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Relative efficacy and economics of seed treatment and newer insecticides against sucking and borer pests of summer mungbean in coastal Odisha

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Abstract
The present study was undertaken to study the relative efficacy and economics of seed treatment and newer insecticides against sucking and borer pests of mungbean during summer 2015 and 2016. Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of thiamethoxam 25 WG @ 50 g a.i./ ha was highly effective against sucking pests like whiteflies, aphids and thrips in mungbean. Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and insecticides like indoxacarb14.5 SC @ 65g a.i./ha was highly effective against pod borers like *Maruca vitrata* (Geyer) in mungbean. Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of spinosad 45 SC @ 73 g a.i./ ha was also effective against thrips and pod borers in mungbean. Seed treatment with imidacloprid 48 FS @ 5ml/kg seed and spraying of indoxacarb 14.5 SC @ 65g a.i./ha recorded highest yield (8.9 quintal/ha), highest net return over control (Rs 27,850/-) and highest B:C ratio (2.86) , so a better management option for farmers as they will get higher net return and profit.

Keywords: Mungbean, sucking pests, *Maruca vitrata*, seed treatment, indoxacarb, net return

1. Introduction

Pulses are an important component of the daily diet of common man after cereals. Being hub of proteins they are often described as poor-man's meat [1]. Pulses not only boost the human health but also play a vital role in enhancing the soil health by adding nitrogen to it through biological nitrogen fixation in form of root nodulation. Pulses, the food legumes, have been grown by farmers since millennia providing nutritionally balanced food to the people of India [2]. Greengram or mungbean (*Vigna radiata* L. Wilczek) is an important short duration legume and grown in all the seasons in Odisha. Greengram is an important source of easily digestible high quality protein for vegetarians and sick persons. Mungbean is grown in 213.16 '000ha' with yield of 464kg/ha and production of 98.91 MTs during *kharif* season whereas the area is 643.91'000ha' with yield of 480kg/ha and production of 309.08 MTs during *rabi* season in Odisha [3]. The yield potential of mungbean is seriously affected by several biotic and abiotic factors. Under changing climatic conditions, constant evolution of biotypes and development of resistance of insect-pests have created problems for the farmers. The annual yield loss due to the insect pests has been estimated at about 30 per cent in urdbean and mungbean. On an average, 2.5 to 3.0 million tons of pulses are lost annually due to pest problems [4]. The crop is affected by various sucking pests like aphids, whiteflies, thrips etc. and defoliators like spodoptera, and hairy caterpillars, leaf roller (*Hedylepta indicata*) and pod borers like *Maruca sps*. and *Helicoverpa sps*. The most serious insect pests attacking on greengram includes whitefly (*Bemisia tabaci*), bean thrip (*Megalurothrips distalis*), gram pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca vitrata*) [5]. Whiteflies cause damage to plants directly by sucking the cell sap from leaves and also induce some physiological disorders by injecting some phytotoxins into leaves. Spotted pod borer is one of the major biotic constraints for pulses production which can cause damage to the economic plant parts such as flower buds, flowers and pods. Larvae are translucent with dark brown spots on each segment and larval period lasted from 11 to 21 days and the duration of total life cycle varied from 27 to 36 days on different hosts [6]. It is basically a hidden pest and completes its larval development inside the web formed by rolling and tying together leaves, flowers, buds and pods. This typical concealed feeding protects the larvae from natural enemies, human interventions or other adverse factors including insecticides [7].

The farmers solely rely upon insecticide application for control of the pests. The injudicious and indiscriminate use of insecticides by the farmers has created several pesticide hazards. Broad spectrum insecticides such as organophosphates, carbamates and pyrethroids have been used to control the whitefly since long time. But, they are highly toxic to humans and beneficial organisms and their injudicious use lead to development of resistance and development of biotypes in *B. tabaci* and control failures were observed with those insecticides in recent past [8]. Therefore the present study was planned for evaluation of efficacy and economics of seed treatment and selective new chemicals for the management of sucking pests and pod borers in summer mungbean which can be passed on to the farmers for the benefit of mankind and environment.

