



Demonstration of IPDM Module for the Management of Major Defoliating Insect Pests and Wilt Disease of Chickpea in Prakasam District Andhra Pradesh

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ABSTRACT

Background: A front line demonstration (FLD) on integrated pest and disease management for management of major defoliating insect pests and wilt diseases in chickpea was conducted at Krishi Vigyan Kendra, Darsi, Prakasam District, Andhra Pradesh during 2020-21 and 2021-22.

Methods: The field trials were conducted in Bhodanampadu and Abbayapalem villages of Prakasam District, Andhra Pradesh in an area of 4 hectares in 10 farmer's fields during 2020-21 and 2021-22.

Result: The results revealed that mean larval population of *H. armigera* and *S. exigua* / 10 plants of two years were 1.4 and 1.87 in IPDM module over 8.23 and 4.12 larval population/10 plants during 2020-21 and 2021-22 respectively in farmers practice. Mean wilt disease incidence of two years were 7.5 per cent in IPDM module over 18 per cent in farmers practice. IPDM plot gave an average yield of 13.78 q/ha as compared to farmer's practices i.e 11.25 q/ha. The per cent increase in yield over control was 16.8 and 31.4 during 2020-21 and 2021-22, respectively. The net returns were Rs. 44568, Rs. 24061 and Rs. 35675, Rs. 10875 in IPDM plot and farmers practice plot during 2020-21 and 2021-22 respectively. The average cost benefit ratio was 1:2.23 and 1:1.87 in IPDM and farmers practice plot, respectively.

Key words: Chickpea, Defoliating insect pests, Disease management, Front line demonstration, Integrated pest, Wilt disease.

INTRODUCTION

Chickpea is an important grain legume crop of tropical and subtropical countries in Asia, Africa and Latin America. In the Andhra Pradesh, the normal area sown is 4-5 lakh hectares during *Rabi* season. In the Prakasam district, chickpea is cultivated during *Rabi* season in an area of 92410 ha and 87400 ha during 2020-21 and 2021-22 respectively. The major constraints in chickpea cultivation is insect pests like *Helicoverpa armigera*, *Spodoptera exigua* and *Fusarium* wilt and dry root rot diseases that pose great threat to chickpea production. *H. armigera* inflicts heavy loss on chickpea from the stage of a seedling up to its maturity, but the maximum damage is caused during pod formation stage and it causes 10-60% yield loss in chickpea (Srinivastava, 2007). *S. exigua* causes heavy damage to the germinating seedlings and the crop up to the vegetative stage. In severe cases, it defoliates the crop completely at early stages of growth (Jagadish and Sharma, 2017). Chickpea wilt caused by *Fusarium oxysporium* is the most important soil borne disease of chickpea throughout the world and particularly in the Indian sub-continent. *Fusarium* wilt pathogen can destroy the crop completely and reduces yield, especially in low rainfall regions which is permanent threat to the chickpea growing areas. This diseases causes yield losses up to 100% under favorable conditions (Anjaiah *et al.*, 2003). Prakasam district is a drought prone area where it receives low rainfall and wilt is serious problem in chickpea growing areas. Most of the farmers are using

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only pesticides for the control of this pest and diseases and this has led to an increase in the cost of cultivation. There is no single tool available for controlling this pest and diseases, but integrated pest and disease management (IPDM) is mooted as a crop protection package to keep pest population below the economic threshold level. Regular monitoring of the pest is the basis of IPM decision making. Where, information on severity of pest damage, vulnerable stage of the insect for imposing treatments and favorable conditions for disease spread can be gathered. In this context the Integrated pest and disease management (IPDM) module has been validated in the field conditions at Prakasam district during 2020-

21 and 2021-22 to reduce the major defoliating insect pests and wilt disease.

