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Assessment of Sucking and Fruit Borer Insect Pests Management Technology with Raised Beds Plantation (resource conservation modules) in Chilli (*Chilli annuum* L.)

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Abstract: *Trials were carried out during two consecutive years, 2011-12 to 2012-13, on sucking and fruit borer insect pests' management technology modules with flat and raised beds planting methods of Chilli was assessed under farmers' field conditions to assess their effects of six IPM modules on insect pests. Keeping in view of an effective extension approach for dissemination of plant protection technologies for sustainable production of chilli, among IPM modules evaluated, MT-3 comprising safer molecule of insecticide was the most effective module against sucking and fruit borer insect pests. The mean per cent infestation of insect pest complex in chilli was least (6.9) in T3 which was on par with T4 (9.95). Higher infestation per cent of insect pest complex was shown in T1 (13.9), T2 (17.5) & T5 (19.65), respectively and highest infestation 24.7 was observed in T6 (farmers practice). Higher chilli yield (58.6 q/ha) was observed in treatment MT -3 (Chilli Planting on ridge-bed, Neemcake @ 250 kg/ha + vermicompost @ 625 kg/ha at transplanting (TP) and need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emamectin benzoate 5 % WDG @ 125 g/ha) followed by treatment TM-4 (Chilli planting on flat plain field, with Neemcake @ 250 kg/ha + vermicompost @ 625 kg/ha at transplanting (TP) and need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emamectin benzoate 5 % WDG @ 125 g/ha) and TM-1 (Chilli Planting in furrows, Marigold trap crop (one row of marigold for every 18 rows of chilli), vermicompost @ 2.5 t/ha + Neem cake @ 250 kg/ha, need based application of Diafenthiuron @ 1g/l and profenofos@ 2 ml/l .). Further, highest B: C ratio (3.2) was recorded by MT-3 followed by TM-4 and TM-1. It was found the significantly lower, i.e., 6.9 % mean insect pests infestation was noticed in chilli with assessed and demonstrated plant protection technologies modules in comparison to farmers practice 24.7 %. The significantly higher fruit yield @ 58.6 q/ha, net return Rs 96077 /ha with cost benefit ratio 3.12 were also recorded over farmers practice, i.e., 32.5 q/ha, Rs 35645/ha and 1.84, respectively. Over the past decade, there has been increasing interest in the development, evaluation and adoption of raised bed planting technology for a wide range of crops in central India. Raised beds offer possibilities of diversifying to water-logged sensitive crops such as chilli, soybean and maize during the monsoon season. Farmers were happy with transplanting of chilli on Raised beds and the modules T3 gave highest yield.*

Key Words: *Chilli, sucking insect, fruit borer, ridge-bed planting, management modules, assessment and sustainable production*

INTRODUCTION

Chilli (*Chilli annuam* L.) is an important spice as well as vegetable crop grown all over India. Chilli exports in 2014-15 touched a record 3, 47,000 tones valued at Rs 3,517.10 crore. The annual chilli production in the country is about 13-14 lakh tonnes. Chilli (*Chilli annuum* L.) belongs to the family Solanaceae and is one of the most important widely cultivated crops grown for the value of its fruits in India. Besides traditional use of chilli as vegetables, spices, condiments, sauces and pickles, it is also being used in pharmaceuticals, cosmetics and beverages

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(Tiwary *et al.*, 2005). Although, the crop has got great export potential besides huge domestic requirement, a number of limiting factors have been attributed for low productivity. Among them, occurrence of viral diseases as well as ravages caused by insect pests are significant ones. The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in the field as well as in storage (Anon, 1987), amongst these, aphids, *Myzus persicae* Sulzer. *Aphis gossypii* Glover. Thrips, *Scirtothrips dorsalis* Hood., yellow mite, *Polyphagotarsonemus latus* Banks and fruit borer, *Helicoverpa armigera (*Hubner)are the most vital production constraints. During the last two decades, insecticidal control of chilli pests in general and especially in irrigated crop characterized by high pesticide usage, has posed problems of residues in the fruits (Nandihalli, 1979 and Joia *et al.*, 2001). Besides pest resurgence, insecticide resistance and destruction of natural enemies (Mallikarjuna Rao and Ahmed, 1986), both domestic consumption and as well as export of chilli necessitates production of quality chillies devoid by contamination of pesticides, industrial chemicals and aflotoxins. But the presence of organophosphorous pesticide residues in chillies has been a major non-tariff barrier against export of chillies to developed countries. Keeping this in mind, therefore, several issues are need to be re examined, put to evaluation so that a sound management programme is evolved with least or no pesticide usage.