2. Materials and Methods

The field experiments were planned and conducted at Center for Pulses Research, OUAT, Berhampur, Odisha during summer 2015 and 2016 to evaluate the efficacy of different treatments for management of sucking and borer pests of mungbean. The experimental site comes under East & South East Coastal Plain zone and is situated at 19^0 18' N Latitude, $84^0$54' E Longitude and at an altitude of 34 m above MSL. The mungbean variety OUM 11-5 (Kamadeva), a short duration variety of 55 days was sown in (30 X 10) cm spacing in plots of size 20 m^2 area following recommended agronomic practices. The treatment details are, T1) Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed, T2) T_1 + NSKE 5% 20 DAS for sucking pests & 30 DAS for borers, T3) T_1 + indoxacarb14.5 SC @ 65g a.i./ha at 30 DAS, T4) T_1 + emamectin benzoate 5 SG @ 11g a.i./ ha at 30 DAS, T5) T_1 + thiamethoxam 25 WG @ 50 g a.i./ha at 30 DAS, T6) T_1+ spinosad 45 SC @ 73 g a.i./ ha at 30 DAS, T7) T_1 + profenophos 50 EC @ 200 g a.i./ha at 30 DAS and T8) untreated control (Table 1). The seed was treated with imidacloprid 48 FS @ 5 ml/kg seed in all seven treatments except control. Then spraying of insecticides was made using a battery operated knapsack sprayer using a spray volume of 500 l/ha. Spraying of NSKE @ 5 for sucking pests was done 20 days after sowing and 30 days after sowing for borers. There was no spraying of insecticides at 30 days after sowing as the variety was harvested at 55 days of sowing being a short duration variety. The observations of insect pest population were recorded at 3rd and 7th days after spraying and the mean value was worked out. The percent leaf area damage, number of whiteflies per upper trifoliate leaf, number of aphids per upper trifoliate leaf, number of thrips per 10 flowers. In each treatment, five plants per replication were selected at random for collection of data. The percent pod damage at harvest was calculated by counting the total number of pods and the number of damaged pods and expressed in percentage. The seed yield after harvest were recorded from each plot and then converted to q/ha. Then the mean data of both the years were worked out. Then percent reduction of insect pests over control (PRC) and percent increase of yield over control (PIC) were calculated.

2.1 Statistical analysis

In the experiment, eight number of different treatments including control in three replications were set in Randomised Block Design (RBD). The square root transformation of raw data obtained from field observation were made by using formula $\sqrt{x + 0.5}$. Then the converted data were analysed as per the procedure laid out by Gomez and Gomez, 1984 [9]. The table for ANNOVA (Analysis of Variance) consisted of source of variation (replication, treatment, error), degree of freedom, sum up square (SS), Mean Sum up square (MSS), F value (MSS/EMS) were worked out and compared with 'F' table at 5 for significance of contribution of source for variation. Standard Error of means (SEm) was worked out with formula i:e: ($\sqrt{Error\ mean\ sum\ up\ square}$ / $\sqrt{Replication}$) , Critical difference (CD) was calculated with formula CD= $t_{5\%}$ at error degree of freedom × $\sqrt{2}$ × SEm. The values were compared on basis of critical difference and interpretations were made accordingly.

3. Results and Discussion

3.1 Whiteflies

In both the years, the population of whiteflies was minimum during first 15-20 days after sowing in all the treatments except control. This was due to the effect of seed treatment but the population increased thereafter. During the year 2015, the mean data collected at 3rd and 7th days after spraying indicated that the population of whiteflies in treated plots was significantly lower than the control and it ranged from 5.0 to 24.5 numbers/trifoliate leaf among the treatments (Table 1). Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) recorded lowest population of whiteflies (5.0 numbers/trifoliate leaf), followed by seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T 6) , (6.5 numbers/trifoliate leaf) against 24.5 numbers/trifoliate leaf in untreated control. In the field experiment conducted during 2016, the mean data collected at 3rd and 7th days after spraying indicated that the population of whiteflies in all the treatments was significantly lower than the control (20.8 numbers/ trifoliate leaf) and it ranged from 3.2 to 16.7 numbers/trifoliate leaf among the treatments (Table 1). Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) recorded lowest population of whiteflies (3.2 numbers/trifoliate leaf), followed by seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (4.8 numbers/trifoliate leaf), (T6) against 20.8 numbers/trifoliate leaf in untreated control. Variations in whitefly population due to different treatments were significantly different from each other in both the years.

