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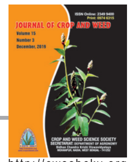

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Efficacy of module based integrated approach to combat major insect pests infesting summer green gram

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ABSTRACT

The research study was carried out at District Seed Farm (A-B Block) of B.C.K.V. during two consecutive pre-kharif seasons of 2017 and 2018 to find out the comparative efficacy of an IPM module in rectifying the pest problem on summer green gram over farmers' practices. Green gram variety 'IPM 02-3' was accommodated in the IPM module, whereas one popular variety 'Samrat' was considered for farmers' practices. Experimental results reveal that IPM strategies including seed dressing with imidacloprid 17.8 SL @ 5 ml kg^{-1} seed, setting up of yellow sticky traps @ 50 numbers ha^{-1}, spraying of NSKE 5% (i.e. 50 g l^{-1} of water), spraying of thiamethoxam 25 WG @ 0.4 g l^{-1} for sucking pests and spinosad 45 SC @ 0.2 ml l^{-1} for pod boring insects altogether quite effectively reduced the population of whitefly (5.62 per trifoliate) and thrips (1.98 per ten flowers), pod damage caused by Maruca vitrata (6.72 per cent) as well as increased the yield considerably during both the years. The farmers' practice involving four rounds of spray with a pre-mixture insecticide i.e. chlorpyriphos 50% + cypermethrin 5% EC at 2 ml l^{-1} of water at ten days gap recorded higher pest population (whitefly 31.14 per trifoliate and thrips 20.09 per ten flowers) and pod damage (30.55 per cent) caused by spotted pod borer. Comparatively more produce and higher benefit cost ratio was also gained from IPM strategy in comparison with farmers' practices, hence the above mentioned IPM module can be recommended for better and profitable pest management in summer green gram over growers own methods of cultivation.

***Keywords*:** Comparative economics, comparative efficacy, green gram, insect pests, IPM, *Vigna radiata,* yield

Green gram, scientifically known as *Vigna radiata* (L.) Wilczek and generally termed as golden bean or mung bean, is a popular grain legume among Asian countries including India, Bangladesh, China, Nepal, Bhutan, Srilanka, Myanmar, Pakistan, Thiland, Phillipines, Vietnam, Cambodia, Indonesia etc. The crop is also cultivated in Southern Europe having hot and dry climates and in Southern United states also. In India, it was third most significant pulse crop after chickpea and pigeonpea (Ved *et al*., 2008, Swaminathan *et al*., 2012). It's probable centre of origin is the Indian subcontinent (de Candolle, 1886; Vavilov, 1926; Zukoviskiz, 1962) and afterwards it spreads to the other tropical parts of the world by Indian immigrants. This important pulse crop can be raised in diverse climatic conditions. It is known for containing a good amount of protein (22-24%) that is easily digestible and it also contains several essential amino acids (Malik, 1994; Metha, 1970). Green gram seeds are also used as livestock feed. Haytowitz and Matthews (1986) estimated that one hundred gram of green gram seeds can supply important mineral nutrients like 132 mg of calcium, 6.74 mg of iron, 189 mg of magnesium, 367 mg of phosphorus, 124 mg of potassium and vitamins. Focusing on production scenario it can be found that India has more than 70% contribution in the total global production of mungbean. Third advanced estimate revealed that India met with a mungbean production of 2.34 million tonnes during the year 2019-20 (Anon., 2020). Rajasthan, Karnataka, Maharashtra, Madhya Pradesh, Odisha and Telangana are the leading states in accommodating maximum green gram production area. Besides the abiotic factors there are various biotic constraints that prevent the pulse crop to reach its maximum yielding capacity. The crop is prone to be infested by a broad spectrum of insect pests and disease pathogens (Lal, 1985) and among them insect and non insect pest reduces the yield that may reach as low as 5-6 q ha^{-1} (Lal *et al*., 1980). According to Muthomi *et al.* (2008), approximately 200 insect pests were found infesting green gram and black gram crop belonging to 48 families representing the orders like Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera and Thysanoptera along with seven mite species belonging to the order Acarina. It was reported that insect pest infestation in different states of India resulted in a yield reduction of green gram up to 30% (Soundararajan and Chitra, 2011). The pests that