'Believing through seeing' and 'learning by doing' accomplished through assessment and demonstrations help in technology integration. The process arouses interest and improves the adoption, because it is based on the principles of 'learning by doing' and 'seeing is believing'. Technology demonstration is the most effective way to show how a thing works, how to do the work, principles involved in an operation and to show the effective results of the technology/methodology adopted. Green revolution technologies have now been widely adopted, and the process of diminishing returns to additional input usage has set in. Concurrently, agricultural production continues to be constrained by a number of biotic and abiotic factors. For instance, insect pests, diseases and weeds cause considerable damage to potential agricultural production. Due to their tender and supple nature, vegetables are most prone to pest attack and at a conservative estimate cause about 20 – 25% losses (Sardana *et al.*, 2004). The losses though cannot be eliminated altogether, can be reduced. Until recently, chemical pesticides were increasingly relied upon to limit the production losses. Pesticide consumption in India increased from 15 g/ha in 1955-56 to near about 550g/ha in 2010-11. Introduction of green revolution technologies in mid-1960s gave a fillip to pesticide use, and in 1975-76, it had increased to 266 g/ha, and reached a peak of 404 g/ha in 1990-91 (Birthal, 2003). Although, there is a paucity limited availability of reliable time-series information on pest-induced production losses, anecdotal evidences suggest increase in losses (Pradhan 1983, Atwal 1986, Dhaliwal and Arora, 1996), despite increase in the pesticide use. The paradox is explained in terms of rising pests problem, technological failure and changes in crop production systems. Despite use of pesticides, insect pests and diseases cause considerable losses in agricultural crops. The crop protection technologies and practices embedded provide better protection against insect pests, improve crop yields and net benefits to the farmers. Farmers are facing scarcity to improved and competent plant protection technology for diminish the losses caused by due to infestation of different insect pests in their farms for sustainable production.

A range of 'resource conserving technologies' (RCTs) is yet to process of under development for cropping systems, The goals of these new technologies include increasing profitability for farmers, increasing food production and its nutritional value to match population growth, and environmental sustainability. For achieving these goals, increasing the productivity and the water and nutrient use efficiency of cropping systems, reducing water use, reducing atmospheric and groundwater pollution, and reversing the decline in soil organic matter content are requird. RCTs at various stages of investigation, development and adoption include direct drilling, retention of stubbles, raised beds, laser leveling, and use of leaf colour charts for guiding N application. Bed planting, another promising RCT, was introduced for wheat in the mid 1990s and produced similar or higher yields compared with conventional tillage and sowing on the flat system. Furthermore, bed planting offers many other benefits, including the opportunity for mechanical weed control as well as reductions in lodging, sowing rate and water logging. Irrigation water use is also greatly reduced (by 30–50%) on beds in India, but whether this is a total water saving is uncertain (Roth*, et. al*. 2005). While many other crops are currently grown in rotation in India, their total production is very small. Crop diversification will also reduce problems of diseases, insect pest damage and weeds, and also improve nutrient use efficiency.

No work has been done to minimize the losses due to insect pests and validate the suitable plant protection technology modules for management of insect pests in chilli to the farmers of Gird agro climatic zones of Madhya Pradesh in central India. Therefore, the present study was undertaken with the following specific objective:

1. An Impact Assessment of resource conservation technology modules for sucking and fruit borer insect pests' management in Raised beds planted Chilli (*Chilli annuum* L.)