The mean data of two years (2015 and 2016) indicated that the whitefly population ranged from 4.1 to 22.7 among the treatments including control. The percent reduction over control (PRC) was highest, (81.9) in imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) followed by 74.8 reduction in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T6). The PRC ranged from 22.5 to 81.9 among the treatments. The findings clearly states that the seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of insecticides thiamethoxam 25 WG @ 50 g a.i./ha and spinosad 45 SC @ 73 g a.i./ ha are highly effective for management of whitefly population in mungbean. The findings are in accordance with the earlier findings that the foliar application of thiamethoxam 25 WG at 100 g a.i./ha resulted in more than 90 per cent reduction in the population of aphids, leafhoppers and whiteflies in cotton [10]. The treatments with combination of seed treatment with thiamethoxam 35 FS @ 3 g/ kg seed + thiamethoxam 25 WG @ 25 g a.i./ha was also found to be effective in controlling the sucking pest population in mungbean [11]. The findings are in accordance with the study which revealed that the mean per cent of reduction over untreated control (PROC) found in an increasing pattern with imidacloprid 17.8% SL and thiamethoxam 25% WG and recorded the lowest (1.42, 1.49/cage/plant) population of whitefly with highest (66.91, 63.54) PROC after first spray and a similar trend of insecticidal efficacy at second spray with lowest (0.28, 0.32/cage/plant) population of whitefly with highest (68.44, 66.20) PROC [12]. The efficacy of thiamethoxam 25% WG in present investigation are in line with the findings that amongst the treatments, a combination of seed treatment with thiamethoxam (Cruiser™) at 4 g kg^{-1} and carbendazim (Bavistin™) + TMTD (Thiram™) at 2.5 g kg^{-1} (1:1 ratio) followed by foliar applications of thiamethoxam (Actara™) 0.02% and carbendazim 0.05% at 21 and 35 d, respectively after sowing recorded lowest intensity of cercospora leaf spots and mungbean yellow mosaic. Vector (whitefly) populations were also the lowest in this treatment during all stages of the crop [13].

3.2 Aphids

The population of aphids was minimum during first 15- 20 days after sowing in all the treatments except control during 2015 and 2016 due to the effect of seed treatment but the population increased thereafter. During the year 2015, the mean data collected at 3rd and 7th days after spraying indicated that the population of aphids was significantly lower in the treated plots and it ranged from 4.5 to 18.4 numbers/trifoliate leaf as against 25.7 numbers/trifoliate leaf in untreated control (Table 1). Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) recorded minimum population of aphids (4.5 numbers/trifoliate leaf), followed by 7.5 numbers/trifoliate leaf in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of profenophos 50 EC @ 200 g a.i./ha (T7) as against 25.7 numbers/trifoliate leaf in untreated control. During 2016, the mean data collected at 3rd and 7th days after spraying indicated that the population of aphids in all the treatments was significantly lower than the control and it ranged from 3.2 to 18.4 numbers/trifoliate leaf among the treatments against 26.2 numbers/trifoliate leaf in untreated control (Table 1). Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) recorded minimum population of aphids (3.2 numbers/trifoliate leaf), followed by seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of profenophos 50 EC @ 200 g a.i./ha (T7), (5.4 numbers/trifoliate leaf) as against 26.2 numbers/trifoliate leaf in untreated control. All the treatments were significantly different from each other in terms of aphid population/trifoliate leaf in both the years. The mean data of two years (2015 and 2016) indicated that the aphid population/trifoliate leaf ranged from 3.9 to 17.6 among the treatments. The percent reduction over control (PRC) was higher, 85.0 in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) followed by 75.0 reduction in seed treatment with imidacloprid 48 FS @ 5ml/kg seed + spraying of profenophos 50 EC @ 200 g a.i./ha (T7). The PRC ranged from 32.3 to 85.0 among the treatments. The findings clearly states that seed treatment with imidacloprid 48 FS @ 5ml/kg seed and spraying of insecticides thiamethoxam 25WG @ 50 g a.i./ha and profenophos 50 EC @ 200 g a.i./ha are highly effective for management of aphid population in mungbean. The current findings are in agreement with earlier findings that imidacloprid gave a 70.94 and 72.7% initial kill, and a 75.84 and 79.66% reduction as the general mean of effect in the 2010 and 2011 seasons, respectively, while thiamethoxam caused 58.48 and 65.83% initial kill, and a 65.87 and 69.81% reduction as the general mean of the effect in the two seasons in cotton [14]. The efficacy of thiamethoxam was in line with the findings that aphids though appeared for a short period had a distinctly lower built up in cyazypyr (1.33 plants^{-1}) followed by emmamectin benzoate and thiamethoxam (3.00-3.33 plant^{-1}) as compared to 25.23 plant^{-1} in untreated control [15]. The findings of the present study are in accordance with the findings that the treatment of thiamethoxam 0.025 per cent resulted in 92.61 reduction of aphid, *A. craccivora* in cluster bean [16].

