Research Article

Managing Bean Thrips (*Megalurothrips distalis*) on Mungbean (*Vigna radiata* L.): A Comparative Study of Natural and Synthetic Control Methods

Muhammad Nadeem[1], Jamshaid Iqbal[2], Muneer Abbas[1*], Niaz Hussain[1], Muhammad Tariq Javeed[1], Abdul Ghaffar[1], Muhammad Irshad[1], Muhammad Aslam[1], Gul Rehman[2] and Shahar Yar Ahsan[1]

[1]Arid Zone Research Institute, Bhakkar 30000, Punjab, Pakistan; [2]Faculty of Agriculture, Gomal University, Dera Ismail Khan 29111, Khyber Pakhtunkhwa, Pakistan.

Abstract | During the study, different control practices, such as host plant resistance, imidacloprid seed treatment combined with the use of blue sticky traps, neem seed kernel extract, the entomopathogenic fungus *Beauveria bassiana* and synthetic insecticides (acephate and chlorfenapyr), were tested individually and in various combinations for managing thrips (*Megalurothrips distalis*). A mungbean genotype, 13TM-04, known for its comparative resistance, was chosen for these trials. The treatments, whether applied alone or in various combinations, showed significant differences in efficacy when compared with each other. A combination of treatments viz., imidacloprid seed treatment+ installation of blue sticky traps and chlorfenapyr 360 SC @ 100ml/acre spray was observed to be the most successful against thrips and resulted in maximum yield 1970.1 kg/ha of mungbean. While imidacloprid seed treatment with blue sticky trap installation, alone, did not show distinctive impact on the thrips population as well as on the yield in mungbean. The imidacloprid seeds treatment remained effective up to 38 days after sowing against the thrips. The application of chlorfenapyr and acephate, either individually as sprays or in combination with other control measures, resulted in a notable reduction in the thrips population. For the management of *M. distalis* in mungbean combination of imidacloprid seed treatment, blue sticky traps installation and chlorfenapyr at 100 ml/acre should be applied. Current studies provide useful information to adopt integrated pest management of thrips at Bhakkar district for the local farmers for better crop yield.

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***Correspondence** | Muneer Abbas, Arid Zone Research Institute, Bhakkar 30000, Punjab, Pakistan; **Email:** m.abbas1902@gmail.com
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Introduction

Pulses offer highly nutritious food and play a unique role in sustainable crop production by maintaining soil health and productivity Sujatha and Bharpoda (2017). Mungbean (*Vigna radiata* (L.) R. Wilczek) generally referred to as green gram, is an essential and widely recognized summer pulse crop