MATERIALS AND METHODS

Description of the study area

Different villages were surveyed by scientists of Krishi Vigyan Kendras. While collecting preliminary information of cropping pattern and resource availability, it was found that the farmers of these villages were found to suffer from the severe insect pests infestation in chilli crop and they were poor in using management practices. They were also not aware about the recent technical knowledge of improved agricultural plant protection practices. Looking to the demand of region, the present study was conducted in chilli grown by farmers with major insect pests problem in them.

Period, location, climate, soil and crops

The field experiment was laid down in kharif during two consecutive years 2011 – 12 and 2012 – 13 at 36 farmers' fields in 6 villages of district Morena falls in Gird agro climatic zone of Madhya Pradesh, which is situated in central India.

Madhya Pradesh is bounded by the states of Uttar Pradesh and Rajasthan on the north, Uttar Pradesh and Chhattisgarh on the east, Maharasthra on the south and Gujarat on the west. It is located between latitudes 23^0 10′ N and longitudes77^0 12′ E. The mean annual maximum and minimum temperature is ranged from 50^0 to 2^0 C. The average annual rainfall received from 750 mm, out of which 90 per cent received during rainy season from mid June to end of September. The soils of study area are sandy light and alluvial. All type of crops *viz.*, cereals, legumes, oil seeds, vegetables and fruit crops are being grown.

Sample procedure, sample size, data collection and analysis

Six farmers' fields were selected for assessment of sucking and fruit borer insect pests management technology modules with raised beds planting in Chilli with compared to farmers practices. All the chilli crops were transplanted on the raised beds in the time and recommended agronomical package of practices were followed in all the plots. Each Technology module was laid out in an area of 0.1 ha. Each module was further demarcated into six regions to serve as replications for observations and statistical analysis. The observation was made on five randomly selected plants from each treatment at 70, 85, 100 and 115 DAT. Observations were recorded on the leaf per cent infestation of sucking insect pests from three top, middle and bottom leaves of the canopy from three randomly selected plants. The per cent fruit damage was worked out by counting total number fruits per plant and number of fruits damaged per plant on five randomly selected plants in each treatment at every picking. Chillies were harvested from entire plot and yield was converted to quintals per hectare. Different insect pests management technology modules are given in table 1. Random Block Design were applied for the statically analysis. Data of damage plant part per cent were recorded after sowing of the crop till harvesting. The data of per cent infestation of damaged plant was calculated by using following formula.

$$Damage\ plant\ percentage = \frac{Damaged\ plant / part / leaf / fruit}{Total\ plant / leaf / fruit} \times 100$$

Yield, net return and cost; benefit ratio were also calculated to find out the economics of various modules under study.

Cost Benefit Ratio

The fruit yield per plot was recorded and computed to quintal per hectare. The benefit-cost ratio (CBR) of different modules was calculated by estimating different cost of cultivation and return from fruit yield after converting them to one hectare of land. The average market price of chilli was rupees 2400 per q during the experimental period. Benefit-cost ratio was calculated using the following formula:

$$CBR = \frac{Benefit}{Total\ cost\ of\ cultivation}$$

where, Benefit = Total return – Total cost of cultivation

Table 1
Different modules for sucking and fruit borer insect pest management in chilli.

Modules	*Insect pest management technologies*
T1	Chilli Planting in furrows, Marigold trap crop (one row of marigold for every 18 rows of chilli), vermicompost 1.25 t/ha + Neem cake 250 kg/ha, need based application of Diafenthiuron @ 1g/l and profenofos@ 2 ml/l .
T 2	Chilli Planting in plain, Marigold trap crop(one row of marigold for every 18 rows of chilli), neemcake 250 kg/ha + vermicompost 1.25 t/ha, need based sprays of NSKE @ 5% and NPV @250 LE/ha
T 3	Chilli Planting on raised bed farrow, Neemcake 250 kg/ha + vermicompost 1.25 t /ha at transplanting (TP) and Need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emmamectin benzoate 5 % WDG @ 125 g/ha
T 4	Chilli Planting on flat plain field, Neemcake 250 kg/ ha + vermicompost 1.25 t /ha at transplanting (TP) and Need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emmamectin benzoate 5 % WDG @ 125 g/ha
T 5	100 per cent RDF, recommended plant protection(RPP)- two sprays of dimethoate (1.7 ml/ l) and dicofol (2.5 ml/l) + carbaryl (4 g/l) .
T 6	Farmers practice- Non IPM-module: 2 weeding (15 and 30 DAT) + Endosulfan 35 EC (2 ml/l) 3 sprays at 35, 65, and 85 DAT