MATERIALS AND METHODS

The field trials were carried out in ten farmers field of Bodanampadu and Abbayapalem villages of Prakasam District, Andhra Pradesh during *Rabi* season (October II fortnight to February I fortnight) in an area of 4 hectares (each year) under front line demonstration. In Bodanampadu village chickpea is cultivated in an area of 50 acres. Bodanampadu village is situated at 15.85°N latitude and 79.59°E longitude and at an elevation of 121 meters above sea level. Abbayapalem village is situated at 15.84°N latitude and 79.55°E longitude and at an elevation of 121 meters above sea level. In Abbayapalem village chickpea is cultivated in an area of 45 acres. The soil type is light red soils with a pH ranged 7.88-8.28 and EC of 0.11-0.24 ms/cm with a soil nutrients of organic carbon 0.68-1.05%, nitrogen 190-265 kg/ha, phosphorous 22-36 kg/ha and potassium 539-781 kg/ha.

All the agronomic practices like sowing, irrigation, fertilizers application and herbicides spraying were the same in both IPDM module and farmers practice in their respective years. The detailed description of IPDM module and farmers practice is given in Table 1. The IPDM module was assessed in *Rabi* season during 2020-21 and 2021-22.

IPDM module

- Deep summer ploughing.
- Use of wilt resistant variety NBeG 49.
- Seed treatment with *Trichoderma viride* @ 10 g/kg of seed.
- Application of *Trichoderma viride* @ 2 kg with 90 kg FYM and 4 kg neem cake before sowing.
- Following optimum spacing.
- Fixing of bird perches after crop establishment.
- Application of correct dosage of fertilizers at appropriate stages of crop growth.
- Marigold as trap crop.
- Installation of pheromone traps @ 4 traps/acre.
- As a prophylactic measure spray neem oil @ 1 liter/acre (15 days after sowing).
- Based on ETL: Spraying of Chlorantraniliprole 18.5% SC @ 50 ml/ac against pod borers.

Economic threshold levels (ETLs)

Spodoptera exigua-one larvae/square meter under the soil near cut plant at seedling stage; *Helicoverpa armigera*-5-8 eggs or 2 early instar/10 plants or one mature larvae (more than 1 cm in length)/10 plants or 1 meter row at vegetative/reproductive stage.

Farmers practice

Sowing of wilt susceptible JG 11 chickpea variety, not following seed treatment and use of imbalance fertilizers, not following IPDM practices and indiscriminate spraying of insecticides.

These studies also provide information about the favourable periods for pest buildup that help in the management of the pest. The meteorological data on Maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall was collected from Andhra Pradesh State Development Planning Society, Vijayawada, Andhra Pradesh for *Rabi* season. To know the correlation between *Spodoptera exigua* and *Helicoverpa armigera* population and weather parameters, a correlation test was conducted. Through data analysis tool the full model regression equations and correlation were analyzed.

Data were recorded on adult moth trap catches/trap/week and numbers of larvae of *S. exigua* and *H. armigera*, on 10 randomly selected plants at five spots were collected.

The incidence of wilt was recorded randomly in 1 m² in five spots of a field. The number of healthy and diseased plants was counted in 1 m². The data on disease incidence was recorded using the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of wilted plants}}{\text{Total number of plants}} \times 100$$

Information of yield data, economic evaluation in terms of gross returns, net profit earned and cost benefit ratio was recorded.

In this study, the economic analysis of technology was worked out by calculating the total cost of cultivation (Total cost incurred for cultivation of chickpea), gross return (Yield × Price of the produce), net return (Gross returns - Total cost of cultivation) and C:B ratio (Gross returns /Total cost of cultivation) of IPM module followed plot and farmer's practice plot.

	IPDM	Farmer
Deep summer ploughing	Yes	No
Use of wilt resistant variety NBeG 49	Yes	No
Seed treatment with <i>Trichoderma viride</i> @ 10 g/kg of seed		
Application of <i>Trichoderma viride</i> @ 2 kg with 90 Kg FYM and 4 kg neem cake before sowing	Yes	No
Following optimum spacing	Specify what was the spacing	Specify what was the spacing
Etc.		

