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Effect of different Agro techniques for pod borer complex management in Pigeonpea (*Cajanus cajan* L. Millsp.)

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Abstract
A field experiment was conducted during the rainy season of 2014-2015 on ""Evaluation of agro-techniques for yield maximization in pigeonpea [*Cajanus cajan* (L.) Millsp.]" at Experimental Farm of Agricultural research station Badnapur, Marathwada Agril. University, Parbhani. To find out The IPM treated plot *viz.*, IPM; INM + IPM; IWM + IPM and INM+IWM+IPM recorded significantly lower population of *Helicoverpa armigera*, Plume moth, Maruca and pod fly and percent of pod damage by *Helicoverpa armigera*, Plume moth, *Maruca* and pod fly as compared to untreated plot. In IPM treated plot INM + IWM + IPM recorded significantly highest seed yield followed by IWM + IPM as compared to control.

Keywords: Pigeon pea, pest management, IPM

Introduction
Pulses constitute an important ingredient in predominantly vegetarian diet and are important source of protein that nutritionally balances the protein requirement of vegetarian population. They supply minerals and vitamins and provide an abundance of food energy. Pulses provide a cheaper source of nutrients/ proteins as they generally contain nearly twice as much as protein as that of cereals and hence correctly called poor man's meat. Pulses are also important for sustainable agriculture enriching the soil through biological fixation. (Hariprasanna and Bhatt, 2002) [3].

Pigeonpea is most important *kharif* pulse crop. Pigeon pea is a main source of protein (22.3 per cent), minerals (3.5 per cent), and carbohydrates (57.6 per cent) and provides 335 k cal energy per 100g. It accounts for about 11.8% of the total pulse area and 17% of the total pulse production of the country. Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Andhra Pradesh accounts for 87% area of the country and 83.8% of total production. Bihar and Haryana have the highest productivity 1115 kg ha^{-1} and 1036 kg ha^{-1} respectively.

Over 250 species of insects belonging to 8 orders and 61 families have been found to attack the pigeonpea. Among these only few are economically important as pest *viz*., Tur plume moth, *Exelastis atomosa* (Walsh), *Helicoverpa armigera* (Hubner) and Tur Pod fly, *Melanagromyza obtusa* (mall) collectively referred as "Pod borer complex". This pod borer complex recorded economical damage at various places ranging 30 to 100 per cent. As result we have to import pulses from other countries by investing a huge amount, in addition to direct loss to cultivators (Lal and Katti, 1998) [2]. Hence pest management is an important aspect for increasing yield in pigeonpea. Integrated Pest Management (IPM) is a system that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury. Due to this combination of these management practices help the farmers for increased yield in pigeonpea.

Materials and Methods
The experiment was laid out in randomized block design (RBD) with nine treatments replicated three times during *kharif*, 2014 at Experimental Farm of Agricultural research station Badnapur, Marathwada Agril. University, Parbhani. The soil of the experimental field was clay loam, low in available N, medium in available P and very high in K content and slightly alkaline in reaction.

The total rainfall received during crop growth period was 639.2 mm in 33 rainy days. Well decomposed FYM (5 t/ha) was applied as per treatment and incorporated in to soil. Seeds of pigeonpea variety BSMR-853 sown on 19 July, 2014 as per treatment by dibbling method. Recommended dose of fertilizer 25 kg N and 50 kg P_2O_5 and 15 kg Z, 20 kg S were applied through urea and single super phosphate before dibbling. The gross and net plot sizes were24.3 and 14.04 m^2 respectively. The seeds were treated with rhizobium and PSB culture @ 200 g/kg seed just before sowing. Cost of cultivation, net returns as well as BC ratio were also worked out.

Data pertaining to population of pod borer complex before 50% flowering are presented in table 1. Before 50% flowering, the population of *Helicovrpa armigera*, Plume moth, and *Maruca* was uniformly distributed among all plots.