RESULTS AND DISCUSSION

Data presented in table 2 indicate that all the technological modules were effective significantly over farmers practice in reducing the per cent infestation of sucking insect pest complex. The minimum infestation percentage (8.9) recorded in module T3, indicated there significantly higher effectiveness in comparison to rest of the modules. The per cent infestation in modules T4, T1, T2 and T5 increases gradually with significant differences among them. Higher infestation per cent of sucking insect pest complex was observed in T1 (15.3), T2 (18.6) and T5 (20.2) and highest 26.0 percent infestation was registered in T6 (farmers practice). The least infestation percentage of fruit borer complex was found in T3 (4.9) among the different modules and it was superior over other treatments. Higher infestation per cent of fruit borer complex was recorded in T4 (8.2), T1 (12.5), T2 (16.4) , T5 (19.1) and T6 (23.4). Further, the mean infestation per cent of insect pest complex in chilli was least (6.9) in T3 and was at par with T4 (9.95). The mean higher infestation percentage of insect pest complex was in T1 (13.9), T2 (17.5) and T5 (19.65) and highest infestation was observed in T6 farmers practice (24.7). The lowest incidence of insect pests in module T3 might be due to the effect of raised beds plantation coupled with need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emamectin benzoate 5 % WDG @ 125 g/ha. Effectiveness of organic amendments *viz.,* neem cake and vermicompost besides neem derivatives against sucking pests has been documented by various workers (Varghese and Giraddi, 2005, Giraddi and Smitha, 2004, Mallikarjun Rao and Ahmed, 1986 and Mallikarjun Rao *et al.,*1999a and 1999b), which lend support to the present findings. The population density of fruit borer in different soil amendments like neem cake and vermicompost (either in combination with neem derivatives or alone) tried against chilli fruit borer has given significant results (Varma, 1994., Mallikarjun Rao *et al.* 1998., Giraddi *et al.* 2003 and Ravikumar, 2004). Further, the present findings are in conformity with report of Shivaramu (1999) who also observed that module comprising of 18 : 1 of chilli : marigold proportion and sequential application of Achook, Dipel and carbaryl recorded less larval load of *H. armigera* and fruit damage in chilli. Similarly, Shrinivasan *et al.,* (1994) reported that 14 and 16 rows of marigold as a trap crop and two sprays of endosulfan on 28th and 35th days after transplanting gave better control of *H. armigera* in tomato ecosystem. Highest fruit yield (58.6 q/ha) of chilli was recorded in module T3 which was significantly superior over other modules. The lowest yield (32.5 q/ha) was registered in module T6 (Farmers' practice). Influence of neemcake and vermicompost on different yield attributing characters and yield are well documented by Smitha (2002), which support to the present findings. The details of cost of cultivation analysis for different IPM modules have been presented in Table 3. Based on fruit yield, the module T3 (3.15) ranked first followed by T4, T1, T2, and T5. The farmers practice (T6) recorded lowest B:C ratio of 1.84. Similar trend

Table 2
Pooled mean infestation per cent and yield obtain in different management technology modules.