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cause economic damage are whitefly (*Bemisia tabaci*), aphid (*Aphis craccivora*), jassids (*Empoasca kerri*), bean thrips (*Megalurothrips distalis* and *Thrips palmi*), flower thrips (*Megalurothrips usitatus*), spotted pod borer (*Maruca vitrata*), gram pod borer (*Helicoverpa armigera*) and Bihar hairy caterpillar (*Spilosoma obliqua*) (Oliveira *et al.,* 2001; Kooner *et al*., 2006; Swaminathan *et al*., 2012). Among the sucking pests whitefly is the most devastating one that is a polyphagous pest, cosmopolitan in nature and it causes direct damage by feeding plant sap as well as indirect damage by transmitting certain plant pathogenic begomoviruses (Oliveira *et al.,* 2001; Biswas *et al.*, 2008; Singh *et al.*, 2016; Singh and Singh, 2014). Due to heavy infestation of white fly the crop becomes blackish in appearance as severe sap sucking of the pest results in honey dew secretion, where black sooty mould grows up and that reduces the photosynthetic ability of the plant (Lal and Jat, 2015). Whitefly is very well known for transmitting Mungbean Yellow Mosaic Virus (MYMV) irrespective of the population as in very low population density it is still capable of transmitting the virus in a vast area (Sastry and Singh, 1973; Brown and Czosnek, 2002; Khattak *et al*., 2004). MYMV infected plant produces a yellow foliage and also yellow/ green mosaic pattern appears on the mature leaves. Virus contaminated plant produces very less number of flowers, pods and seeds, as a result of which yield reduction may vary from 30 to 70% (Marimuthu *et al.,* 1981). Verma *et al.* (1980) reported three species of thrips viz., *Frankliniella schultzei* Trybom, *Thrips flavus* Schrank, and *Megalurothrips distalis* Karny infesting on summer mungbean across the country. *Megaluro thrips* is the most important one among the three that lacerates floral tissue and tender parts of summer mungbean and sucks the oozing sap which causes premature flower shed and terminal shoot elongation of the plant. Infested plant becomes bushy and grain yield reduces considerably (Kooner *et al.,* 1983). The estimated yield reduction of green gram was reported as 40% due to infestation of thrips (Sreekanth, 2002). According to Chandrayudu *et al.* (2008) and Yadav and Singh (2014), the most notorious pod borer of green gram, red gram, black gram and other common bean is spotted pod borer (*Maruca vitrata* Geyer). The larvae of this insect damage the crop by three ways: by webbing floral buds, flowers, tender pods and floral shoots, by feeding and by contaminating them with excreta (Singh and Allen, 1980; Sharma, 1998; Rekha and Mallapur, 2007). Due to floral webbing and hiding inside the webbed parts the pest can escape from insecticidal treatments hence the pest is very difficult to control (Sharma, 1998). Yield loss of 10-80% in different grain legumes due to the pest was earlier recorded (Sharma 1998; Sambath Kumar *et al.,* 2014) and pod damage of 30% in green gram was reported by Umbarker and Parsana (2014). To suppress the pest load on a crop farmers usually depend on different chemicals for quick efficacy without caring about the proper chemical, proper dose, proper application method, proper time and impact on the crop ecosystem, therefore problems of resistance and resurgence as well as residue problem become generated. Use of certain synthetic chemicals randomly may develop resistance in the focussed pest as well as resurgence in *Bemisia* and overall the surrounding environment gets contaminated and loss of biodiversity also occurs in the crop ecosystem (Hussain *et al*, 2001; Rao and Reddy, 2003). A single management tactic based on the application of synthetic insecticide only promotes several hazards and causes obstacles in the advancement of sustainability (Vega *et al*., 2009, Miller *et al*., 2010). Thus, different control measures viz., physical, biological, cultural and chemical methods are integrated in an IPM system (Kennedy and Sutton, 2000). IPM tactics not only reduce the environmental risks but also reduce cost of crop protection and additional yield increment. Hence this experimentation was performed to point out the benefits of adopting an IPM module in the summer green gram crop in comparison with farmers' practices of pest management.

