobacco caterpillar (*Spodoptera litura*). The modules were synthesized on the location basis pest management requirements. Conventional system vis a vis farmers' practice (FP), using application of agronomic factors and pest control, commonly practiced by the local farmers, was applied in the non IPM plots.

Funnel shaped pheromone traps were placed at the rate of three pheromone traps/acre at an equal distance of 50 m apart in a diagonal fashion from each other in the

field to monitor the population of *S. litura*. These traps consisted of a smooth plastic funnel (21 cm diameter, 20 cm length) and a polythene bag (50 × 30 cm) with a pheromone septum (lure) impregnated with 70:30 mixture of (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate and two components of the sex pheromone of the female (Chow 1999, Schroeder 2003). Screened field cages were placed

Table 1 Composition of different integrated pest management modules

Module	Treatment
M ₁	beta-cyfluthrin 750 ml/ha + azadirachtin 2.0 litres/ha Dichlorovos 76 EC@ 0.1% + ic @ Indian mustard
M ₂	Lambda-cyhalothrin @ 0.004% and Difenconazol @ 0.02% (Score 25 EC) after 15 days of 1st spray; Lambda-cyhalothrin @ 0.004% after 45 days of transplanting + ic @Chinese cabbage
M ₃	Azadirachtin @ 5ml/L after 45 days of transplanting; Difenconazol @ 0.02% after 15 days of 1st spray in-corporated with high quality mechanical control + ic @Chinese cabbage
M ₄	B.t.k. 1.25 kg/ha + diflubenzuron 200 g/ha + endosulfan 0.25 litre/ha + ic @Chinese cabbage
M ₅	NSKE + Lufenuron + endosulfan 0.25 litre/ha + ic @ Indian mustard
M ₆	Lambda-cyhalothrin @ 0.004% (Bravo 5%) after 45 days of transplanting; □ Mixture of Malathion (0.05%) and Dithane Z 78 @ 0.25% (Dithane 75 WP) after 15 days of 1st spray
M ₇	B.t.k. 1.25 kg/ha + diflubenzuron 200 g/ha + endosulfan 1.25 litre/ha + ic @Chinese cabbage
M ₈	Dichlorovos 76 EC@ 0.1% + NSKE (5%) spray+ entomopathogenic fungal (<i>Verticillium lecani</i>) formulation 500g/ha at 10 days interval + Spray SINPV 250LE (2 × 109) in the evening for early instars + ic @Chinese cabbage
M ₉	Azadirachtin @ 5ml/L after 45 days of transplanting, Btk (15g/10 L) and Dithane Z- 78 @ 0.25% after 15 days of 1st spray; Mechanical cultural practices + ic @Chinese cabbage
M ₁₀	Azadirachtin @ 5ml/L + Fipronil 5% SC + Emmamectin benzoate + Bt formulations (Delfin®/Dipel)+ Spray SINPV 250LE (2 × 109) in the evening for early instars + ic @Chinese cabbage
M ₁₁	Spray of Bt (1g/litre) if DBM 1.0/plant or NSKE 5% (3 sprays) or novaluron 10 EC @ 100 ml/acre (18-25 DAP) or spinosad 45 SC ic @Chinese cabbage
M ₁₂	diflubenzuron 200 g/ha + spinosad 15 g a.i./ha + azadirachtin 2.00 litre/ha + ic @coriander
M13	Dichlorovos 76 EC@ 0.1% NSKE (5%), spray of entomopathogenic fungal (<i>Verticillium lecani</i>) formulation @ 500 g/ha at 10 days interval, spray of Bt formulations (Delfin®) @ 500 g/ha at 35 , three foliar sprays of SINPV @ 300 LE/ha (0.05%) in jaggery (2%) at an interval of 10 days at early morning and late evening ic @coriander
FP	Lufenuron + Endosulfan 1.25 litre/ha+ Captan 2.0

into blocks of cabbage which were either treated with the pheromone or left untreated. The lures were changed at an interval of 30 days. The height of the trap was kept 30 cm above the plant canopy.

