International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal
ISSN No: 2456 - 6470 | www.ijtsrd.com | Volume - 2 | Issue – 5

Influence of Various Intercrops on Pod Borers in Black Gram

Selvam. K[1], **Dr. D. S. Rajavel**[2]
[1]Student, [2]Professor and Head
[1]Department of Entomology, Agriculture College and Research Institute Madurai,
Tamil Nadu Agricultural University, PN Pudur, Coimbatore, Tamil Nadu, India
[2]Proffessor and Head, Regional Research Station, Kovilankulam, Virudhunagar Tamil Nadu, India

ABSTRACT
The aim of this study was to observe the influence of various intercrops on pod borers in black gram under rain fed condition. Among the different intercrops studied, marigold recorded the lowest mean population of spotted pod borer (0.74 larva/plant) and gram blue butterfly larva (0.88 larva/plant)and natural enemies like Coccinellids (2.68 beetles/plant) and spider population (1.73 spider/plant) was maximum in black gram intercropped with maize. The maximum equivalent yield was obtained from black gram intercropped with marigold (6.04 q/ha) followed by black gram intercropped with maize (5.24 q/ha).In conclusion marigold proved to be effective intercrop to control major pod borer and also enhance the population of natural enemies.

Keywords: *Black gram, Marucavitrata, Euchrysopscnejus, intercrops, natural enemies and yield*

The pulse crop *viz., Vigna mungo* (L.) Hepper [Synonyms: *Phaseolus mungo* L. (1753)], is often known as black gram which is native to India and Central Asia. It has been grown in these regions since prehistoric times (Vavilov, 1926) and it is an important legume crop in India throughout the year. In India, black gram occupies an area of about 342.79 thousand hectares with a total production of about 2930.60 thousand tonnes (Anon., 2015). Black gram is drought tolerant and gives reasonable yields with as little as 650 mm of rainfall (CBS Kenya Govt, 2003).

In Tamil Nadu, black gram is cultivated in an area of 3.41 lakh ha with 1.21 lakh tonnes production and an average productivity of 354.84 kg ha $^{-1}$ .Besides this, it also contain calorie (350/100g) with vitamins *viz.*, B1, B2 and Miyacin (0.42, 0.37 and 2.0 mg/100g). A part from being major source of protein, it is a rich source of minerals viz., calcium, iron and phosphorus (185, 8.7 and 345 mg/100g). It also contains 56.6 per cent carbohydrates and 1.2 per cent fat. Being rich in protein and phosphoric acid, it is an important part in our diet and animal feed, it helps in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. It is also drought resistant crop and suitable for dry land farming (Parmar *et al.* 2015).Among the several factors responsible for poor yield, undoubtedly, insect infestation is considered as one of the most important factor. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest problems (Rabindra *et al.*, 2004). In India, avoidable yield loss to the tune of 7-35 per cent due to insect-pest infestation in black gram and green gram has been recorded. The annual yield loss due to insect pests has been estimated to 30 per cent in black gram (Hamad and Dubey, 1983).

The key pod borers of black gram include the lepidopteran caterpillars *viz.* the spotted pod borer, *Maruca testulalis* (Geyer) [*Maruca vitrata*], the spiny pod borer, *Etiella zinckenella* Tretsche, the blue butterflies, *Lamp ides boeticus* Linnaeus and *Euchrysops cnejus* Fabricius; the gram caterpillar, *Helicoverpa armigera* (Hubner), and Pink pod borer, *Cydia ptychora* Meyr. However, the blue butterflies, *Lampides boeticus*, *Euchrysops cnejus*, the spotted pod borer, *Maruca testulalis* (Geyer) [*Maruca vitrata*], Pink pod borer, *Cydia ptychora* Meyr are reported as major pests (Srinivasan, 2014). Among

the pod borers, a serious pest of pulse grain was spotted pod borer, *Maruca vitrata* (Geyer) (Taylor, 1967 and Raheja, 1974). Zahid *et al.,* (2008) reported 20–30 per cent pod damage due to *M. vitrata* in green gram. It was known to cause an economic loss of 20 - 25 per cent and a yield loss of 2 – 84 per cent (Vishakantaiah and Jagadeesh Babu, 1980). Among the pod borers, the blue butterfly, *Lampides boeticus* and *Euchrysops cnejus* (Lepidoptera: Lycaenidae) was considered as one of the major borers of black gram (Ganapathy and Durairaj, 2000). The species diversity or the population level of natural enemies may be influenced by the complex environment of the crops. Properly planned cropping system such as non-host crops are cost effective component of IPM. Hence keeping all the above aspects in view, the present investigation a study on impact of different intercrops along with black gram was tested against pod borers in blackgram.