RESULTS AND DISCUSSION

The data presented in Table 2 indicated that the pheromone trap catches of *S. exigua* were negligible during 42nd and 43rd standard week and gradually increased and reached peak level at 45th standard week (14.6 adult moths/trap/week) and further started to decrease. Whereas pheromone trap catches of *H. armigera* were negligible from 42nd to 50th standard week. From 51th standard week started to increase and reached peak level at 05th standard week (14.68 adult moth trap catches/trap/week) during 2020-21.

During 2020-21 pheromone trap catches of *S. exigua* adult moth were positive correlated with weather parameter like minimum temperature (0.50), rainfall (0.30) and negatively correlated with morning relative humidity (-0.61). Regression analysis of the *S. exigua* incidence during 2020-21 indicates that all the parameters *i.e.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall together influenced *S. exigua* incidence to the extent of 59 per cent ($R^2 = 0.59$).

The full model regression equations developed is as follows.

$$Y = 113.4 + (0.28) \text{ Max Temp} + (-2.18) \text{ Min Temp} + (-1.04) \text{ Morning RH} + (0.43) \text{ Evening RH} + (-0.23) \text{ RF}$$

During 2020-21 pheromone trap catches of *H. armigera* adult moth were positive correlated with weather parameter like morning relative humidity (0.49), maximum temperature (0.23) and negatively correlated with minimum temperature (-0.57), evening relative humidity (-0.41).

Regression analysis of the *H. armigera* incidence during 2020-21 indicates that all the parameters *i.e.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall together influenced *H. armigera* incidence to the extent of 74 per cent ($R^2 = 0.74$).

The full model regression equations developed is as follows.

$$Y = -76.8 + (0.54) \text{ Max Temp} + (0.66) \text{ Min Temp} + (0.77) \text{ Morning RH} + (-0.38) \text{ Evening RH} + (0.30) \text{ RF}$$

The data presented in Table 3 indicated that the pheromone trap catches of *S. exigua* were negligible during 42nd and 43rd standard week and gradually increased with 15.2 adult moth trap catches/trap/week) and further started to decrease. Whereas pheromone trap catches of

Table 1: Details of botanical/chemical insecticides used in IDPM model followed plots.

Botanical insecticide/ chemical insecticide	Dosage of formulation/ acre (g or ml)	Main group/primary site of action	Subgroup/ class	Waiting period (days)
Azadirachtin 0.03% EC	1000	Azadirachtin	Unkonwn mode of action	05
Chlorantranilprole 18.5% SC	50	28	Diamide	11

Table 2: Pheromone trap catches of *Spodoptera exigua* and *Helicoverpa armigera* in chickpea and weather parameters influencing the population during 2020-21.

Standard meterological week (SMW)	Period	Average number of male moths/trap /week		Weather parameters				
		<i>Spodoptera exigua</i>	<i>Helicoverpa armigera</i>	T (°C) max	T (°C) min	RH (%) morning	RH (%) evening	Rainfall (mm)
42	15 Oct-21 Oct	0	0	31.78	24.67	85.9	62.62	2.67
43	22 Oct-28 Oct	0	0	33.3	24.3	85.8	57.3	0.03
44	29 Oct-4 Nov	13.4	0	33.5	24.3	76.1	46.4	0
45	5 Nov-11 Nov	14.6	0	32.0	23.6	81.3	52.0	0.3
46	12 Nov-18 Nov	10.3	0	29.3	23.5	98.0	90.6	7.7
47	19 Nov-25 Nov	7.4	0	31.3	22.8	93.7	78.7	0
48	26 Nov-02 Dec	8.3	0	27.08	20.9	85.5	66.5	23.17
49	03 Dec-09 Dec	3.2	0	29.56	22.45	96.4	72.31	0
50	10 Dec-16 Dec	1.8	0	29.9	19.8	100	60.44	0
51	17 Dec-23 Dec	2.3	0.53	21.4	20.13	96.35	61.88	0
52	24 Dec-31 Dec	1.3	3.32	28.8	19.05	97.95	60.48	0
01	01 Jan-07 Jan	0.9	5.21	27.9	20.95	97.8	67.8	0
02	08 Jan-14 Jan	0.9	7.13	31.2	20.91	93.11	56.4	0
03	15 Jan-21 Jan	0	10.24	31.54	19.7	99.14	55.17	0
04	22 Jan-28 Jan	0	12.57	32.35	19.57	97.7	50.65	0
05	29 Jan-04 Feb	0	14.68	31.88	20.34	100.07	53.54	0