IPM Module M_1 and M_5 were inter-cropped with Indian mustard (*Brassica juncea*) (Bender 1999). In these IPM Modules mustard rows with every 25 cabbage rows were intercropped and the first row of mustard was sown 15 days before and second 25 days after cabbage planting (Singh 2006) While in the M_{12} and M_{13} , the border with coriander was adopted against DBM (Francisco 2004, Hasheela 2010). The rest of the modules were incorporated with Chinese cabbage (*Brassica rapa* subsp *pekinensis*) as trap crop against DBM in cabbage (Rai 2014).

IPM relies on the need based chemical treatment strictly based upon the Economic Threshold Limits of the pest (Pedigo 1986, Hoffmann 1993, Pimentel 1997). So to combat the pest problems the following different modules

were tested that were initiated in last week of November and continued till mid of December followed by harvest.

RESULTS AND DISCUSSION

The IPM modules against aphid and diamondback moth were evaluated and the best module which showed reduced larval population and also gave maximum yield were beta-cyfluthrin 750 ml/ha + azadirachtin 2.0 litres/ha and Dichlorovos 76 EC@ 0.1% (M_1) followed by lambda-cyhalothrin @ 0.004% and Difenconazol @ 0.02% (Score 25 EC) after 15 days of 1st spray. The moderate ones were azadirachtin @ 5ml/l after 45 days of transplanting; Difenconazol @ 0.02% (M_3), B.t.k. 1.25 kg/ha + diflubenzuron 200 g/ha + endosulfan 0.25 litre/ha (M_4), NSKE + Lufenuron + endosulfan 0.25 litre/ha (M_5) and lambda-cyhalothrin @ 0.004% (Bravo 5%) after 45 days of transplanting; Malathion (0.05%) and Dithane Z 78 @ 0.25% (Dithane 75 WP) (M_6). However the least effective

Table 2 Comparative performance of various integrated pest management modules

IPM Modules	Cabbage plant (0.00245 ha) (%)	Total cabbage head produced (%)	Unable to produce cabbage head (%)	Total commercial cabbage heads (No./q)	Un-commercial cabbages (%)		Yield (t/ha)	Net return (₹/0.5ha)	Effective ranking
					Insect attack	Disease incidence			
M1	99 (99)	98	01	95 (0.475)	02	01	19.38	48 500	I
M2	99 (99)	97	03	94 (0.470)	03	0	19.18	47 959	II
M3	98 (98)	96	04	92 (0.460)	03	01	18.77	46 930	III
M4	99 (99)	95	04	91 (0.455)	04	01	18.55	46 428	IV
M5	98 (99)	96	06	90 (0.450)	05	01	18.36	45 918	V
M6	99 (99)	98	08	90 (0.450)	06	0	18.36	45 918	VI
M7	99 (99)	97	09	88 (0.440)	08	01	17.95	44 897	VII
M8	98 (99)	96	09	88 (0.440)	09	00	17.95	44 897	VIII
M9	99 (99)	95	10	85 (0.425)	09	01	17.34	43 860	IX
M10	98 (98)	96	11	85 (0.425)	10	01	17.34	43 860	X
M11	99 (99)	97	12	85 (0.425)	11	01	17.34	43 860	XI
M12	99 (98)	98	13	85 (0.425)	12	01	17.34	43 860	XII
M13	98 (98)	98	13	85 (0.425)	13	00	17.34	43 860	XIII
FP	98 (98)	98	15	83 (0.415)	13	02	16.93	42 346	XIV