MATERIAL AND METHOD

A separate field experiment was conducted at Regional Research Station, Aruppukkottai. The black gram variety, VBN 6 was sown on 12th September, 2017. The crop was grown under rain fed condition and all the agronomic practices were maintained constant as per the requirement of the crop. To evaluate the effect of intercropping black gram with various crops, sole crop of black gram was sown in plots of size 12m2 (4m×3m) maintaining the row-to-row spacing at 30 cm and plant-to-plant distance at 10 cm to serve as control plot. In the intercropped system, three rows of black gram were alternated with one row each of the intercrop (3:1 ratio). The experiment field was laid out as a Randomized Block Design with ten treatments and three replications. The efficacy of various treatment combinations on the pod borers of black gram, when grown as a sole crop, as well as intercropped with various crops was studied by observing the reduction in population of the pod borers and the per cent pod infestation due and further evaluated for yield and rupee equivalent parameters.

Treatment schedules

Treatments	Intercrop combinationcombinations
T1	Black gram + Sunnhemp
T2	Black gram + Sesame
T3	Black gram + Sarigold
T4	Black gram + Coriander
T5	Black gram + Horse gram
T6	Black gram + Cluster bean
T7	Black gram + Mesta
T8	Black gram + Sunflower
T9	Black gram + Maize
T10	Black gram (Sole crop)

ASSESSMENT OF POD BORERS

The pod borer population counts were made on randomly selected five plants on 40, 47, 54, 61 and 68 DAS (Days after sowing).

Population assessment of spotted pod borer, Maruca vitrata

The incidence of spotted pod borer, *M. vitrata* was recorded on five randomly selected plants during flowering to pod formation stage of the crops. The observations were recorded based on damage hole on the pods are with silken tunnel and two or three pods attached with each other (Soundararajan and Chitra, 2011) and the mean number of larvae per plant was worked out.

Population assessment of blue butterfly, Euchrysops cnejus

The incidence of blue butterfly, *E. cnejus* was recorded from five randomly selected plants during flowering to pod formation stage of the crops. The observations were recorded based small hole in pods (Soundararajan and Chitra, 2011) and the mean number of larvae per plant was worked out.

Assessment of flower damage

The number of healthy and infested flowers were counted and recorded from 25 inflorescences randomly selected per plot and percentage of flower infestation due to spotted pod borer and gram blue butterfly was calculated (Soundararajan and Chitra, 2011).

$$\text{Percentage flower infestation} = \frac{\text{No. of infested flowers}}{\text{Total number of flowers}} \times 100$$

Assessment of pod damage

The number of healthy and infested pods were counted and recorded from each treatment and to calculate percentage of pod infestation due to spotted pod borer and gram blue butterfly (Soundararajan and Chitra, 2011).

$$\text{Percentage pod damage} = \frac{\text{No. of infested pods}}{\text{Total no. of pods}} \times 100$$

Assessment of natural enemies

The number of coccinellids and spiders were recorded on five randomly selected plants per plot on 40, 47, 54, 61 and 68 DAS (Days after Sowing).

Observations on equivalent yield of different intercrop combinations

The seed yield of different intercropping systems were converted in to equivalent yield of black gram at prevailing market rate of black gram and other crops with the help of following expression and data so obtained were subjected to analysis of variance (Chaudhary and Kumawat, 2007).

$$\text{Equivalent yield (qha-1)} = \text{Seed yield of main crop (qha-1)} + \frac{\text{[Seed yield of intercrop (qha-1)] x Price of intercrop (Rs./q)]}}{\text{Price of main crop (Rs./q)}}$$

RESULTS AND DISCUSSION

Effect of various intercrops against spotted pod borer, M. vitrata

The data collected from experiment conducted to evaluate the various intercrops to manage spotted pod borer, *M. vitrata* are tabulated in Table 1. From the table it was observed that initial larval population on 40 days after sowing and it is recorded till the harvesting of pods. Mean number of larva prior to treatment ranged from 0.74 to 1.62 larva /plant. Marigold recorded the lowest mean population (0.74 larvae / plant) of spotted pod borer and this was followed by sunnhemp (0.85 larva/ plant) and cluster bean (1.10 larva / plant). The maximum population of *M. vitrata* was recorded in the plots intercropped with horse gram (1.62 larva / plant). While, the sole black gram crop recorded a maximum of 2.28 larva per plant.

Effect of various intercrops against gram blue butterfly, E. cnejus

The data pertaining to the population of gram blue butterfly on black gram grown along with intercrops are presented in the Table 2. The sole black gram is recorded a maximum of 3.28 larva/plant. On the contrary, Marigold intercropped with black gram indicated the lowest population (0.88 larvae / plant) of gram blue butterfly followed by with maize (0.93 larva / plant), sesame (1.41 larva / plant). The highest population of *E. cnejus* was recorded with horse gram (2.18 larva per plant).