of several Asian countries including Pakistan. It is broadly distributed all around the world along with tropical and subtropical regions wherein south and southeast Asia become the principle grown region (Chadha, 2010). As compared with other summer crops, mungbean is a short-term crop which needs less water (Nadeem *et al*., 2016). Mungbean is resistant to drought and can tolerate unfavorable ecological conditions therefore it is possible to expand its production in rain fed areas (Afzal *et al*., 2000; Anjum *et al*., 2006). In 2019, the total area of mungbean cultivation in Pakistan was 186.7 thousand hectares, producing 132.7 thousand tons. This represented a 12.6 percent increase in production compared to 2018, when 117.8 thousand tons were produced from 163.2 thousand hectares (Anonymous, 2019-20). The reason for increase in production may be attributed to increase in cultivated area. Mungbean crop has a good yield potential in Pakistan however, as compared to other advance countries the average yield is low in the country. Insect pests pose a major risk for the production of this crop and increase the input cost. Among these, sucking insect pests are of the major importance inflicting heavy losses in crop yield, therefore, right and effective pest management strategies ought to be adopted to limit their losses (Panchabhavi and Kadam, 1990; Venugopal Rao *et al*., 1990; Bashir *et al*., 1991; Khattak *et al*., 2004). Thrips had become one of the most important sucking insect pests of mungbeans. Flower thrips (*Megalurothrips distalis* Karny) is a serious, widespread and regular pest of mungbean causing up to 65% yield losses. It generally harms tender buds and mungbean flowers (Chhabra and Kooner, 1985; Lal, 1985; Hossain *et al*., 2004, 2018). It is a very prolific species with numerous overlapping generations (Shelton *et al*., 2006). Inside the flowers of the plants, a large number of thrips may be seen. Both the nymphs and adults of thrips cause tissue damage by sucking the cell sap (Babar *et al*., 2016). The farmers normally manage thrips by applying chemical insecticides due to ease of application. However, with the passage of time most of the insecticides have become ineffective against thrips due to resistance, resurgence, replacement and ecological imbalance (Helweg *et al*., 2003; Zacharia, 2011) which ultimately increased the cost of production and destroyed beneficial fauna and caused environmental pollution (Adilakshmi *et al*., 2008). Traditional pesticides proved ineffective in managing insect pests, leading to notable crop yield reductions. Conversely, certain bio-rational programs and bio-pesticides have demonstrated greater efficacy than synthetic insecticides in addressing pest issues (Siegwart *et al*., 2015). Insect pathogens are environmentally secure, safe to human and other non-target species and are also considered natural mortality agents therefore can be used with other control tactics. Entomopathogenic fungi (EPF) have a potential to control a variety of insect pests (Reddy *et al*., 2014; Lopes *et al*., 2015; Wakil and Schmitt, 2015; Bayu and Prayogo, 2018). Microbial pesticides can play a prominent part in long-term crop production by providing an effective pest management programs and are safe for environment and other non-target species than chemical control (Khetan, 2000). In this scenario, it is important to identify some environmentally acceptable insect pest management strategies to grow health crop and increase mungbean yield per hectare. The said goal can be accomplished by eco-friendly insect pest control practices with some other newly developed cultivation practices. The use of resistant varieties is a vital practice in IPM (Dilawari and Dhaliwal, 1993). Though, sole reliance on resistant varieties cannot be enough due to difference of climatic conditions. It has to be incorporated with chemical control due to the fact it is more effective than other control methods and it hold the pest infestation below the ETL which is 4-6 thrips per flower. Chemicals may be used in conjunction with other control techniques. Many of the botanicals and entomopathogenic fungi have been investigated and have shown potential to substitute synthetic chemical insecticides. Since they are environmental friendly, the emphasis will be on the promoting of the use of such steps to tackle certain insecticides related concerns (Sohail *et al*., 2015). Current research was aimed at investigating a bio-rational Integrated Pest Management (IPM) approach for monitoring and controlling thrips on mungbean, thereby safeguarding the crop against significant yield losses. This study sought to assess the effectiveness of diverse control methods, including host plant resistance, botanical, microbial, mechanical, and safer chemical controls, both individually and in various combinations under field conditions, to effectively manage thrips on mungbean.

Materials and Methods

Experimental site (31˚3 N, 71˚02 E)

To develop an integrated control model for the management of thrips in mungbean crop, studies

were conducted at the Arid Zone Research Institute (AZRI), Bhakkar, and two farmer fields of District Bhakkar, Pakistan during 2020.

Integrated Pest Management (IPM) study for the control thrips on mungbean was conducted at three locations, i.e., AZRI, Bhakkar, as well as at the Farmer fields of Chak No. 36/TDA and Kotla Jam of District Bhakkar, Pakistan during 2020. Bhakkar's climate is dry, mostly composed of deserts. The rains fall is approximately 213 mm annually.