Treatment details

1. INM (FYM @ 5t ha^{-1} + RDF i.e. NPKSZn) + *Rhizobium* + PSB
2. IWM (Pendimethalin @ 0.75 Kg ha^{-1} on 3 DAE + Imazethapyr @100 g a.i ha^{-1} on 10-15 DAE of weeds + 1 HW on 50 DAS.
3. IPM (Indoxacarb 15.8% EC at the time of Flowering @ 375 ml ha^{-1} + one Systemic insecticide spray 15 days after first spray.
4. INM + IWM.
5. INM+IPM.
6. IWM + IPM.
7. INM +IWM + IPM.
8. Control (Farmer's practices)

Results and Discussion

Table 1: Population of Pod borer complex before 50% flowering.

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average *Maruca* plant^{-1}	Average Pod fly plant^{-1}
T_1 INM	0.4 (0.87)	0.2 (0.79)	0.2 (0.84)	-
T_2 IWM	0.6 (1.013)	0.2 (0.84)	0.2 (0.84)	-
T_3 IPM	0.4 (0.94)	0.2 (0.84)	0.2 (0.84)	-
T_4 INM + IWM.	0.4 (0.94)	0.2 (0.84)	0.2 (0.84)	-
T_5 INM+IPM.	0.4 (0.95)	0.2 (0.84)	0.2 (0.84)	-
T_6 IWM + IPM.	0.4 (0.95)	0.2 (0.84)	0.2 (0.82)	-
T_7 INM +IWM + IPM.	0.6 (1.016)	0.2 (0.84)	0.2 (0.84)	-
T_8 Control (Farmer's practices)	0.4 (0.95)	0.2 (0.84)	0.2 (0.83)	-
SE +m	0.048	0.040	0.069	
C.D.at 5%	NS	NS	NS	
GM	0.95	0.83	0.83	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

One day before first spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera* Plume moth and *Maruca* one day before first spray are presented in Table 3 and depicted.

As per the treatment schedule the First spraying was adapted at 50% flowering with the Indoxacarb 15.8% EC @ 375 ml ha^{-1}. The population of *Helicoverpa armigera*, Plume moth and *Maruca* was uniformly distributed before spraying.

One day after first spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera*, Plume moth and *Maruca* one day after first spray are presented in Table 4 depicted.

One day after first spraying, the population of *Helicoverpa armigera;* Plume moth and *Maruca* were significantly reduced in all the treated plots over untreated plots.

Table 2: Population of Pod borer complex one day before first spraying.

Treatments	Average Helicoverpa plant^{-1}	Average Plume moth plant^{-1}	Average Maruca plant^{-1}	Average Pod fly plant^{-1}
T_1 INM	1.4 (1.37)	0.6 (1.04)	0.2 (0.83)	-
T_2 IWM	1.0 (1.22)	0.4 (0.94)	0.2 (0.83)	-
T_3 IPM	1.4 (1.37)	0.6 (1.04)	0.2 (0.84)	-
T_4 INM + IWM.	1.4 (1.37)	0.6 (1.05)	0.2 (0.84)	-
T_5 INM+IPM.	1.4 (1.38)	0.6 (1.03)	0.2 (0.82)	-
T_6 IWM + IPM.	1.2 (1.3)	0.6 (1.05)	0.2 (0.84)	-
T_7 INM +IWM + IPM.	1.0 (1.29)	0.6 (1.05)	0.2 (0.84)	-
T_8Control (Farmer's practices)	1.4 (1.37)	0.6 (1.04)	0.2 (0.84)	-

SE +m	0.05	0.06	0.05	
C.D.at 5%	NS	NS	NS	
GM	1.33	1.03	0.83	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