- Peak population of Gram blue butterfly during the crop season

Effect of intercrops against spotted pod borer, M. vitrata and gram blue butterfly, E. cnejus in black gram

The present investigation proves a reduction in pest population due to intercrops. Minimum population of spotted pod borer, *M. vitrata* larva on black gram was recorded with marigold (0.74 larva / plant) followed by sun hemp (0.85 larva/ plant) and cluster bean (1.10 larva/plant) and these results get partial support from the findings of Singh and Singh, (1978) (Fig. 1).

The larval population of gram blue butterfly, *E. cnejus* population on black gram was lowest with marigold (0.88 larva / plant) followed by maize (0.93 larva/ plant) and sesame (1.41 larva/plant).These results are in agreement with that of Alghali (1993) and Ofuya (1991), who recorded similar lower bug populations

and pod borers on cow pea and Dhuri *et al.,* (1986) in cowpea intercropped with maize. Highest pest population in sole maize crop is also supported by Karel *et al.* (1980).

Lesser population of pod borers observed in intercropped green gram plots is in agreement with the report of Gouse and Subbarao (1998) who reported that significantly less larval load of *Helicoverpa armigera* on pigeon pea was observed when it was intercropped with sorghum followed by coriander, marigold and cowpea.

Abdallah (2012) reported that sunflower when sown on the borders of soybean fields attracted *L. boeticus* away from soybean plants while Potdar (2010) reported that pigeon pea + sunflower intercropping system recorded a significantly lower larval population of *H. armigera* per plant than sole crop.

The effect of cluster bean as intercrop on pest incidence was in line with the study of Amaoaka *et al.,* (1983), who reported that when sesame was grown with legumes (cluster bean) comparatively lower capsule damage (6-7%) occured. Balasubramanian *et al.,* (1998) also reported the reduction in pest population due to cluster bean as intercrop in cotton. Intercropped grain yield was maximum with black gram followed by cluster bean (Ahirwar *et al.,* 2009). The pest suppressive effect of marigold is supported by Kumar *et al.* (2008) as chickpea + marigold intercropping significantly reduced larval population of *H. armigera.*

Effect of various intercrops on damage due to spotted pod borer, M. vitrata

Flower damage

From the Table 3 it was observed that flower damage on black gram caused by the pod borer, *M. vitrata* was significantly lesser in intercropped plots than the sole crop plot. Among the various intercrops, marigold (7.43 %) intercropped black gram was recorded with lowest flower damage, followed by black gram with sunnhemp (8.66 %). Highest flower damage was recorded in black gram when raised with horse gram (17.12 %). The sole black gram showed the maximum flower damage of 22.46 per cent.

The per cent reduction of flower damage was maximum (66.91 %) in marigold intercropped with black gram followed by sunnhemp (61.44 %) and horse gram intercropped with black gram showed the least per cent reduction (23.77 %).

Pod damage

The observation on pod damage caused by *M. vitrata* was significantly less in intercropped plots as compared to sole black gram. The data presented in Table 3 showed marigold intercropped with black gram recorded minimum pod damage (6.53 %), followed by black gram raised with sunnhemp (8.39 %). While horse gram intercropped plots recorded 15.94 per cent pod damage whereas the sole black gram plots registered a maximum pod damage of 26.82 per cent. The per cent reduction of pod damage was maximum (75.65 %) in the treatment of black gram intercropped with marigold on pod maturing stage, followed by black gram intercropped with sunnhemp (68.71 %). The treatment of black gram intercropped with horse gram showed the least per cent reduction (40.56 %).

Effect of various intercrops on pod damage due to gram blue butterfly, E. cnejus

Flower damage

The flower damage on black gram caused by the gram blue butterfly, *E. cnejus* are presented in Table 4. Among the various intercrops, the flower damage caused due to *E. cnejus* was minimum when the black gram was intercropped with marigold (3.68 %), followed by black gram with maize (4.33%). Maximum flower damage was recorded in black gram when raised with Mesta (10.43 %). The sole black gram showed the maximum flower damage of 14.88 per cent.

The per cent reduction of flower damage was maximum (75.26 %) in the treatment of black gram intercropped with marigold on flowering stage, followed by black gram intercropped with maize (70.90 %). The treatment of black gram intercropped with Mesta showed the least per cent reduction (29.90 %).

From the table 4, it was observed that marigold recorded minimum pod damage (4.73 %), followed by black gram raised with sesame (5.98 %). While Mesta intercropped plots recorded 11.55 per cent pod damage whereas the sole black gram plots registered a maximum pod damage of 16.34 %. The per cent reduction of pod damage was maximum (71.05 %) in the treatment of black gram intercropped with marigold on pod maturing stage, followed by black

gram intercropped with maize (69.64 %). The treatment of black gram intercropped with Mesta showed the least per cent reduction (29.31 %).

Effect of various intercrops on flower and pod damage due to pod borers

The per cent reduction of flower damage due to *M. vitrata* was maximum (66.91 %) in black gram intercropped with marigold followed by black gram intercropped with sunnhemp (61.44 %). A maximum reduction of pod damage (75.65 %) was recorded in black gram intercropped with marigold followed by black gram intercropped with sunnhemp (68.71 %) (Fig.2).