Experimental design

Diverse manipulate measures like, resistance cultivar 13TM-04, microbial control agents, like, entomopathogenic fungi *Beauveria bassiana* @ 7.5%, mechanical control, such as, use of blue color sticky trap @ 1 trap/treatment, were included in these studies along with imidacloprid 70 WP @ 5 gm/kg of seed treatment, NSKE @ 5% and the use of insecticide, like, spray of acephate @ 330 gm/acre, chlorfenapyr @ 100 ml/acre alone, and in feasible combinations were applied at 3 localions for thrips control. The crop was sown on 25, 27 as well as on 29 May, 2020 at the farmer field of chak No. 36/TDA, AZRI, Bhakkar and farmer field of Kotla Jam, respectively with Randomized Complete Block Design. All agronomic practices were implemented as needed. At each locality, the plot size 5m × 2.4m for each treatment was maintained replicated thrice.

Land preparation and manuring

Sandy loam soil is present in the area which is lacking in organic matter, nitrogen and phosphorus. The soil contains an adequate to marginal amount of potassium. Bhakkar has arid to semi-arid climate. In summer weather is hot and dry while during monsoon season it has moderate spells of rain. For good seed bed preparation, the soil of experimental plots were ploughed twice with desi plough and leveled with the help of heavy wooden plank. Pre-irrigation was carried out before one week of sowing to kill weeds. Being a leguminous crop, mungbean needs a small amount of nitrogenous fertilizer at early growth period. N-P-K 22:57:30 kg/ha was applied as a recommended dose for the mungbean crop (Hossain *et al.*, 2021).

Seed rate and method of sowing

Recommended seed rate i.e., 30 kg/hectare was used and before sowing seed was treated with fungicide Dithane M-45 @ 2.0 gm per kg of seed. Bacterial culture i.e., *Rhizobium leguminosarum* was also applied because it has the ability to fix free nitrogen from the air. With the help manually operated hand driven drill sowing was done keeping row to row (RxR) 30 cm distance with the help of marker and plant to plant (PxP) 10 cm distance. After sowing the seeds were covered with a thin layer of soil. Mungbeans typically require 2-3 irrigation cycles, depending on the prevailing climatic conditions. The first irrigation is typically performed 3-4 weeks after germination. The second irrigation is applied during the flowering stage, while the third irrigation is applied during the pod formation stage.

Application of weedicides

Before sowing Pendimethalin 33EC @ 2.5 L/ha as pre-emergence treatment was applied. When weeds appeared in the experimental trials than manual cleaning of weeds and proper weedicides were applied as and when required. Weedicide Haloxyfop-R-Methyl 10.8EC @ 875 ml/ha was applied for narrow leaves weeds and Lactofen 24% @740 ml/ha was applied for broad leaves weeds. Each trial and treatment was properly labeled. Labeling of trials and treatments was helpful at the time of thrips data and yield data collection.

Materials and Methods

After 90 days of mungbean sowing, the crop was harvested and sun dried before being threshed. After the harvesting and threshing of mungbean crop seed grains were properly sun-dried from each plot and from each replication their weights were calculated. Grain weight per plot were determined and converted to yield/hectare. The imidacloprid seed treatment and blue sticky trap effect on thrips population was observed 38 DAS, at seven days intervals up to 45 days after spray and counted as pre-treatment counts or 24 hours before the first spray application. The efficiency was observed by recording the thrips data before one day application (pre-treatment population) and after 3, 7 and 14 days after each treatment application. After rebuilt of the thrips population second spray application was carried out and again observations were recorded with the same pattern as explained earlier. Yield of each plot was then converted in to yield/hectare. For the control of thrips following treatments were applied at all three experimental locations.

T_1	Imidacloprid 70 WS seed treatment @ 5gm/Kg of seed + Blue sticky trap
T_2	Entomopathogenic fungi *Beauveria bassiana* @ 7.5%.
T_3	Neem' seed kernel-extract @ 5%
T_4	Acephate @ 330 gm/acre
T_5	Chlorfenapyr @ 100 ml/acre
T_6	Imidacloprid 70WS seed treatment @ 5gm/Kg of seed + Blue sticky trap + Entomopathogenic fungi *Beauveria bassiana* @ 7.5%
T_7	Imidacloprid seed treatment + Blue sticky trap +'Neem' seed kernel extract
T_8	Imidacloprid seed treatment + Blue sticky trap + Acephate @ 330gm/acre
T_9	Imidacloprid seed treatment + Blue sticky trap + Chlorfenapyr @ 100 ml/acre
T_{10}	Entomopathogenic fungi *Beauveriabassiana* @ 7.5% + 'Neem' seed kernel-extract
T_{11}	Control