T (°C) max- Maximum temperature; T (°C) min- Minimum temperature; RH (%) Mor- Morning relative humidity; RH (%) eve- Evening relative humidity.

H. armigera were negligible from 42nd to 49th standard week. From 50th standard week started to increase and reached peak level at 05th standard week (19.36 adult moth trap catches/trap/week) during 2021-22. Sagar *et al.* (2022) reported that the *H. armigera* population initiation took place from 6th SMW and reached the peak during 12th and 15th SMW with 37.3 and 62 male moths/trap/week during 2015-16 and 2017-18 respectively.

During 2021-22 pheromone trap catches of *H. armigera* adult moth were positive correlated with weather parameter like evening relative humidity (0.09) and negatively correlated with minimum temperature (-0.66), relative humidity morning (-0.38).

Regression analysis of the *H. armigera* incidence during 2021-22 indicates that all the parameters *i.e.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall together influenced *H. armigera* incidence to the extent of 50 per cent ($R^2 = 0.50$). Mehra *et al.* (2023) reported that all weather parameters collectively accounted for 81.30 and 52.20 per cent variability in *H. armigera* larval population of pod borer during 2014-15 and 2015-16 respectively.

The full model regression equations developed is as follows.

$$Y = 87.5 + (-1.02) \text{ Max Temp} + (-1.17) \text{ Min Temp} + (-0.23) \text{ Morning RH} + (0.01) \text{ Evening RH} + (-0.07) \text{ RF}$$

During 2021-22 pheromone trap catches of *S. exigua* adult moth were positive correlated with weather parameter

like rainfall (0.61), minimum temperature (0.44) and negatively correlated with maximum temperature (-0.26).

Regression analysis of the *S. exigua* incidence during 2021-22 indicates that all the parameters *i.e.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall together influenced *S. exigua* incidence to the extent of 61 per cent ($R^2 = 0.61$).

The full model regression equations developed is as follows:

$$Y = 23.4 + (-1.41) \text{ Max Temp} + (0.94) \text{ Min Temp} + (0.04) \text{ Morning RH} + (-0.08) \text{ Evening RH} + (0.11) \text{ RF}$$

Kamakshi *et al.* (2018) reported that pheromone trap catches of *S. exigua* adult moth in chickpea has positive correlation with minimum temperature ($r=0.78$), maximum temperature ($r=0.73$) and soil temperature ($r=0.887$) and negatively correlated with morning relative humidity ($r=0.544$). Similarly, Spoorthi *et al.* (2017) revealed that pheromone trap catches of *H. armigera* adult moth in chickpea has positive correlation with relative humidity ($r=0.27$) and rainfall ($r=0.09$) during Rabi season, 2016-17.

Maximum larval population was recorded in farmers practice compared to IPDM technology. The mean larval population of *H. armigera*/10 plants of two years were 1.4 in IPDM module over 8.23 larval population/10 plants in farmers practice. Whereas, mean larval population of *S. exigua*/10 plants of two years were 1.87 in IPDM module over 4.12 larval population/10 plants in farmers practice (Table 4). Shankar *et al.* (2014) reported that the larval

Table 3: Pheromone trap catches of *Spodoptera exigua* and *Helicoverpa armigera* in chickpea and weather parameters influencing the population during 2021-22.