The per cent reduction of flower damage caused by *E. cnejus* was maximum (75.26 %) in black gram intercropped with marigold during flowering stage, followed by black gram intercropped with maize (70.90 %). The per cent reduction of pod damage was maximum (71.05 %) in black gram intercropped with marigold followed by black gram intercropped with maize (69.64 %) (Fig3).

The present findings are more or less similar to that of Dar *et al.*,(2003) who reported that the green gram intercropped with maize reduced the pod damage caused by the pod borers (*M. vitrata and L. boeticus*). This is also in accordance with the findings of Singh (2014) who reported less pod damage by the pod borer when chickpea was intercropped with marigold. The experimental results are in agreement with that of Karel *et al.* (1980) who reported less pod borer damage was found on cowpea intercropped with maize. Dutta (1996) also reported that intercropping maize and sorghum along the periphery significantly reduced the population and the damage caused by the pod borers (*M. testulalis M. vitrata* and *L. boeticus*) in cowpea.

Population of coccinellids on black gram grown with different intercrops

The population of predatory coccinellids in various intercrops is presented in Table 5. The experiment results found that black gram intercropped maize recorded the maximum coccinellids population (2.68 beetles/plant) followed by marigold (2.52 beetles /plant) which was on par with coriander intercropped plots (2.51 beetles /plant). The sole black gram crop recorded minimum population of coccinellids (1.78 beetles /plant).

Population of spiders on black gram grown with different intercrops

The data presented in Table 6 revealed that the predatory spider population was minimum (0.96 /plant) in sole black gram and maximum population of spiders (1.73/plant) was recorded in maize, followed by black gram with marigold (1.70 /plant) which was on par with Mesta (1.67/plant) similarly, sunflower (1.54/ plant) and coriander (1.52 /plant) also on par with each other.

Effect of various intercrops on the incidence of natural enemies of black gram

Black gram intercropped with maize recorded significantly maximum population of coccinellids (2.68 coccinellids / plant). This was followed by black gram inter cropped with marigold (2.52 coccinellids / plant), coriander (2.51 coccinellids / plant) and Mesta (2.39 coccinellids / plant). The sole black gram crop recorded minimum population of coccinellids (1.78 coccinellids /plant) (Fig 4). A maximum population 1.73 spiders/plant was recorded when black gram intercropped with maize followed by black gram with marigold (1.70 spiders/plant) which was on par with mesta (1.67 spiders/plant) and intercrop sunflower recorded 1.54 spiders/ plant followed by coriander (1.52 spiders/plant) (Fig. 4).

The present findings are in agreement with the intercropping studies carried out by Oloo and Ogeda (1990) who opined that a suitable environment could be available for natural enemies when intercropped with sorghum and maize. A natural enemy favored intercrop of coriander has been envisaged by the report of Rizk (2001) in which the intercropping faba bean with coriander (*Coriandrum sativum*) significantly increased the natural enemy population which in turn significantly decreased the population of *A. craccivora*. The low incidence of insect pests and high incidence of predators in cotton intercropped with cluster bean has been observed by Balasubramanian *et al.* (1998) and Kasina *et al.* (2006) which is in agreement with the present studies.

Effect of various intercrops on black gram yield

The effects of various intercrops on black gram yield are presented in Table 7. The grain yield calculated was maximum in the sole crop (4.40 q/ha). While, the highest equivalent yield was obtained from black gram intercropped with marigold (6.04 q/ha) which was significantly superior over other intercrop combinations. The black gram intercropped with

maize recorded significantly maximum equivalent grain yield (5.24 q/ha) followed by Mesta (4.77 q/ha), cluster bean (4.62 q/ha), sunnhemp (4.57 q/ha), coriander (3.69 q/ha), horse gram (3.89 q/ha), sesame (3.81 q/ ha), sunflower (3.80 q/ha).

Effect of various intercrops on equivalent yield of black gram

The present results showed that the equivalent yields obtained in the plots of sole crop and intercropped plots are in conformatory with the reports of Choudhary and Kumawat (2007) by registering a sole crop yield of 4.40 q/ha while the highest yield was recorded from black gram intercropped with marigold (6.04 q/ha) which was significantly superior over other intercrop combinations (Fig. 5). These results get a partial support from the findings of Alghali (1993). The influence on the yield obtained due to intercropping with cluster bean and sesame were also conformed and supported with investigations of Ahirwar *et al.* (2009).