Module	*Technologies*	*Sucking insect pests infestation %*	*Fruit borer infestation %*	*Mean insect pests infestation %*	*Yield q/ha*
T1	Chilli Planting in furrows, Marigold trap crop (one row of marigold for every 18 rows of chilli), vermicompost 1.25 t /ha + Neem cake 250 kg/ha, need based application of Diafenthiuron @ 1g/l and profenofos@ 2 ml/l .	15.3 (3.91)	12.5 (3.53)	13.9 (3.72)	45.9
T 2	Chilli Planting in plain, Marigold trap crop (one row of marigold for every 18 rows of chilli), neemcake 250 kg/ha + vermicompost 1.25 t/ha, need based sprays of NSKE @ 5% and NPV @250 LE/ha	18.6 (4.31)	16.4 (4.04)	17.5 (4.18)	41.7
T 3	Chilli Planting on ridge-bed, Neemcake 250 kg/ha + vermicompost 1.25 t /ha at transplanting (TP) and Need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emmamectin benzoate 5 % WDG @ 125 g/ha	8.9 (2.98)	4.9 (2.18)	6.9 (2.62)	58.6
T 4	Chilli Planting on flat plain field, Neemcake 250 kg/ha + vermicompost 1.25 t /ha at transplanting (TP) and Need based application of Spinosad 45 % SC @ 200 g.a.i./ha, sprays of Nimbecidine @ 5 ml/l and Emmamectin benzoate 5 % WDG @ 125 g/ha	11.7 (3.41)	8.2 (2.86)	9.95 (3.51)	50.3
T 5	100 per cent Recommended dose of fertilizer, recommended plant protection (RPP)- two sprays of dimethoate (1.7 ml/l) and dicofol (2.5 ml/l) + carbaryl (4 g/l).	20.2 (4.49)	19.1 (4.37)	19.65 (4.43)	38.8
T 6	Farmers practice- Non IPM-module: 2 weeding (15 and 30 day after transplanting) + Endosulfan 35 EC (2 ml/l) 3 sprays at 35, 65, and 85 DAT	26.0 (5.6)	23.4 (4.83)	24.7 (4.97)	32.5
	SEM	(0.11)	(0.18)	(0.12)	(0.16)
	CD at 5 %	(0.36)	(0.57)	(0.38)	(0.42)
	CV	(4.84)	(8.43)	(5.35)	(6.23)

Values in parenthesis are "x transformed was also followed in CBR of different modules It can be concluded that module T3, and T4 may be considered for sustainable production of chilli. The CBR ratio was also calculated by Vishwakarma *et al.* (2010) for different treatments having organic formulations and novel pesticides against insect pest of chilli and found better then others.

Many other studies also reported similar or higher yields for crops grown on raised beds as compared with flats fields also reduces irrigation water (30–50 %). Raised beds offer the additional possibility of direct drilling, and reducing tillage costs and associated greenhouse gas emissions. There are no long-term studies to evaluate crop performance; effects on soil physical and chemical properties; components of the water balance; effects of weeds, diseases and insect pests (Ram, *et. al.*, 2005). Early, results of participatory farmer evaluations of crops on beds at Ghaziabad were extremely promising (Balasubramanian *et al.*, 2003; Gupta *et al* 2002). Mean yields of crops on beds on 19 farmers fields were 6% higher than mean yields of flat planting. Growing chilli on beds has many advantages including reduced irrigation water, (30–50%), seed rate (25–30%), lodging, water logging, germination of weed, infestation of disease and insect pest, the opportunity for mechanical weeding and fertilizer placement, and improved timeliness of operations due to better surface drainage.

Based on the results obtained in experiments it may be concluded that chilli planting on raised bed and application of vermicompost and neem cake @ 1.25 t /ha and 250 kg/ha respectively and need based application of Spinosad 45 % SC @ 200 g.a.i./ha, & Emmamectin benzoate 5 % WDG @ 125 g/ha is profitable to the chilli growers as evident with CB ratio.

Table 3
Analysis of cost of cultivation in different management technology modules

Module	*Average Cost of cultivation (Rs/ha)*	*Average Gross Return (Rs/ha)*	*Average Net Return (Rs/ha)*	*Benefit-Cost Ratio (Gross Return / Gross Cost)*
T1	44247.0	110160	65913	2.48
T 2	43680.0	100080	56400	2.29
T 3	44563.0	140640	96077	3.15
T 4	44029.0	120720	76691	2.74
T 5	42975.0	93120	50145	2.16
T 6	42355.0	78000	35645	1.84

Note: Rs. 2400/q Sale price of chilli

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