Table 3: Population of Pod borer complex at one day after first spraying

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average *Maruca* plant^{-1}	Average Pod fly plant^{-1}
T_1 INM	1.4 (1.37)	0.6 (1.04)	0.2 (0.79)	-
T_2 IWM	1 (1.22)	0.4 (0.94)	0.2 (0.83)	-
T_3 IPM	0.2 (0.83)	0 (0.71)	0 (0.71)	-
T_4 INM + IWM.	1.4 (1.32)	0.6 (1.05)	0.2 (0.84)	-
T_5 INM+IPM.	0.2 (0.83)	0.02 (0.83)	0.04 0.75	-
T_6 IWM + IPM.	0.2 (0.84)	0.2 (0.83)	0 (0.71)	-
T_7 INM +IWM + IPM.	0.2 (0.83)	0 (0.71)	0 (0.71)	-
T_8 Control (Farmer's practices)	1.4 (1.37)	0.6 (1.04)	0.2 (0.84)	-
SE +m	0.06	0.04	0.03	
C.D.at 5%	0.204	0.134	0.101	
GM	1.203	0.897	0.77	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

One day before second spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera*, Plume moth and Pod fly at one day before second spray are presented in Table 3 and depicted.

As per the treatment schedule the second spraying was adapted at 15th days after first spaying with the Dimethoate 30 EC 0.06 per cent. The population of *Helicoverpa armigera* was uniformly distributed before second spraying, Where as the population of plume moth significantly lower in first spray treated plot *viz.*, IPM;INM +IPM; IWM + IPM and INM +IWM +IPM. The population of pod fly significantly lower in INM + IPM which was on par with INM;IPM and control.

Table 4: Population of Pod borer complex at one day before second spraying

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average Pod fly plant^{-1}	Average *Maruca* plant^{-1}
T_1 INM	1 (1.22)	0.8 (1.13)	1 (1.22)	-
T_2 IWM	1 (1.21)	0.8 (1.14)	1.6 (1.45)	-
T_3 IPM	0.4 (0.94)	0.4 (0.94)	1 (1.22)	-
T_4 INM + IWM.	1 (1.22)	0.8 (1.13)	1.6 (1.42)	-
T_5 INM+IPM.	0.4 (0.94)	0.4 (0.94)	1 (1.21)	-
T_6 IWM + IPM.	0.4 (0.95)	0.4 (0.95)	1.6 (1.45)	-
T_7 INM +IWM + IPM.	0.6 (1.04)	0.4 (0.95)	1.45 (1.6)	-
T_8Control (Farmer's practices)	0.6 (1.05)	0.8 (1.13)	1.4 (1.38)	-
SE +m	0.08	0.048	0.05	
C.D.at 5%	NS	0.145	0.17	
GM	1.07	1.04	1.3	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

One day after second spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera*, Plume moth and pod fly at one day after second spray are presented in Table 6 and depicted.

One day after first spraying, the population of *Helicoverpa armigera* and Plume moth were significantly reduced in all the treated plots over untreated plots. Whereas population of pod fly was significantly lower in only INM; IPM and INM + IPM plots.

Days after second spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera*, Plume moth and pod fly at 15 day after second spray are presented in Table 7.

15 day after second spraying, the population of *Helicoverpa armigera*; Plume *moth* and pod fly were significantly reduced in all the treated plots over untreated plots.

Table 5: Population of Pod borer complex at one day after second spraying

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average Pod fly plant^{-1}	Average *Maruca* plant^{-1}
T_1 INM	1 (1.22)	0.8 (1.14)	1 (1.19)	-
T_2 IWM	1 (1.20)	0.8 (1.14)	1.6 (1.45)	-
T_3 IPM	0.2 (0.83)	0 (0.71)	1 (1.22)	-
T_4 INM + IWM.	1 (1.22)	0.8 (1.14)	1.6 (1.47)	-
T_5 INM+IPM.	0.4 (0.84)	(0.4 (0.84)	1 (1.24)	-
T_6 IWM + IPM.	0.2 (0.87)	0.2 (0.87)	1.6 (1.45)	-
T_7 INM +IWM + IPM.	0 (0.71)	0.04 (0.75)	1.6 (1.45)	-
T_8 Control (Farmer's practices)	1 (1.22)	0.8 (1.14)	1.4 (1.37)	-
SE +m	0.04	0.04	0.06	
C.D.at 5%	0.146	0.132	0.20	
GM	1.015	0.96	1.33	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