CONCLUSION

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Table1. Effect of various intercrops on spotted pod borer, *M. vitrata*

S. No	Intercrop combinations	Mean number of larvae per plant					Pooled Mean *
		40 DAS	47 DAS	54 DAS	61 DAS	68 DAS	
1	Black gram + sunnhemp	1.43	1.11	0.86	0.55	0.31	0.85
		(1.19)^{bc}	(1.05)^{a}	(0.92)^{b}	(0.74)^{b}	(0.55)^{b}	(0.89)^{b}
2	Black gram + sesame	1.80	1.63	1.40	1.27	1.07	1.43
		(1.34)^{ef}	(1.27)^{d}	(1.18)^{e}	(1.12)^{e}	(1.03)^{f}	(1.19)^{d}
3	Black gram + marigold	1.39	1.22	0.60	0.38	0.14	0.74
		(1.17)^{ab}	(1.10)^{b}	(0.77)^{a}	(0.61)^{a}	(0.37)^{a}	(0.80)^{a}
4	Black gram + coriander	1.33	1.63	1.73	1.73	1.60	1.60
		(1.15)^{a}	(1.27)^{d}	(1.31)^{f}	(1.31)^{g}	(1.26)^{i}	(1.26)^{e}
5	Black gram + horse gram	1.63	1.53	1.87	1.66	1.43	1.62
		(1.27)^{d}	(1.23)^{c}	(1.36)^{g}	(1.28)^{g}	(1.19)^{h}	(1.27)^{e}
6	Black gram + cluster bean	1.47	1.70	0.93	0.73	0.70	1.10
		(1.21)^{c}	(1.30)^{de}	(0.96)^{c}	(0.85)^{c}	(0.83)^{c}	(1.03)^{c}
7	Black gram + mesta	1.73	1.73	1.73	1.57	1.37	1.62
		(1.31)^{e}	(1.31)^{e}	(1.31)^{f}	(1.25)^{f}	(1.17)^{g}	(1.27)^{e}
8	Black gram + sunflower	1.87	1.63	1.27	1.13	0.97	1.37
		(1.36)^{f}	(1.27)^{d}	(1.12)^{d}	(1.06)^{d}	(0.98)^{e}	(1.16)^{d}
9	Black gram + maize	1.60	1.53	1.30	1.57	0.90	1.38
		(1.26)^{d}	(1.23)^{c}	(1.14)^{d}	(1.25)^{f}	(0.94)^{d}	(1.16)^{d}
10	Black gram (Sole crop)	2.73	2.27	2.03	2.17	2.20	2.28
		(1.65)^{g}	(1.50)^{f}	(1.42)^{h}	(1.47)^{h}	(1.48)^{j}	(1.50)^{f}
	SEd	**0.0155**	**0.0141**	**0.0137**	**0.0134**	**0.0119**	**0.0154**
	CD (P=0.05%)	**0.0327**	**0.0296**	**0.0288**	**0.0281**	**0.0250**	**0.0323**

DAS- Days After Sowing. Figures in the parentheses are √x values * Peak population of spotted pod borer during the crop season

Table2. Effect of various intercrops against gram blue butterfly, *E. cnejus*

S. No	Intercrop combinations	Mean number of larvae per plant					Pooled Mean *
		40 DAS	47 DAS	54 DAS	61 DAS	68 DAS	
1	Black gram + sunnhemp	2.33	2.40	1.97	1.80	1.10	1.92
		(1.52)^{d}	(1.54)^{f}	(1.40)^{f}	(1.34)^{f}	(1.04)^{e}	(1.37)^{d}
2	Black gram + sesame	2.03	2.22	1.20	1.02	0.62	1.41
		(1.42)^{c}	(1.48)^{e}	(1.09)^{c}	(1.00)^{c}	(0.78)^{c}	(1.16)^{b}
3	Black gram + marigold	1.87	1.22	0.69	0.51	0.13	0.88
		(1.36)^{b}	(1.10)^{b}	(0.83)^{a}	(0.71)^{a}	(0.36)^{a}	(0.87)^{a}
4	Black gram + coriander	1.77	1.87	1.66	1.54	0.88	1.54
		(1.33)^{a}	(1.36)^{c}	(1.28)^{d}	(1.24)^{d}	(0.93)^{d}	(1.23)^{c}
5	Black gram + horse gram	2.03	2.66	2.27	2.10	1.88	2.18
		(1.42)^{c}	(1.63)^{g}	(1.50)^{g}	(1.44)^{h}	(1.37)^{i}	(1.47)^{e}
6	Black gram + cluster bean	2.09	2.10	2.00	1.65	1.35	1.83
		(1.44)^{c}	(1.44)^{d}	(1.41)^{f}	(1.28)^{e}	(1.16)^{f}	(1.35)^{d}
7	Black gram + Mesta	2.70	2.63	1.87	1.80	1.75	2.15
		(1.64)^{e}	(1.62)^{g}	(1.36)^{e}	(1.34)^{f}	(1.32)^{h}	(1.45)^{e}
8	Black gram + sunflower	1.80	1.88	1.90	2.00	1.66	1.84
		(1.34)^{ab}	(1.37)^{c}	(1.37)^{e}	(1.41)^{g}	(1.28)^{g}	(1.35)^{d}
9	Black gram + maize	2.04	0.87	0.76	0.66	0.32	0.93
		(1.42)^{c}	(0.93)^{a}	(0.87)^{b}	(0.81)^{b}	(0.56)^{b}	(0.92)^{a}
10	Black gram (Sole crop)	3.40	3.07	3.35	3.20	3.40	3.28
		(1.84)^{f}	(1.75)^{h}	(1.83)^{h}	(1.78)^{i}	(1.84)^{j}	(1.81)^{f}
	SEd	**0.0165**	**0.0170**	**0.0108**	**0.0154**	**0.0107**	**0.0146**
	CD (P=0.05%)	**0.0346**	**0.0358**	**0.0227**	**0.0323**	**0.0225**	**0.0307**