Standard meteorological week (SMW)	Period	Average number of male moths/trap/week		Weather parameters				
		<i>Spodoptera exigua</i>	<i>Helicoverpa armigera</i>	T (°C) max	T (°C) min	RH (%) Mor	RH (%) eve	Rainfall (mm)
42	15 Oct-21 Oct	0	0	34.5	25.77	99.7	53.57	15.01
43	22 Oct-28 Oct	0	0	32.0	24.78	95.16	67.6	0
44	29 Oct-4 Nov	15.2	0	29.9	24.67	100	100	79.28
45	5 Nov-11 Nov	12.3	0	29.45	23.6	95.14	95.14	66.71
46	12 Nov-18 Nov	9.6	0	29.97	25.08	100	100	81.71
47	19 Nov-25 Nov	4.3	0	30.12	24.57	100	100	76.57
48	26 Nov-02 Dec	5.2	0	28.97	23.7	97.42	97.42	75.57
49	03 Dec-09 Dec	3.2	0	31.28	22.84	85.57	85.57	69.14
50	10 Dec-16 Dec	2.0	0.14	30.31	22.27	98.07	98.07	61.11
51	17 Dec-23 Dec	3.1	1.25	29.74	18.37	91.52	91.52	49.07
52	24 Dec-31 Dec	2.3	2.30	30.66	18.8	98.9	98.9	59.23
01	01 Jan-07 Jan	1.3	6.25	30.28	20	97.54	97.54	51.9
02	08 Jan-14 Jan	0	10.5	30.64	20.68	98.64	98.64	61.46
03	15 Jan-21 Jan	0	14.52	29.21	20.28	98.25	98.25	54.98
04	22 Jan-28 Jan	0	17.25	31.17	21.01	84.31	84.31	44.8
05	29Jan-04 Feb	0	19.36	27.52	16.32	91.41	91.41	42.28

T (°C) max- Maximum temperature; T (°C) min- Minimum temperature; RH (%) Mor-Morning relative humidity; RH (%) eve- Evening relative humidity.

density of *H. armigera* (0.3/10 plants and 1.1/10 plants) and *S. exigua* (0.2/10 plants and 42.7/10 plants) on chickpea in Andhra Pradesh during the 2010-11 and 2011-12 post rainy season respectively. Vipin *et al.* (2022) reported that one *H. armigera* larvae density/plant, 29.05, 24.78 per cent pods were damaged during 2015-16 and 2016-17, respectively and with the increase in larvae density/ plant there was increase in damage pods. At 2, 3, 4 and 5 larval density per plant, the percentage of damaged pods on number basis were 39.16, 48.78, 52.50 and 64.55 during 2015-16. While 36.45, 47.78, 56.32 and 67.76 per cent respectively during 2016-17.

Weather and climatic factors influence the wilt incidence

During the demonstration period *i.e* from October II fortnight to February I fortnight, 231.3 mm and 248.95 mm of rainfall was received during 2020-21 and 2021-22 respectively. Maximum mean temperature was 31.50°C and 29.89°C; minimum mean temperature was 22.23°C and 21.66°C; mean morning relative humidity was 94.15 per cent and 92.86 per cent; mean evening relative humidity was 58.31 per cent and 54.61 per cent during 2020-21 and 2021-22 respectively (Table 5). The spread of wilt pathogens is more in heavy soil types compared to light soils and also wilt incidence was higher under rainfed conditions due to favourable conditions of high temperature and low moisture prevailed during crop growth period Thaware *et al.* (2015). Wilt incidence increases when chickpea is grown in warmer and drier climates (>25°C) (Nene *et al.*, 2012).