MATERIALS AND METHODS

The present experiment was executed in the District Seed Farm (A-B Block) of Bidhan Chandra Krishi Viswavidyalaya situated at Kalyani, Nadia, West Bengal during two successive pre-*kharif* seasons of 2017 and 2018. For studying the relative efficacy of the IPM module two mungbean varieties viz. 'IPM 02-3' and 'Samrat' were grown having thirteen replications of each following the recommended agronomic package of practices of green gram cultivation. The concerned seeds were sown @ 25 kg ha^{-1} as recommended optimum for the summer season (Jeswani and Baldev, 1990) during the first week of March. Different components of the IPM module were executed in the plot (10 m x 10 m) having the green gram variety IPM 02-3 and the plot having the variety Samrat (10 m x 10 m) were grown with normal farmers' practices of crop protection. In the IPM module, 5 ml of imidacloprid 17.8 SL are mixed with 1 kg of seed for protecting the crop from sucking pest during the earlier phase of crop growth. During the active vegetative growth, i.e. at 25 days after sowing (DAS) yellow sticky traps @ 50 numbers ha^{-1} were installed in the IPM plot to monitor the appearance and growth of sucking pest population mainly whitefly population. When the presence of whiteflies was observed on the traps, one neem based botanical insecticide viz., NSKE 5% was applied. During the flower bud initiation and the flowering stage, thiamethoxam 25 WG was sprayed at 0.4 g l^{-1} of water for managing sucking pests mainly thrips at 40 DAS. At 50 DAS, the crop was sprayed with spinosad 45 SC @ 0.2 ml l^{-1} of water for controlling the lepidopteran borer pest mainly spotted pod borer (*M. vitrata*). In the plot having green gram variety 'Samrat', normal farmers' practices were followed. In this plot no seed treatment was done, no traps for pest monitoring were installed as well as no botanicals were applied. In this plot only one insecticide, a premixture of chlorpyriphos 50% + cypermethrin 5% EC @ 2 ml l^{-1} of water was applied four times started from the onset of pests in 10 days interval and 1st spray was given at 30 DAS. The population of whitefly and thrips were computed after final spray in case of both the treatments (IPM and non-IPM). The population of whitely was counted from 5 trifoliate leaves of five randomly selected plants and the thrips population was recorded from 10 randomly selected flowers from those five randomly selected plants. The whitefly population (both adult and nymph) was taken out from the ventral surface of the trifoliate leaves during the early morning hours. For obtaining the thrips population, the flowers were taken and shaken carefully on a white paper and the exposed thrips were counted quickly because of their rapid movement. After that overall mean population of both the pests were worked out in both the treatments. Damage caused by pod borers was estimated by calculating per cent pod damage from both IPM and non IPM plots during harvest. 100 green gram pods were collected randomly from IPM and non IPM plot avoiding the border rows. Among the collected pods a total number of damaged pods were counted to enumerate pod damage per cent. Green gram seed yield (kg ha^{-1}) was obtained after harvest from both the plots and afterwards, incremental benefit cost ratios were calculated during both the years of experimentation considering the present market price of green gram seeds.