DAS- Days After Sowing. Figures in the parentheses are √x values

Table3. Effect of various intercrops on damage due to spotted pod borer, *M. vitrata*

S. No	Intercrop combinations	Per cent damage (%)			
		Flower damage (%)	Per cent reduction over control	Pod damage (%)	Per cent reduction over control
1	Black gram + sunnhemp	8.66	61.44	8.39	68.71
		(17.11)^{b}		(16.83)^{b}	
2	Black gram + sesame	10.88	51.55	11.94	55.48
		(19.26)^{d}		(20.21)	
3	Black gram + marigold	7.43	66.91	6.53	75.65
		(15.81)^{a}		(14.80)^{a}	
4	Black gram + coriander	13.64	39.26	12.88	51.97
		(21.67)^{f}		(21.03)^{ef}	
5	Black gram + horse gram	17.12	23.77	15.94	40.56
		(24.43)^{i}		(23.53)^{h}	
6	Black gram + cluster bean	12.64	43.72	12.53	53.28
		(20.82)^{e}		(20.73)^{de}	
7	Black gram + mesta	16.55	26.31	14.73	45.07
		(24.00)^{h}		(22.56)^{g}	
8	Black gram + sunflower	14.33	36.19	13.63	49.17
		(22.24)^{g}		(21.66)^{f}	
9	Black gram + maize	9.43	58.01	10.56	60.62
		(17.88)^{c}		(18.96)^{c}	
10	Black gram (Sole crop)	22.46	-	26.82	
		(28.28)^{j}		(31.19)^{i}	-
	SEd	**0.1899**	-	**0.3023**	-
	CD (P=0.05%)	**0.3989**	-	**0.6352**	-

Values in the parentheses are arc sine transformed. Each value is the mean of three replication. In a column, means followed by common letter are not significantly different by LSD (P = 0.05)

Table4. Effect of various intercrops on pod damage due to gram blue butterfly, *E. cnejus*

S. No	Intercrop combinations	Per cent damage (%)			
		Flowering stage		Pod maturing stage	
		Flower damage (%)	Per cent reduction over control	Pod damage (%)	Per cent reduction over control
1	Black gram + sunhemp	8.22	44.75	10.93	33.10
		(16.66)^{g}		(19.30)^{g}	
2	Black gram + sesame	4.92	66.93	5.98	63.40
		(12.81)^{c}		(14.15)^{b}	
3	Black gram + marigold	3.68	75.26	4.73	71.05
		(11.05)^{a}		(12.56)^{a}	
4	Black gram + coriander	5.43	63.50	7.22	55.81
		(13.47)^{d}		(15.58)^{c}	
5	Black gram + horse gram	7.38	50.40	9.44	42.22
		(15.76)^{f}		(17.88)^{e}	
6	Black gram + cluster bean	7.57	49.12	9.88	39.53
		(15.96)^{f}		(18.32)^{f}	
7	Black gram + mesta	10.43	29.90	11.55	29.31
		(18.83)^{h}		(19.86)^{h}	
8	Black gram + sunflower	5.98	59.81	8.35	48.89
		(14.15)^{e}		(16.79)^{d}	
9	Black gram + maize	4.33	70.90	4.96	69.64
		(12.00)^{b}		(12.86)^{a}	
10	Black gram (Sole crop)	14.88		16.34	
		(22.69)^{i}	-	(23.84)^{i}	
	SEd	**0.1921**	-	**0.1731**	
	CD (P=0.05%)	**0.4035**		**0.3637**	

Values in the parentheses are arc sine transformed Each value is the mean of three replication. In a column, means followed by common letter are not significantly different by LSD (P = 0.05)