Higher per cent of wilt disease incidence was recorded in farmers practice compared to IPDM practice. The mean wilt disease incidence of two years was 7.5 per cent in IPDM module over 18 per cent in farmers practice

(Table 6). Heavy incidence of wilt disease was encountered in farmers practice due to not sowing of resistant variety, no seed treatment and lack of application of *Trichoderma viride* in the fields while it got checked in IPDM fields. Parmar and Gohel, (2024) revealed that seed biopriming of *T. viride* or *T. asperellum* followed by soil application of *T. viride* or *T. asperellum* enriched FYM found significant for the disease management as well as higher yields. Venakatamanamma *et al.* (2018) reported that the NBeG 49 genotype showed resistant reaction to wilt disease incidence in the field and green house screening with an average wilt disease incidence of 5.50 per cent during 2014-15 and 2015-16. Similarly, Badariprasad *et al.* (2019) reported that NBeG 47 chickpea variety found tolerant to *Fusarium* wilt disease incidence with an average of 9.09 per cent compared to check variety JG 11 where per cent of wilt disease incidence is 13.52. The pathogen *F. oxysporum* f. sp. *ciceris* is a highly variable nature of growth, colonization and infection also. So, it regularly overcomes the host (chickpea) resistance and causes highly yield loss with their pathogenic nature. The individual management strategy was not applicable to control the pathogen and yield loss. Despite a combined application strategy was given better management in the wilt of chickpea especially on *Rabi* season (Murali *et al.*, 2024).

Regular monitoring of the insect pests and diseases in the year 2020-21 and 2021-22 revealed that defoliating insect pests *Spodoptera exigua*, *Helicoverpa armigera* are the major insect pests followed by low infestation of aphids. Among diseases, *Fusarium* wilt and dry root rot was the major problem followed by rust and blight. Rust disease which became serious problem during 2021-22.

Table 4: Impact of IPDM technology on defoliating insect pests in chickpea during 2020-21 and 2021-22.

Year	<i>Helicoverpa armigera</i> larvae/10 plants		<i>Spodoptera exigua</i> larvae/10 plants	
	IPM	Farmers practice	IPM	Farmers practice
2020-21	1.6	7	1.3	3
2021-22	1.2	9.46	2.45	5.25
Mean	1.4	8.23	1.87	4.12

Table 5: Weather parameter prevailed during the demonstration period.

Month	2020-21				2021-22			
	T (°C)	T (°C)	RH (%)	RH (%)	T (°C)	T (°C)	RH (%)	RH (%)
	max	min	mor	eve	max	min	Mor	eve
October II fortnight	34.73	27.84	95.76	61.44	30.94	25.14	97.93	54.8
November I and II fortnight	30.8	23.05	83.9	65.84	28.06	24.6	98.2	64.2
December I and II fortnight	29.49	20.41	96.91	64.4	29.2	19	87	52
January I and II fortnight	30.5	20.93	97.25	56.17	29.24	19.61	93.01	55.54
February I fortnight	32.02	18.95	96.94	43.7	32.05	19.98	88.2	46.52
Mean	31.50	22.23	94.15	58.31	29.89	21.66	92.86	54.61

T (°C) max- Maximum temperature; T (°C) min- Minimum temperature; RH (%) Mor- Morning relative humidity; RH (%) eve- Evening relative humidity.

Table 6: Per cent disease incidence of *Fusarium oxysporum* f.sp. *ciceris* in chickpea during 2020-21 and 2021-22.

Year	Wilt incidence (%)	
	NBeG 49 variety + IPDM practices	JG 11 variety + Farmers practice
2020-21	6.50	16.00
2021-22	8.50	20.00
Mean	7.5	18

Table 7: Economic analysis of demonstration in chickpea.

Year	Yield q/ha		Gross returns (Rs. ha ⁻¹)		Net returns (Rs. ha ⁻¹)		C:B ratio	
	IPM module	Farmer practice	IPM module	Farmer practice	IPM module	Farmer practice	IPM module	Farmer practice
2020-21	16.06	13.75	72281	61875	44568	35675	1:2.60	1:2.36
2021-22	11.5	8.75	51750	39375	24061	10875	1:1.86	1:1.38
Mean	13.78	11.25	62015	50625	34314	23275	1:2.23	1:1.87

Yield impact

The mean yield of farmers practice was 11.25 q/ha. Whereas it was 13.78 q/ha in IPDM module. In IPDM module, which gave 22.48 per cent increase in yield over farmers practice. Economic performances of chickpea under front line demonstration were depicted in (Table 7). Jat, B.L (2020) reported that average chickpea yield production was 19.2 and 19.8 q/ha was observed in demonstrated technology as compared to farmer's practices (15.6 and 15.4 q/ha during 2018-19 and 2019-20 years, respectively.