3.3 Thrips

During the year 2015, the mean data collected at 3rd and 7th days after spraying indicated that the populations of thrips ranged from 4.3 to 24.3 numbers/10flowers among the treatments as against 32.5 numbers/10flowers in untreated control (Table 1). T5 recorded minimum population of thrips (4.3 numbers/10 flowers), followed by T7 (7.5 numbers/10 flowers) as against 32.5 numbers/10 flowers in untreated control. During 2016, the populations of thrips in all the treatments were significantly lower than the control and it ranged from 8.0 to 22.0 numbers/10 flowers among the treatments as against 44.0 in untreated control (Table 1). T5 recorded minimum population of thrips (8.0 numbers/10 flowers), followed by T6 (10.0 numbers/10 flowers) compared to 44.0 numbers/10 flowers in untreated control. All the treatments were significantly different from each other in terms of thrips population/10 flowers in both the years. The mean data of two years (2015 and 2016) indicated that the thrips population ranged from 6.2 to 23.2 numbers/10 flowers among the treatments as against 38.3 numbers/10 flowers in untreated control. The percent reduction over control (PRC) was higher, 83.8% in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha (T5) followed by 73.6% reduction in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T6). The PRC ranged from 39.4% to 83.8% among the treatments. The findings clearly states that the seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of insecticides thiamethoxam 25 WG @ 50 g a.i./ ha and spinosad 45 SC @ 73 g a.i./ ha are highly effective for management of thrips population in mungbean. The efficacy of thiamethoxam, and spinosad in the present study is in line with the findings that amongst six newer molecules tested, thiamethoxam, emmamectin benzoate and cyazypyr were most promising against thrips (1.0-2.0 thrips/plant) followed by spinosad and cartap hydrochloride (5.0-7.0 thrips/plant) as against 18.30 thrips/plant in untreated control [15]. The efficacies of thiamethoxam 25 WG in present findings are in accordance with findings that among the various insecticides, thiamethoxam 25 WG @ 0.01% (0.33) was found significantly superior than the rest of the insecticides under study and at par with imidacloprid 70 WG @ 0.014% (0.46). Diafenthiuron 50 WP @ 0.05% (1.11), flonicamid 50 WG @ 0.015% (1.19) and dimethoate 30 EC @ 0.03% (1.35) stood next in order so far their effectiveness against flower thrips is concerned [17].

3.4 Defoliators

During the year 2015, the mean data collected at 3rd and 7th days after spraying indicated that the percent leaf infestation by defoliators were significantly lower than the control and it ranged from 3.4 to 16.5 among the treatments as against 18.7 in untreated control (Table 2). Lowest percent leaf infestation (3.4) was recorded in T7, followed by 3.8 in T4 as against 18.7 in untreated control. During 2016, the mean data collected at 3rd and 7th days after spraying indicated that the percent leaf infestation by defoliators were significantly lower than the control and it ranged from 4.5 to 13.6 among the treatments as against 21.3 in untreated control (Table 2). T7 recorded minimum percent leaf infestation (4.5) followed by 5.7 in T 4 as against 21.3 in untreated control. All the treatments were significantly different from each other in terms of percent leaf infestation as influenced by defoliators in both the years.

The mean data of two years (2015 and 2016) indicated that the percent leaf infestation ranged from 3.9 to 14.6 among the treatments as against 20.0 in untreated control. The percent reduction over control (PRC) was higher, 80.5 in T 7 followed by 76.0 reduction in T4. The PRC ranged from 30.5 to 80.5 among the treatments. The findings clearly states that the seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of insecticides like profenophos 50 EC @ 200 g a.i./ ha and spraying of emamectin benzoate 5 SG @ 11g a.i./ ha are highly effective for management of defoliators in mungbean. The findings of the present study are not in line with the findings that Phosalone and neem seed kernel extract were equally effective in controlling defoliators on the intercropped green gram (80.55 and 68.57%, respectively) This may be due to that the treatments tested in the present study were not tested in the cited study conducted earlier [18].

3.5 Pod Borers

The percent pod damage was computed by counting the total number of pods and the number of damaged pods during harvest. During the year 2015, the percent pod damage by pod borers ranged from 2.3 to 20.6 among the treatments as against 21.3 in control (Table 2). Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of indoxacarb 14.5 SC @ 65g a.i./ha (T3) recorded minimum percent pod damage (2.3) followed by seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of emamectin benzoate 5 SG @ 11g a.i./ ha (T4) (3.6) as against 21.3 in untreated control. During 2016, the percent pod damage by pod borers ranged from 6.9 to 17.4% among the treatments as against 23.2 in untreated control (Table 2). T3 recorded minimum percent pod damage (6.9) followed by 7.5 damage in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T6), which were statistically at par with each other but significantly superior as compared to 23.2 in untreated control.