Table5. Population of coccinellids on black gram grown with different intercrops

S. No	Intercrop combinations	Mean number of coccinellids / plant					Pooled Mean *
		40 DAS	47 DAS	54 DAS	61 DAS	68 DAS	
1	Black gram + sunnhemp	1.70	1.59	1.99	2.13	2.05	1.89
		(1.30)^{c}	(1.26)^{g}	(1.41)^{f}	(1.45)^{g}	(1.43)^{f}	(1.37)^{f}
2	Black gram + sesame	1.83	1.68	2.22	2.35	2.10	2.03
		(1.35)^{b}	(1.29)^{f}	(1.48)^{e}	(1.53)^{f}	(1.44)^{f}	(1.42)^{e}
3	Black gram + marigold	1.55	2.42	2.73	2.88	3.03	2.52
		(1.24)^{d}	(1.55)^{b}	(1.65)^{b}	(1.69)^{b}	(1.74)^{b}	(1.57)^{b}
4	Black gram + coriander	1.93	2.48	2.51	2.66	2.99	2.51
		(1.38)^{a}	(1.57)^{ab}	(1.58)^{c}	(1.63)^{d}	(1.72)^{bc}	(1.58)^{b}
5	Black gram + horse gram	2.01	2.12	2.38	2.49	2.36	2.27
		(1.41)^{a}	(1.45)^{d}	(1.54)^{d}	(1.57)^{e}	(1.53)^{e}	(1.50)^{d}
6	Black gram + cluster bean	1.38	2.23	2.48	2.59	2.56	2.24
		(1.17)^{e}	(1.49)^{c}	(1.57)^{cd}	(1.60)^{d}	(1.59)^{d}	(1.49)^{d}
7	Black gram + mesta	1.40	2.29	2.66	2.77	2.86	2.39
		(1.18)^{e}	(1.51)^{c}	(1.63)^{f}	(1.66)^{c}	(1.69)^{c}	(1.53)^{c}
8	Black gram + sunflower	1.25	1.79	2.38	2.44	2.56	2.08
		(1.11)^{f}	(1.33)^{e}	(1.54)^{d}	(1.56)^{e}	(1.59)^{d}	(1.43)^{e}
9	Black gram + maize	1.74	2.55	2.88	3.00	3.25	2.68
		(1.31)^{c}	(1.59)^{a}	(1.69)^{a}	(1.73)^{a}	(1.80)^{a}	(1.62)^{a}
10	Black gram (Sole crop)	2.01	1.43	1.86	1.74	1.88	1.78
		(1.41)^{a}	(1.19)^{h}	(1.36)^{g}	(1.31)^{h}	(1.37)^{g}	(1.33)^{g}
	SEd	**0.0143**	**0.0168**	**0.0167**	**0.0136**	**0.0183**	**0.0166**
	CD (P=0.05%)	**0.0301**	**0.0353**	**0.0352**	**0.0286**	**0.0384**	**0.0349**

DAS- Days After Sowing. Figures in the parentheses are √x values. * Peak population of coccinellids during the crop season

Table6. Population of Spiders on black gram grown with different intercrops

S. No	Intercrop combinations	Mean number of spiders / plant					Pooled Mean *
		40 DAS	47 DAS	54 DAS	61 DAS	68 DAS	
1	Black gram + sunnhemp	0.70	1.51	1.58	1.62	1.73	1.42
		(0.83)^{f}	(1.22)^{d}	(1.25)^{cd}	(1.27)^{d}	(1.31)^{d}	(1.18)^{d}
2	Black gram + sesame	0.65	1.44	1.53	1.57	1.69	1.37
		(0.80)^{g}	(1.19)^{e}	(1.23)^{d}	(1.25)^{d}	(1.29)^{de}	(1.15)^{d}
3	Black gram + marigold	1.02	1.73	1.82	1.86	2.09	1.70
		(1.00)^{c}	(1.31)^{b}	(1.34)^{b}	(1.36)^{b}	(1.44)^{b}	(1.29)^{ab}
4	Black gram + coriander	0.78	1.55	1.66	1.74	1.87	1.52
		(0.88)^{e}	(1.24)^{cd}	(1.28)^{c}	(1.31)^{c}	(1.36)^{c}	(1.22)^{c}
5	Black gram + horse gram	0.60	1.02	1.14	1.29	1.38	1.08
		(0.77)^{h}	(1.00)^{g}	(1.06)^{f}	(1.13)^{f}	(1.17)^{f}	(1.03)^{f}
6	Black gram + cluster bean	0.87	1.22	1.35	1.48	1.62	1.30
		(0.93)^{d}	(1.10)^{f}	(1.16)^{e}	(1.21)^{e}	(1.27)^{e}	(1.13)^{e}
7	Black gram + mesta	1.13	1.62	1.77	1.82	2.03	1.67
		(1.06)^{i}	(1.27)^{c}	(1.33)^{b}	(1.34)^{b}	(1.42)^{b}	(1.28)^{b}
8	Black gram + sunflower	1.08	1.54	1.63	1.69	1.79	1.54
		(1.03)^{b}	(1.24)^{d}	(1.27)^{c}	(1.29)^{c}	(1.33)^{cd}	(1.23)^{c}
9	Black gram + maize	0.55	1.84	1.93	2.02	2.35	1.73
		(0.74)^{a}	(1.35)^{a}	(1.38)^{a}	(1.42)^{a}	(1.53)^{a}	(1.28)^{a}
10	Black gram (Sole crop)	0.73	0.87	1.02	1.08	1.12	0.96
		(0.85)^{f}	(0.93)^{h}	(1.00)^{g}	(1.03)^{g}	(1.05)^{g}	(0.97)^{g}
	SEd	**0.0102**	**0.0133**	**0.0162**	**0.0116**	**0.0180**	**0.0114**
	CD (P=0.05%)	**0.0215**	**0.0280**	**0.0340**	**0.0243**	**0.0378**	**0.0239**