RESULTS AND DISCUSSION

Comparative efficacy of IPM module over farmer's practices on insect pests' infestation

The results of the first year experimentation (Table 1 and Fig. 1) stated that population of the major sucking insect pests viz. whitefly and flower thrips as well as the per cent pod damage due to infestation of spotted pod borer were recorded less in the IPM module in respect to farmers' practices e.g. the mean whitefly population in IPM module was 7.4 per trifoliate leaf of 5 plants against 39.0 per trifoliate leaf of 5 plants in farmers' practices, thrips population in IPM module was 2.2 per 10 flowers, whereas in farmers' practices it was 23.8 per 10 flowers and per cent pod damage in IPM module was 7.8 but it was 32.6 in farmers' practices. Same trend of pest incidence has been observed during the second year where IPM module recorded less pest incidence compared to the grower's practices (Table 1 and Fig. 2). The less incidences of whitefly (3.84 per trifoliate), thrips (1.76 per 10 flowers) and pod damage (5.63%) by *M. vitrata* were recorded in IPM plots against those recorded in farmers' practices e.g. whitefly (23.28 per trifoliate), thrips (16.37 per 10 flowers) and per cent pod damage (28.49). The pooled result of those two years study reveals relatively less occurrence of those insect pests in IPM module (whitefly: 5.62 per trifoliate, thrips: 1.98 per 10 flowers and damage in pods by spotted borer: 6.72%) as compared to farmers' practices (whitefly: 31.14 per trifoliate, thrips: 20.09 per 10 flowers and damage in pods by spotted borer: 30.55%).

Comparative efficacy of IPM module over farmer's practices on crop yield and economics

During the first year, the seed productivity was obtained maximum in IPM Module (933.33 kg ha^{-1}) compared to farmers' own practices (550.0 kg ha^{-1}) (Table 2). An extra yield of 383.33 kg ha^{-1} was obtained from IPM module. The total cost for pest management was estimated as Rs. 7940.00 with a gross return of Rs. 55,999.80 as obtained from the seed yield in case of IPM module. Where as in farmers' practices a total amount of Rs. 5,600.00 was spent for pest management from which a gross return of Rs. 33,000.00 was recorded. The incremental benefit cost ratio of 1:6.05 and 1:4.89 was enumerated from IPM components and the farmer's practices, respectively. Likewise, during the second year of experimentation, IPM adopted plots produced higher yield (1205 kg ha^{-1}) than growers' own practices (817 kg ha^{-1}) (Table 3). An advantage of extra yield (388 kg ha^{-1}) was gained in the IPM adopted plots. During the second year, the overall estimated cost incurred for the IPM package was Rs. 7940.00 per hectare and for farmers' practices it was Rs. 5600.00 per hectare. Assumed gross return from selling of the produce was Rs. 72,300.00 per hectare and Rs. 49,020.00 per hectare for IPM module and farmers' practices, respectively. As like the first season higher incremental benefit cost ratio (8.10:1) has been observed from the IPM module as against the incremental benefit cost ratio from farmers' practices (7.75:1).

The superiority of the IPM module over the farmer's practices has been established from the results of the present experiment. The overall efficiency of an IPM module depends on the relative or collaborative

Table 1: Comparative efficacy of the IPM module over farmers' practice on insect pests' infestation in summer green gram

Treatments	No. of whitefly (both adult and nymph) per trifoliate leaf			No. of thrips per 10 flowers			%pod damage		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
T_1 (IPM Module)	7.40	3.84	5.62	2.20	1.76	1.98	7.80	5.63	6.72
T_2 (Farmers' practice)	39.00	23.28	31.14	23.80	16.37	20.09	32.60	28.49	30.55

T_1: Sowing of crop variety IPM 02-3 + Seed treatment with imidacloprid + Monitoring with yellow sticky trap + Application of NSKE at initial observation in trap + Spraying of thiamethoxam at 40 DAS + Spraying of spinosad at 50 DAS

T_2: Sowing of crop variety Samrat + Four times spraying of chlorpyriphos 50% + cypermethrin 5% EC at 10 days interval

Table 2: Comparative economics of the IPM module over farmers' practice in summer green gram during first year (2017)