The mean data of two years indicated that the percent pod damage ranged from 4.6 to 19.0 among the treatments as against 22.3 damage in control. The percent reduction over control (PRC) was higher, 79.4 in T3 followed by 71.3 reduction in T6. The PRC ranged from 14.8 to 79.4 among the treatments. The findings clearly states that the seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed and spraying of insecticides like indoxacarb14.5 SC @ 65g a.i./ha and spinosad 45 SC @ 73 g a.i./ ha are highly effective for management of pod borers like *Maruca vitrata* in mungbean. The efficacy of indoxacarb and spinosad are in line with the earlier findings that the effectiveness of indoxacarb 14.5 SC @1 ml/l was followed by spinosad 45 SC @ 0.4 ml/l and emamectin benzoate 5 SG @ 0.4 g/ l which recorded 0.10 and 0.13 larva/ plant at 7 DAT of I and II application in blackgram [1]. The effectiveness of spinosad 45 SC and indoxacarb 14.5 SC against pod borers found in the present study were also reported in the findings that spinosad 45 SC and indoxacarb 14.5 SC were most effective and significantly superior to other treatments with 80.7 and 79.2 per cent larval reduction of *Maruca vitrata* (Geyer) on mungbean over control [19]. The current findings are in agrrement with the findings that indoxacarb 14.5% SC, spinosad 45% SC and profenophos 50% EC were the most effective treatments against spotted pod borer (Maruca vitrata) on mungbean and significantly superior to other treatment with 75.04, 73.02 and 68.50 larval population reduction with maximum yield of mungbean i.e. 8.09, 9.06 and 8.59 q/ha respectively, over control [20].

3.6 Yield

The seed yield was recorded at harvest of mungbean. During the year 2015, the yield varied from 5.2 to 9.0 q/ha among the treatments as against 4.9 q/ha in control (Table 2). The seed treatment with imidacloprid 48 FS @ 5ml/ kg seed + spraying of indoxacarb 14.5 SC@ 65g a.i./ha (T3) recorded highest yield, 9.0 q/ha followed by 8.5 q/ha in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T6) which were statistically at par, but significantly superior as compared to 4.9 q/ha in untreated control. During the year 2016, the yield varied from 6.1 to 8.7 q/ha among the treatments (Table 2). T3 recorded highest yield, 8.7 q/ha followed by 8.4 quintal /ha in T6, which were statistically at par but significantly superior as compared to 4.3 q/ha in untreated control. All the treatments recorded significantly higher grain yield over untreated control.

The mean data of two years (2015 and 2016) indicated that the highest grain yield of 8.9 q/ha was recorded in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of indoxacarb 14.5 SC @ 65g a.i./ha (T3), followed by 8.5 q/ha in seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of spinosad 45 SC @ 73 g a.i./ ha (T6) against 4.6 q/ha in untreated control. The percentage increase in grain yield over control (PIC) was highest in T3 (93.5), followed by 84.7 in (T6). The findings clearly states that the treatment with indoxacarb14.5 SC as one of the spray registered highest yield followed by spraying of spinosad 45 SC which is due to the higher efficacy of the molecules towards control of pod borers. It has been reported earlier that during rabi 2011 and 2013 indoxacarb 14.5 SC @ 1.0 ml/l recorded significantly higher yield (466.7 and 496.33 kg/ ha) followed by spinosad 45 SC @ 0.4 ml/ l (448.3 and 485.0 kg/ ha) and emamectin benzoate 5WG @ 0.4 g/l (456.0 and 477.0 kg/ ha) in urdbean [1]. The efficacy of indoxacarb and spinosad in terms of higher yield is in line with the earlier findings that the maximum yield in mungbean was recorded in treatment indoxacarb 14.5 SC (11.8q/ha) followed by spinosad 45 SC (11.1q/ha) which were at par with each other [19].

3.7 Economics

The economics of various treatments were computed basing on the cost of insecticides and other cost of production like seed, fertilizer, labour wage, cost of ploughing, irrigation etc. The cost of insecticides were calculated (Table- 3). The cost of production of different treatments, mean yield, gross return and net return per ha, increased net return over control and B:C ratio were calculated (Table-4).The highest cost of insecticides was found in T_6 (Rs 3380/-/ha), followed by T_2 (Rs 2500/-/ha), T_3 (Rs 2250/-/ha), and lowest in T_7 (Rs 1020/-/ha). The total cost of production excluding cost of insecticides was Rs 19500/- per ha in all the treatments. The net return was computed by deducting the cost of production from the gross return obtained by selling the grains @ Rs 70/- per kg. The highest net return over control and B:C ratio was found in T_3 (Rs 27,850/-, 2.86), followed by T_6 (Rs 23,920, 2.60) and lowest in T_1 (Rs 7200/-, 1.99). So, from the economics study, it was clearly found that T_3, i:e, seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of indoxacarb 14.5 SC @ 65g a.i./ha is a better management option for farmers as they will get higher net return and profit.