Total transplant =100/ IPM field, 0.00245 ha

Table 3 Comparing the integrating pest management and farmers' practices

Parameters	IPM plot	Farmers' practice plot
Number of sprays	6	13-14
Average yield (t/ha)	18.10	16.93
Cost of cultivation (₹/0.5ha)	2,200	5,000
Net return (₹/0.5 ha)	45,442	42,346

were Azadirachtin @ 5ml/l + Fipronil 5% SC + Emmamectin benzoate + Bt formulations (Delfin®/Dipel)+ Spray SINPV 250LE (2 × 109), Spray of Bt (1g/litre) if DBM 1.0/plant or NSKE 5% (3 sprays) or novaluron 10 EC @ 100 ml/acre (18-25 DAP) or spinosad 45 SC and diflubenzuron 200 g/ha + spinosad 15 g a.i./ha + azadirachtin 2.00 litre/ha, respectively, M₁₀, M₁₁ and M₁₂. The maximum yield of cabbage heads was obtained in module M₁ followed by M₂ Table 2.

The IPM plots were treated with reduced number of sprays 5-6 in compared to farmers' plot, i.e. 13-14, however the former ones reported yield 18.10 tonnes/ half ha while the later yielded 16.93 tonnes/half ha (Table 3). The net enhanced profit in M1 was 12308 ₹/ha in comparison to farmers' practice that was 3028 ₹/ha (Table 4) as the cost of cultivation in farmers practice was nearly ₹ 5000 / 0.5 ha in comparison to ₹ 2200/ 0.5 ha approximately in IPM plots (Table 3). So the yield was higher by 15-20 percent as well as residue free or organic in real means. Net returns for cabbage in winter season were ₹ 97000/ha in IPM fields and ₹ 82000/ ha with farmers' practices. So the M1 delivered a net enhanced profit of ₹ 12308 / ha followed by M2, i.e. ₹ 11226 /ha in comparison to Farmers conservation pest management practice (Table 4). The farm produce of the farmers may be more beneficiary if they are is supplied to organic food marts. Thus, IPM is an example of sustainable intensification, defined as "producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Pretty 2011, 2014).

The present investigation also supports the findings of Mahalakshmi *et al.* (2002) who also reportedly treated larval population of diamondback moth successfully in cabbage crop. Similar results were reported earlier by Walunj *et al.* (2001). While Mala (2006) reported the effectiveness of emamectin benzoate and endosulfan against diamond back moth which was adopted in farmers' plot in the present study. Deshmukh *et al.* (2015) also concluded with similar conclusion while testing with different IPM modules in cabbage and achieved that the highest gross realization over control was in M1, M2 and M3 was 124950, 104125 and 3320 ₹/ha, respectively.

Shukla and Kumar (2006) also incorporated Azadirachtin 2.0 litres/ha in pest management modules and conferred it as best component to reduce larval population and also gave maximum yield. Effectiveness of *Bacillus thuringiensis* var.

Table 4 Comparing not enhanced profit (₹/ha) of different IPM modules

IPM modules	Net return (₹/0.5ha) (a)	Enhanced net result (₹/0.5ha) (b)	Net enhanced profit (₹/ha) (a-b)
M1	48500	6154	12308
M2	47959	5613	11226
M3	46930	4584	9168
M4	46428	4082	8164
M5	45918	3572	7144
M6	45918	3572	7144
M7	44897	2551	5102
M8	44897	2551	5102
M9	43860	1504	3008
M10	43860	1514	3028
M11	43860	1514	3028
M12	43860	1514	3028
M13	43860	1514	3028

kurstaki in combination of neem was validated successful component of IPM by Sailaza and Krishnayya (2003). Singh *et al.* (2006) indicated that intercropping of mustard in cabbage recorded minimum activity of diamondback moth larvae in cabbage. Ojha and Singh (2003) reported minimum number of larvae of diamondback moth, semilooper and head borer while intercropped with Indian mustard. Thus, the present findings are in agreement of combination of the past reports related to sustainable pest management on the crop. The study is an initial trial for constructing a location specific IPM module for cabbage.

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