Economic impact

In this study, the economic impact of technology was worked out by calculating total cost of cultivation, gross return, net return and C:B ratio of IPDM module followed plot and farmer practice plot. Total cost was calculated by total sum of expenditure of land preparation, seed, irrigation, labour component, cost incurred for fertilizers, pesticides and harvesting.

The economic analysis results revealed that the chickpea recorded highest mean gross returns of IPDM module were 62015 Rs. ha⁻¹ as compared to 50625 Rs. ha⁻¹ farmers practice. Net returns of IPDM module were 34314 Rs. ha⁻¹ as compared to 23275 Rs. ha⁻¹ in farmers practice. The C:B ratio in IPDM module was 1:2.23 while, in farmer practice was 1:1.87. IPDM module proved beneficial in respect of yield and economics of chickpea (Table7).

It was evident from the results that C:B ratio of chickpea crop in IPDM module was higher than the farmer practice. The factor responsible for lower C:B ratio in farmer practice because of non adoption of IPDM module for defoliating insect pests and wilt disease management in chickpea crop. However, increase in C:B ratio in treatment plot was due to the adoption of IPDM module.

The present findings are in conformity with the findings of Yadav *et al.* (2022) reported an average yield of 19.85 q/ha with net returns of Rs. 74690 (C:B 1:3.1) in IPM plot compared to farmers practices which obtained an yield of

14.5 q/ha with net returns of Rs. 46935 (C:B 1:1.8) in chickpea crop. Similarly, Jayalakshmi *et al.* (2022) reported an average yield of 14.36 q/ha with improved desi variety Nandyal gram 49 by following improved technology (IPM and IDM) in demonstration field whereas in farmers practice field which obtained an yield of 12.05 q/ha in chickpea crop.

CONCLUSION

IPDM module was formulated and tested for the management of major defoliating insect pests and wilt disease and seems to be promising as other IPM modules in the management of other pests in pulse crops. The mean larval population of *H. armigera*/10 plants of two years were 1.4 in IPDM module over 8.23 larval population/ 10 plants in farmers practice. Whereas, mean larval population of *S. exigua*/10 plants of two years were 1.87 in IPDM module over 4.12 larval population/10 plants in farmers practice. Higher per cent of wilt disease incidence was recorded in farmers practice compared to IPDM practice. The mean wilt disease incidence of two years was 7.5 per cent in IPDM module over 18 per cent in farmers practice. Heavy incidence of wilt disease was encountered in farmers practice due to not sowing of resistant variety, no seed treatment and lack of application of *Trichoderma viride* in the fields while it got checked in IPDM fields. The mean yield of farmers practice was 11.25 q/ha. Whereas it was 13.78 q/ha in IPDM module. In IPDM module, which gave 22.48 per cent increase in yield over farmers practice. The C:B ratio in IPDM module was 1:2.23 while, in farmer practice was 1:1.87. IPDM module proved beneficial in respect of yield and economics of chickpea. Therefore, this can be one of the viable options for the management of major defoliating insect pests and wilt disease in the future. It can be concluded that growing of wilt resistant variety by following seed treatment and 1-2 insecticidal sprayings in combination with IPDM interventions against major defoliating insect pests are

enough to achieve higher yields when compared to farmer practices with 2-3 insecticidal mixture sprayings. By reducing the number of sprayings and cost of plant protection paves way for reduced environmental pollution and also decreases the impact on natural enemies. Farmers may adopt this IPDM technology for effective control of major defoliating insect pests and wilt disease in chickpea for higher yields.

Conflict of interest

The authors declare that they have no conflict of interests.

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