Table 1: Population of sucking pests in mungbean as influenced by different treatments

Treatment details	No. of Whitefly/ trifoliate leaf (Mean of 3rd and 7th DAS)				No. of Aphids/ trifoliate leaf (Mean of 3rd and 7th DAS)				No. of Thrips /10 Flowers (Mean of 3rd and 7th DAS)			
	2015	**2016**	**Mean**	**PRC**	**2015**	**2016**	**Mean**	**PRC**	**2015**	**2016**	**Mean**	**PRC**
T1 (Seed treatment with Imidacloprid 48.0 FS @ 5 ml/ kg seed)	15.4 (3.99)	12.2 (3.56)	13.8	39.2	16.8 (4.16)	18.40 (4.29)	17.6	32.3	24.3 (5.03)	22.0 (4.73)	23.2	39.4
T2 (T_1 + NSKE 5% at 20 DAS for sucking pests & 30 DAS for borers)	16.7 (4.15)	14.4 (3.85)	15.6	31.2	18.4 (4.35)	16.00 (4.05)	17.2	33.8	22.5 (4.85)	14.0 (3.78)	18.3	52.2
T3 (T_1 + Indoxacarb14.5 SC @ 65g a.i./ha at 30 DAS)	18.4 (4.35)	16.7 (4.13)	17.6	22.5	14.0 (3.81)	12.20 (3.55)	13.1	49.6	20.7 (4.65)	15.0 (3.93)	17.9	53.3
T4 (T_1 +Emamectin benzoate 5 SG @ 11g a.i./ ha at 30 DAS)	12.6 (3.62)	10.3 (3.26)	11.5	49.3	12.2 (3.56)	11.80 (3.49)	12	53.8	15.6 (4.06)	16.0 (3.98)	15.8	58.7
T5 (T_1 + Thiamethoxam 25 WG @ 50g a.i./ha at 30 DAS)	5.0 (2.34)	3.2 (1.90)	4.1	81.9	4.5 (2.23)	3.20 (1.90)	3.9	85.0	4.3 (2.3)	8.0 (2.91)	6.2	83.8
T6 (T_1+ Spinosad 45 SC @ 73 g a.i./ ha at 30 DAS)	6.5 (2.64)	4.8 (2.29)	5.7	74.8	9.3 (3.13)	8.00 (2.86)	8.7	66.5	10.1 (3.33)	10.0 (3.22)	10.1	73.6
T7 (T_1 + Profenophos 50 EC @ 200 g a.i./ ha at 30 DAS)	8.1 (2.93)	7.3 (2.73)	7.7	66.1	7.5 (2.83)	5.40 (2.38)	6.5	75.0	8.5 (3.08)	12.0 (3.52)	10.3	73.1
T8 (Untreated Control)	24.5 (5.0)	20.8 (4.60)	22.7		25.7 (5.12)	26.20 (5.13)	26.0		32.5 (5.79)	44.0 (6.66)	38.3	
SE(m)±	0.11	0.25			0.37	0.36			0.16	0.31		
CD (0.05)	0.34	0.76			1.11	1.10			0.49	0.94		

PRC- Percentage reduction over control
Figures in parenthesis represent square root transformed values

Table 2: Percent leaf damage, pod damage and yield in mungbean in different treatments