Treatments	Seed yield (kg ha^{-1})	Yield increase (kg ha^{-1})	Cost of management *(Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Incremental Benefit cost ratio**
T_1 (IPM Module)	933.33	383.33	7,940.00	55,999.80	48,059.80	6.05:1
T_2 (Farmers' practice)	550.00	-	5,600.00	33,000.00	27,400.00	4.89:1

Table 3: Comparative economics of IPM module over farmers' practice in summer green gram during second year (2018)

Treatments	Seed yield (kg ha^{-1})	Yield increase (kg ha^{-1})	Cost of management *(Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Incremental Benefit cost ratio**
T_1 (IPM Module)	1205.00	388.00	7,940.00	72,300.00	64,360.00	8.10:1
T_2 (Farmers' practice)	817.00	-	5,600.00	49,020.00	43,420.00	7.75:1

* Estimated overall cost (for 1 ha) based on cost of seed treating chemical, monitoring equipment, botanical insecticide, chemical insecticide as per market availability including labour charges for spray application

** C: B ratio is computed on the basis of treatment cost for crop protection and grain yield only [Considered cost: Imidacloprid 17.8 % SL = Rs. 230 per 50 ml, Yellow sticky trap = Rs. 200 per pack (25 pieces), NSKE powder = Rs. 1800 per 5 kg, Thiamethoxam 25% WG = Rs. 400 per 100g, Spinosad 45 SC = Rs. 1520 per 100 ml, Chlorpyriphos 50% + Cypermethrin 5% EC = Rs.900 per l, Labour charge for spraying = Rs. 500 for one hectare, Selling price of green gram = Rs. 60 per kg]

effectiveness of component strategies. Earlier studies revealed that treatment with NSKE elevated the efficiency of the IPM module as it provided protection against the forthcoming infestation of plume moth (*Exelastis atomosa*) and lycaenid borer grass blue butterfly (*Lampides boeticus*) (Jayaraj *et al*., 1993). This finding partially supports the present findings. Previously it was also observed that the application of NSKE 5% provided better result in population suppression of white fly in mungbean (Hussain *et al.,* 2001). Gajendran *et al.* (2006) reported that some IPM tactics like seed treatment, an application of NSKE 5% during flowering stage increased the efficiency of management strategy in managing pod borer and pod bug in comparison with farmers' practice. These findings closely support the present findings. They also obtained higher yield and cost benefit ratio from IPM plot than farmers' practice as observed in the present experiment. Panduranga *et al.* (2011) revealed that imidacloprid treated seed elevated the efficiency of integrated module as it provided protection against whitefly up to 25 days after sowing. Previously it was advised that spraying of NSKE at 50 g l^{-1} followed by seed dressing with thiamethoxam 70 WS 0.2% and foliar application of thiamethoxam 25 WG 0.02% provide considerable reduction of flower thrips, along with the application of spinosad 45 SC @ 0.2 ml l^{-1} which is the most promising treatment for managing spotted pod borer infesting green