Table 6: Population of Pod borer complex at 15 days after second spraying

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average Pod fly plant^{-1}	Average *Maruca* plant^{-1}
T_1 INM	1.2 (1.30)	0.6 (1.01)	1.6 (1.42)	-
T_2 IWM	1.2 (1.30)	0.6 (1.05)	1.2 (1.31)	-
T_3 IPM	0.2 (0.84)	0.83 (0.2)	1 (1.22)	-
T_4 INM + IWM.	1.2 (1.3)	0.94 (0.4)	1.6 (1.42)	-
T_5 INM+IPM.	0.4 (0.84)	0.8 (1.13)	0.8 (1.13)	-
T_6 IWM + IPM.	0.2 (0.82)	0.5 (1.04)	0.5 (1.04)	-
T_7 INM +IWM + IPM.	0 (0.71)	0 (0.71)	0.6 (1.05)	-
T_8 Control (Farmer's practices)	1.4 (1.38)	0.6 (1.04)	1.2 (1.35)	-
SE +m	0.06	0.05	0.06	
C.D.at 5%	0.194	0.083	0.20	
GM	1.05	0.97	1.24	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

30 days after second spraying

Data pertaining to effect of insecticide on population of *Helicoverpa armigera*, Plume moth and pod fly at 30 day after second spray are presented in Table 8.

30 day after second spraying, the population of *Helicoverpa armigera* and Plume *moth* were significantly reduced in all the treated plots over untreated plots. Whereas pod fly population was lower in INM + IPM and INM + IWM + IPM.

Table 7: Population of Pod borer complex at 30 days after second spraying.

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average Pod fly plant^{-1}	Average *Maruca* plant^{-1}
T_1 INM	0.6 (1.19)	0.4 (0.95)	1.2 (1.3)	-
T_2 IWM	0.4 (0.94)	0.4 (0.94)	1 (1.22)	-
T_3 IPM	0 (0.71)	0 (0.71)	0.8 (1.136)	-
T_4 INM + IWM.	0.6 (1.05)	0.2 (0.84)	1 (1.22)	-
T_5 INM+IPM.	0.4 (0.84)	0.04 (0.75)	0.6 (1.19)	-
T_6 IWM + IPM.	0.4 (0.75)	0.2 (0.83)	0.4 (0.94)	-
T_7 INM +IWM + IPM.	0 (0.71)	0 (0.71)	0.4 (0.94)	-
T_8 Control (Farmer's practices)	0.4	0.4	0.8	-

	(0.94)	(0.95)	(1.13)	
SE +m	0.05	0.03	0.04	
C.D.at 5%	0.15	0.11	0.14	
GM	0.89	0.836	1.13	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

Populations of pod fly before harvesting

Data pertaining to effect of insecticide on population of pod fly before harvest are presented in Table 8.

Significantly lower population of pod fly was observed in treated plot *viz.*, IPM; INM + IPM IWM + IPM and INM + IWM + IPM respectively as compared to untreated plot.

Table 8: Population dynamics of Pod borer complex before harvesting

Treatments	Average *Helicoverpa* plant^{-1}	Average Plumemoth plant^{-1}	Average Pod fly plant^{-1}	Average *Maruca* plant^{-1}
T_1 INM	-	-	1.00 (1.22)	-
T_2 IWM		-	1.00 (1.22)	-
T_3 IPM	-	-	0.40 (0.94)	-
T_4 INM + IWM.	-	-	1.00 (1.22)	-
T_5 INM+IPM.	-	-	0.40 (0.91)	-
T_6 IWM + IPM.	-	-	0.40 (0.94)	-
T_7 INM +IWM + IPM.	-	-	0.40 (0.95)	-
T_8 Control (Farmer's practices)	-	-	1.00 (1.21)	-
SE +m			0.06	
C.D.at 5%			0.18	
GM			1.08	

Figures in parentheses are $\sqrt{x + 0.50}$ transformed values

Per cent of pod damage by pod borer complex at harvest

Data pertaining to percent (%) of pod damage by *Helicoverpa armigera*; Plume moth; *Maruca* and pod fly at harvest are presented in table 9 and depicted. The harvested pods were observed for pod damage with *Helicoverpa armigera*; Plume moth; *Maruca* and pod fly.