Treatment details	% Leaf damage by defoliators (Mean of 3rd and 7th DAS)				% pod damage by *Maruca sps.* (during harvest)				Seed Yield (q/ha)			
	2015	**2016**	**Mean**	**PRC**	**2015**	**2016**	**Mean**	**PRC**	**2015**	**2016**	**Mean**	**PIC**
T1 (Seed treatment with Imidacloprid 48.0 FS @ 5 ml/ kg seed)	16.5 (4.12)	11.3 (3.37)	13.9	30.5	20.6 (4.59)	17.4 (4.21)	19.0	14.8	5.2	6.1	5.7	23.9
T2 (T_1 + NSKE 5% at 20 DAS for sucking pests & 30 DAS for borers)	15.6 (4.01)	13.6 (3.74)	14.6	27.0	19.5 (4.47)	10.8 (3.32)	15.2	31.8	7.0	7.2	7.1	54.3
T3 (T_1 + Indoxacarb14.5 SC @ 65g a.i./ha at 30 DAS)	8.5 (3.0)	7.8 (2.84)	8.2	59.0	2.3 (1.67)	6.9 (2.71)	4.6	79.4	9.0	8.7	8.9	93.5
T4 (T_1 +Emamectin benzoate 5 SG @ 11g a.i./ ha at 30 DAS)	3.8 (2.07)	5.7 (2.46)	4.8	76.0	3.6 (2.02)	9.9 (3.21)	6.8	69.5	8.3	7.4	7.9	71.7
T5 (T_1 + Thiamethoxam 25 WG @ 50g a.i./ha at 30 DAS)	11.2 (3.42)	10.8 (3.34)	11.0	45.0	12.6 (3.62)	13.4 (3.71)	13.0	41.7	7.7	6.4	7.1	54.3
T6 (T_1+ Spinosad 45 SC @ 73 g a.i./ ha at 30 DAS)	10.1 (3.25)	12.3 (3.55)	11.2	44.0	5.3 (2.4)	7.5 (2.80)	6.4	71.3	8.5	8.4	8.5	84.7
T7 (T_1 + Profenophos 50 EC @ 200 g a.i./ ha at 30 DAS)	3.4 (1.97)	4.5 (2.21)	3.9	80.5	8.6 (3.02)	11.9 (3.48)	10.3	53.8	7.9	7.0	7.5	63.0
T8 (Untreated Control)	18.7 (4.38)	21.3 (4.66)	20.0		21.3 (4.67)	23.2 (4.86)	22.3		4.9	4.3	4.6	
SE (m)±	0.06	0.26			0.37	0.28			0.22	0.42		
CD (0.05)	0.19	0.40			1.11	0.84			0.68	1.26		

PRC- Percentage reduction over control PIC- Percentage increase over control
Figures in parenthesis represent square root transformed values

Table 3: Cost of Plant Protection Chemicals

S. No	Items/Particulars	Unit qty.	Cost/unit	Qty./ha	Cost/ha
1.	Imidacloprid 48.0 FS - Seed treatment	50 ml	200/-	125 ml	500/-
2.	NSKE 5 - 2 sprays	1 kg	40/-	25 kg x 2= 50 kg	2000/-
3.	Indoxacarb 14.5 SC	100 ml	350/-	500 ml	1750/-
4.	Emmamectin benzoate 5 SG	100 g	650/-	200 g	1300/
5.	Thiamethoxam 25 WG	100 g	380/-	200 g	760/-
6.	Spinosad 45 SC	7 ml	155/-	150 ml	3300/-
7.	Profenophos 50 EC	1 litre	520/-	1 litre	520/-

Table 4: Economics of Treatment Details

Treatments	Cost of PP chemicals /ha	Total cost of production (excluding PP chemicals cost)	Total cost of production	Mean Yield (q/ha)	Gross Return (Rs) @ Rs 70/- per kg grain of mungbean	Net Return /ha (Rs)	Increased net return over control	B:C ratio
T1 (Seed treatment with Imidacloprid 48.0 FS @ 5 ml/ kg seed)	500/-	19,500/-	20,000/-	5.7	39,900/-	19,900/-	7,200/-	1.99
T2 (T_1 + NSKE 5% at 20 DAS for sucking pests & 30 DAS for borers)	2500/-	19,500/-	22,000/-	7.1	49,700/-	27,700/-	15,000/-	2.26
T3 (T_1 + Indoxacarb14.5 SC @ 65g a.i./ha at 30 DAS)	2250/-	19,500/-	21,750/-	8.9	62,300/-	40,550/-	27,850/-	2.86
T4 (T_1 +Emamectin benzoate 5 SG @ 11g a.i./ ha at 30 DAS)	1800/-	19,500/-	21,300/-	7.9	55,300/-	34,000/-	21,300/-	2.59
T5 (T_1 + Thiamethoxam 25 WG @ 50g a.i./ha at 30 DAS)	1260/-	19,500/-	20,760/-	7.1	49,700/-	28,940/-	16,240/-	2.39
T6 (T_1+ Spinosad 45 SC @ 73 g a.i./ ha at 30 DAS)	3380/-	19,500/-	22,880/-	8.5	59,500/-	36,620/-	23,920/-	2.60
T7 (T_1 + Profenophos 50 EC @ 200 g a.i./ ha at 30 DAS)	1020/-	19,500/-	20,520/-	7.5	52,500/-	31,980/-	19,220/-	2.56
T8 (Untreated Control)	-------	19,500/-	19,500/-	4.6	32,200/-	12,700/-		1.65

4. Conclusion

The findings of the present study revealed that seed treatment of mungbean reduced the sucking pest population like aphids, whiteflies, thrips upto 20 days after sowing. The seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of thiamethoxam 25 WG @ 50 g a.i./ha effectively managed the sucking pest population like aphids, whiteflies, thrips. Seed treatment with imidacloprid 48 FS @ 5 ml/ kg seed + spraying of indoxacarb @ 65g a.i./ha was effective against pod borers like *Maruca vitrata* and a better management option for farmers as they will get higher net return and profit.