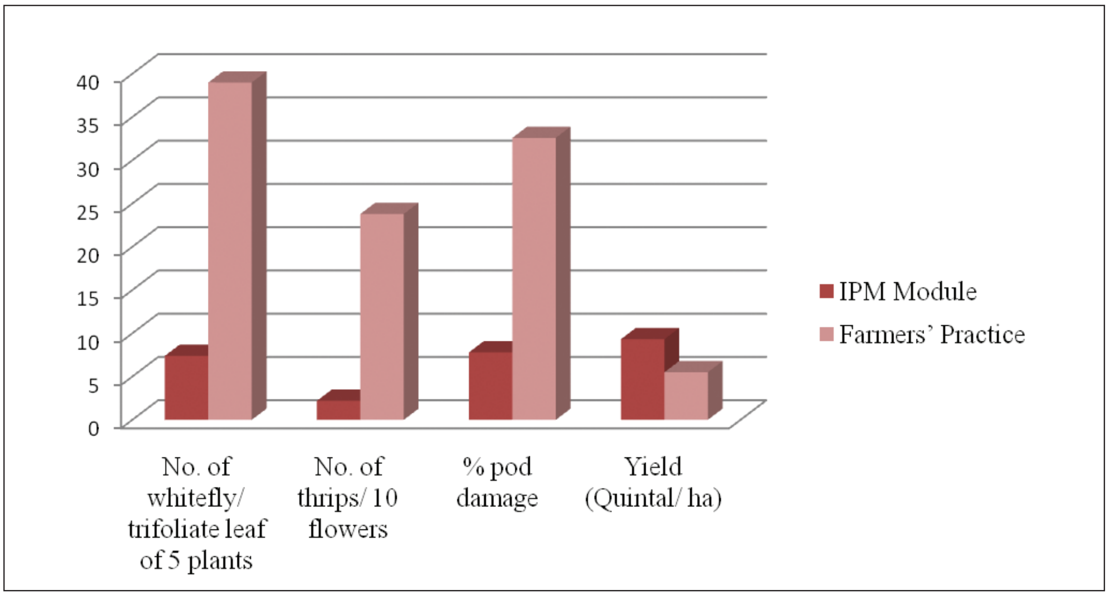

Fig. 1: Post treatment pest population and pod damage recorded in summer green gram in IPM module and farmers' practices during 2017

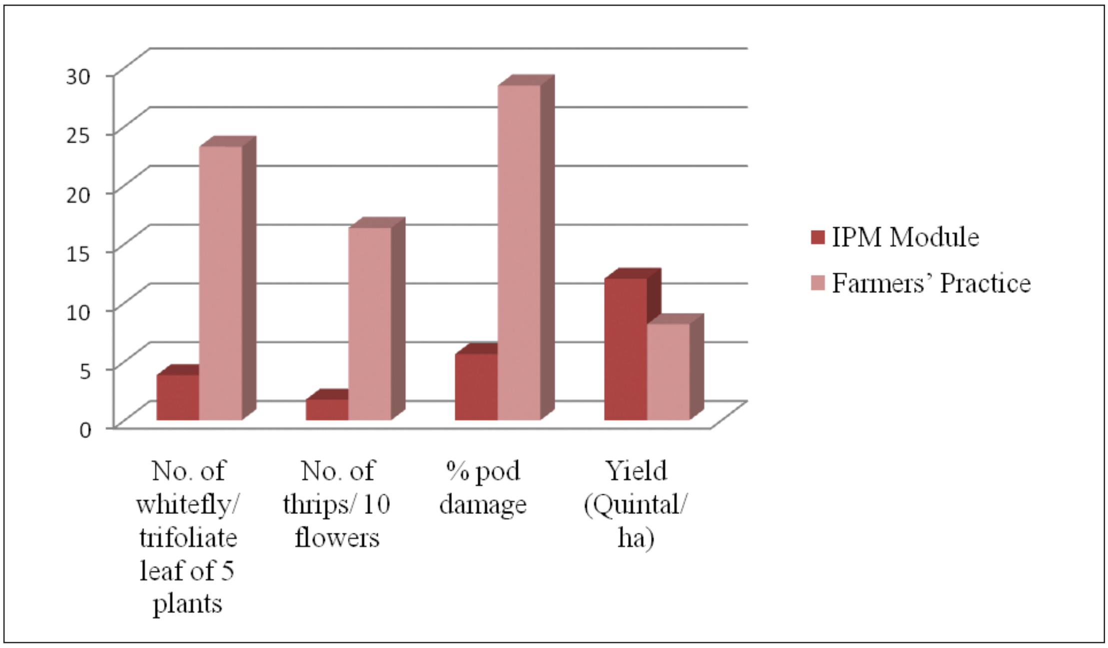

Fig. 2: Post treatment pest population and pod damage recorded in summer green gram in IPM module and farmers' practices during 2018