DAS- Days After Sowing. Figures in the parentheses are √x+0.5 values

*Peak population of spiders during the crop season.

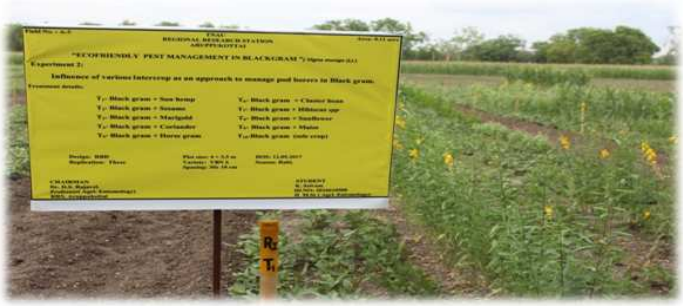
Table7. Effect of various intercrops on black gram yield

S. No	Treatments	Main crop (q/ha)	Intercrop (q/ha)	Equivalent yield (q/ha)
1	Black gram + sunnhemp	3.20	2.90	4.57
				$(2.13)^{cd}$
2	Black gram + sesame	2.58	1.59	3.81
				$(1.95)^{e}$
3	Black gram + marigold	3.25	0.60	6.04
				$(2.45)^{a}$
4	Black gram + coriander	2.53	0.77	3.69
				$(1.91)^{e}$
5	Black gram + horse gram	2.73	1.35	3.89
				$(1.97)^{e}$
6	Black gram + cluster bean	2.40	1.60	4.62
				$(2.14)^{cd}$
7	Black gram + mesta	2.86	2.90	4.77
				$(2.18)^{c}$
8	Black gram + sunflower	2.95	0.99	3.80
				$(1.94)^{e}$
9	Black gram + maize	2.90	3.90	5.24
				$(2.28)^{b}$
10	Black gram (Sole crop)	4.40	0.00	4.40
				$(2.09)^{d}$
	SEd	-	-	**0.0274**
	CD (P=0.05%)	-	-	**0.0576**

*Mean of three replications

Figures in parentheses are square root transformed values in column, means followed by same letters are not significantly different at P=0.05 by LSD (P = 0.05)

PLATES



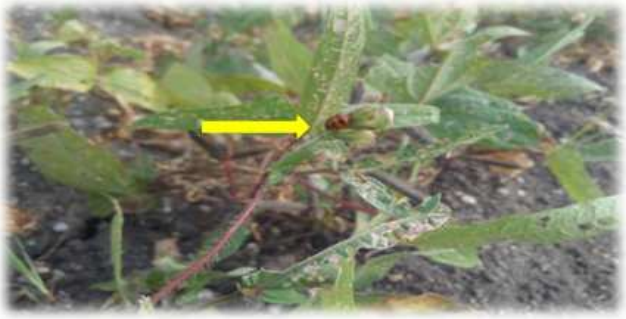
Field trial on various intercrops against major pod borers in black gram

Nature and damage symptom of pod borers in black gram

Larvae of spotted pod borer, *Maruca vitrata*

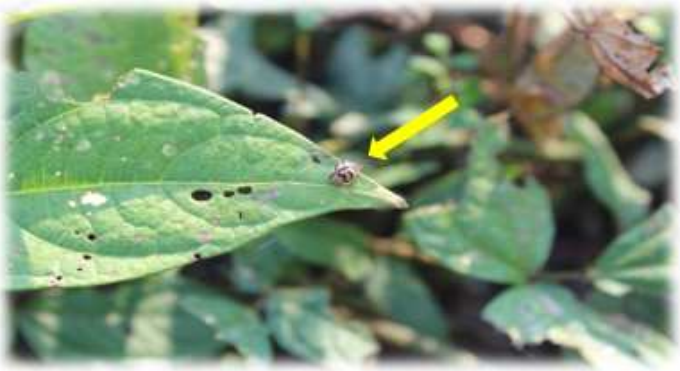
Larvae of gram blue butterfly, *Euchrysops cnejus*

Natural enemies in black gram ecosystem



Adult of *Coccinella undecimpunctata* (L.)

Adult of *Coccinella transversalis* (F.)



Adult of *Cheilomenes sexmaculata* (F.)

Spiders (unidentified)