Percent (%) of pod damage by *Helicoverpa armigera*

The significant reduction in the pod damage with *Helicoverpa armigera* in the IWM + IPM; INM + IWM + IPM;INM; INM +IPM and IPM respectively recorded up to 10.07,10.75,11.28 and 12.90 percent respectively whereas maximum pod damage were observed in INM (28.07) followed by IWM (27.11);Control (28.84) and INM + IWM (25.46).

Percentage (%) of pod damage by Plume moth

The significant reduction in the pod damage with Plume moth in the INM +IWM + IPM; IWM + IPM; INM+IPM and IPM recorded up to 4.99, 5.18, 5.66 and 5.70 percent respectively whereas maximum pod damage were observed in INM (10.20) followed by IWM (9.84); INM + IWM (9.61) and control (8.33).

4.9.3 Percentage (%) of pod damage by *Maruca*

The significant reduction in the pod damage with *Maruca* in the IWM + IPM; INM + IWM + IPM; IPM and INM+IPM recorded up to 2.12, 2.15, 2.20 and 2.57 percent respectively whereas maximum pod damage were observed in Control (4.88) followed by INM (4.68); INM + IWM (4.46) and IWM (4.66).

Table 9: Per cent (%) of pod damage by pod borer complex at harvest

Treatments	% of Pod Damage			
	Helicoverpa	Plume moth	Maruca	Pod fly
T_1 INM	28.07 (31.18)	10.20 (18.56)	4.68 (12.40)	17.48 (24.66)
T_2 IWM	27.11 (31.29)	9.84 (18.24)	4.66 (11.82)	17.53 (24.68)
T_3 IPM	12.90 (20.95)	5.70 (13.71)	2.20 (8.45)	9.43 (17.60)
T_4 INM + IWM.	25.46 (30.25)	9.61 (18.05)	4.46 (12.15)	18.25 (25.25)
T_5 INM+IPM.	11.28 (19.54)	5.66 (13.62)	2.57 (8.88)	10.49 (18.83)
T_6 IWM + IPM.	10.07 (18.04)	5.18 (13.40)	2.12 (8.33)	10.30 (18.47)
T_7 INM +IWM + IPM.	10.75 (19.07)	4.99 (12.83)	2.15 (8.26)	10.35 (18.72)
T_8 Control (Farmer's practices)	23.32 (28.84)	8.33 (16.72)	4.88 (12.58)	17.13 (24.35)

SE +m	1.21	0.73	1.01	0.65
C.D.at 5%	3.66	2.21	3.04	1.98
GM	24.98	15.64	10.24	21.57

Figures in parentheses are angular transformed values

Percentages (%) of pod damage by Pod fly

The significant reduction in the pod damage with Pod fly in the IPM; IWM + IPM; INM+ IWM + IPM and INM + IPM recorded up to 9.43, 10.30, 10.35 and 10.49 percent respectively whereas maximum pod damage were observed in INM + IWM (18.25) followed by IWM (17.53); INM (17.48) and Control (17.13).

Result and Discussion

Effect of IPM The IPM treated plot *viz.*, IPM; INM + IPM; IWM + IPM and INM+IWM+IPM recorded significantly lower population of *Helicoverpa armigera*, Plume moth, Maruca and pod fly and percent of pod damage by *Helicoverpa armigera*, Plume moth, *Maruca* and pod fly as compared to untreated plot. In IPM treated plot INM + IWM + IPM recorded significantly highest seed yield followed by IWM + IPM as compared to control. Similar result was obtained by Singh *et al.* (2003) and Singh *et al.* (2006) [4].

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