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6. References

1. Justin CGL, Anandhi P, Jawahar D. Management of major insect pests of black gram under dryland conditions. Journal of Entomology and Zoology Studies. 2015: 3(1):115-121.
2. Nene YL. Indian pulses through the millennia. Asian Agri-history 2006: 10:179-202.
3. Anonymous. Odisha Agricultural Statistics, Directorate of Agriculture and food production, Odisha. 2013-14, 41.
4. Rabindra RJ, Ballali CR, Ramanujan B. Biological options for insect pests and nematode management in pulses. In: Pulses in New peespective. Indian Society of Pulses Research and Development, Kanpur, India. 2004, 400-425.
5. Kooner BS, Cheema HK, Kaur R. Insect pests and their management. In: Advances in mungbean and urdbean (Eds. M. Ali and Shivkumar), Indian Institute of Pulses Research, Kanpur. 2006, 335-401.
6. Mahalakshmi MS, Sreekanth M, Adinarayana M *et al*. Incidence, bionomics and management of spotted pod borer [*Maruca vitrata* (Geyer)] in major pulse crops in India-A review. Journal of Agricultural Reviews. 2015: 37(1):19-26.
7. Sharma HC. Bionomics, host plant resistance and management of legume pod borer, *Maruca vitrata* – A review. Crop Protection. 1998: 17:373-386.
8. Palumbo JC, Horowitz AR, Prabhaker N. Insecticidal control and resistance management for *Bemisia tabaci*. Crop Protection. 2001: 20:739-765.
9. Gomez KA, Gomez AA. Statistical procedures for agricultural research, John Wiley and sons, New York. 1984, 207-215.
10. Mathirajan VG, Regupathy A. Thiamethoxam 25 WG (Actara): A novel Nicotinyl insecticide for the management of sucking pests of Cotton. Journal of

Ecobiology. 2005: 17(3):223-228.

11. Kharel S, Singh PS, Singh SK. Efficacy of newer insecticides against sucking insect pests of greengram [*Vigna radiata* (L.) Wilczek]. International Journal of Agriculture, Environment and Biotechnology. 2016: 9(6):1081-1087.
12. Birbal B, Singh PS. Evaluation of some newer group of insecticides on the incidence of whitefly (*Bemisia tabaci*) in mungbean (*Vigna radiata* L.) ecosystem. Journal of Experimental Zoology, India. 2016; 19(1):307-312.
13. Dubey SC, Singh B. Seed treatment and foliar application of insecticides and fungicides for management of cercospora leaf spots and yellow mosaic of mungbean (*Vigna radiata*). International Journal of Pest Management. 2010; 56:309-314.
14. Naggar JB, Zidan NA. Field evaluation of imidacloprid and thiamethoxam against sucking insects and their side effects on soil fauna. Journal of Plant Protection Research. 2013: 53(4):375-387.
15. Mishra IOP, Mukherjee SK. Field effecacy of newer molecules on sap feeders of greengram *Vigna radiata* (L.) Wilzeck. Journal of Eco-friendly Agriculture. 2015: 10(2):155-156.
16. Yadav SR, Kumawat KC, Khinchi SK. Efficacy of new insecticide molecules and bioagents against sucking insect pests of cluster bean, *Cyamopsis tetragonoloba* (Linn.) Taub. Legume Research. 2015: 38(3):407-410
17. Sujatha B, Bharpoda TM. Evaluation of insecticides against sucking pests grown during kharif. International Journal of Current Microbiology and Applied. Science. 2017: 6(10):1258-1268.
18. Chitra S, Uthamasamy S. Pest management in greengram (*Vigna radiata* L.) grown under agroforestry. Indian Journal of Agroforestry. 2005; 7(2):49-54.
19. Yadav NK, Singh PS. Bio-efficacy of chemical Insecticides against Spotted Pod Borer, *Maruca testulalis* (Geyer) on Cowpea. International Journal of Agriculture, Environment & Biotechnology. 2014; 7(1):187-190.
20. Bairwa B, Singh PS. Evaluation of certain insecticides against spotted pod borer [*Maruca vitrata (geyer)*] on mungbean (*Vigna radiata*). The BioScan. 2015; 10(3):1037-1039.