gram (Sharma *et al.*, 2011). Berani *et al.* (2018) observed that different botanical insecticides like NSKE 5 % effectively controlled *Spilosoma obliqua* and *M. testulalis* (*vitrata*) in urd bean and provided more yield, which suggests that botanical insecticide like NSKE 5 % used in this experiment not only managed the whitefly population but also showed suppressive effect on the spotted pod borer population. Earlier the successful utilization of yellow sticky traps was suggested for monitoring the population fluctuation of *Bemisia tabaci* (Lu *et al.*, 2012; Maurya and Tiwari, 2018). Formerly it was realized that mungbean crop sprayed with thiamethoxam 25 WG exhibited the lowest population density of thrips and relatively higher yield than non treated crop which is in the very close approximation of the present finding (Anon., 2013). Sujatha and

Bharpoda (2016) reported that thiamethoxam 25 WG (0.01%) was an effective treatment for managing different sucking pests of green gram viz. aphids, jassids, whiteflies, thrips (*T. palmi*), flower thrips (*M. usitatus*) and for providing higher yield as well that closely supports our present findings. The evaluated results are in tune with the results of Umbarkar and Parsana (2014), who reported that the most effective treatment was spinosad at 0.009 per cent for managing spotted pod borer infesting green gram. Yadav and Singh (2014) proved spinosad 45% SC as the most successful (80.7 per cent larval population reduction) one among all other treatments against *Maruca vitrata* (Geyer) infesting mungbean. It was also discovered that IPM module comprised of seed dressing (using imidacloprid 600 FS at 5 ml kg^{-1}), the application of NSKE (5%) and triazophos 40 EC (0.04 per cent) can effectively reduce the populations of sucking pests like whitefly, jassids and thrips and also provide higher seed yield and cost benefit ratio than the farmer's practices (Singh and Singh, 2015). Randhawa and Saini (2015) found that *Maruca vitrata* infesting red gram was effectively controlled by spinosad 48 SC. The treatment also increased the yield and decreased the pod borer population and pod damage significantly. The better efficacy of spinosad against pod borer as resulted in this study is in tune with the results of Kaushik *et al.* (2016) and Kiran Kumar and Tayde (2017), who revealed that spinosad 45% SC drove away the pest to cause minimum infestation in cowpea while producing the highest yield. Singh *et al*. (2018) opined that every IPM module provided better result in reducing the incidence of both *Bemisia* population and mungbean yellow mosaic virus as compared to farmers' practices. The highest grain yield was also obtained by them from IPM module. These findings closely follow the present findings. The superiority of spinosad 45 SC at 75 ml ha^{-1} for managing spotted pod borer in green gram and lablab was earlier shown by Haripriya *et al.* (2021) that supports our present outcome. Previously it was reported that among the different tested IPM module, the biorational module comprising of neem cake application in soil @ 500 kg ha^{-1}, the installation of pheromone traps and bird perches @ 20 ha^{-1}, spraying of NSKE @ 1500 ml ha^{-1} and spinosad @ 200 ml ha^{-1} was the superior module for best protection and maximum yield gain of black gram crop against pod borers. The highest benefit cost ratio was also recorded from that module (Kapoor and Shankar, 2021). These findings are very closely related to the present realisation.

From these two years of experiment, considering the outcomes it can be concluded that IPM module comprises of seed treatment using imidacloprid, the installation of yellow sticky traps, spraying of NSKE 5% at appearance of whitefly in trap, spraying of thiamethoxam at 40 DAS to control sucking pests and spraying of spinosad at 50 DAS to control pod borers, is superior over the farmers' own practices. IPM strategy in one hand increased the seed yield, and in other hand reduced the pest population and pod damage significantly without any harmful impact on the environment through accommodating different available tactics. Higher benefit cost (B:C) ratio was also realized from the adoption of the IPM module.

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