Table 1: *Thrips population per flower difference at 24 h pre-treatment and 3, 7, and 14 days after spray (DAS) using different treatments at different locations during first spray.*

Treatments	Pre treatment			3 DAS			7 DAS			14 DAS		
	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3
T_1	3.00 b	3.31 b	3.51 b	3.42 b	3.62 b	3.82 b	3.71 b	4.00 b	4.13 b	4.09 b	4.40 b	4.64 b
T_2	4.00 a	4.20 a	4.47 a	2.15 c	2.29 c	2.56 c	1.49 c	1.61 c	1.84 c	1.98 f	2.14 e	2.35 e
T_3	4.02 a	4.20 a	4.47 a	1.73 d	1.90 d	2.11 d	1.31 cd	1.42 cde	1.62 cd	3.38 c	3.60 c	3.91 c
T_4	4.00 a	4.20 a	4.40 a	0.73 fg	0.82 fg	1.04 fg	1.40 c	1.52 cd	1.69 cd	2.71 de	2.90 d	3.15 d
T_5	4.02 a	4.20 a	4.47 a	0.58 fgh	0.69 fg	0.84 fg	1.04 de	1.15 ef	1.40 de	1.77 fg	1.93 ef	2.02 ef
T_6	3.13 b	3.29 b	3.55 b	1.82 d	1.98 d	2.24 d	1.22 cde	1.40 cde	1.49 cd	1.73 fg	1.89 ef	2.09 ef
T_7	3.09 b	3.33 b	3.51 b	1.40 e	1.51 e	1.75 e	1.00 e	1.15 ef	1.40 de	3.09 cd	3.31 c	3.65 c
T_8	3.04 b	3.24 b	3.56 b	0.44 gh	0.60 gh	0.80 g	1.09 de	1.25 de	1.45 de	2.42 e	2.53 d	2.80 d
T_9	3.09 b	3.31 b	3.51 b	0.29 h	0.33 h	0.49 h	0.69 f	0.87 fg	1.11 ef	1.49 g	1.62 f	1.82 f
T_{10}	4.02 a	4.22 a	4.47 a	0.89 f	0.98 f	1.15 f	0.53 f	0.64 g	0.82 f	1.49 g	1.69 f	1.89 f
T_{11}	4.07 a	4.29 a	4.51 a	4.13 a	4.32 a	4.49 a	4.38 a	4.64 a	4.82 a	4.82 a	5.08 a	5.25 a
$LSD_{0.05}$	0.41	0.52	0.56	0.33	0.3	0.31	0.3	0.35	0.36	0.4	0.39	0.38

Means with the similar letter(s) in each column and rows for interaction, in column for locations and in rows for treatments are not statistically different from each other at P=0.05 by LSD Test, DAS = Days After Sowing, Location 1 = Farmer Field, 36/TDA, Bhakkar, Location 2 = Arid Zone Research Institute, Bhakkar, Location 3 = Farmer Field,Kotla Jam, Bhakkar.

Observations

The data was obtained 1 day before and 3, 7 and 14 days after the spray (DAS) application. At reproductive stage thrips numbers were recorded. From each treatment five plants were selected randomly and three flowers of each those plants were observed for the collection of thrips data. To collect data, the collected flowers were carefully opened on white paperboard, and the number of thrips was counted using a magnifying lens. The second spray application was conducted after resurgence in the thrips population, and observations were recorded following the same procedure as described earlier. The average population of thrips of each genotype was determined on per flower basis. The blue sticky traps were installed before flowering stage i.e., 31 days after sowing (DAS). Yield data was also recorded from each locality.

Statistical analysis

To determine treatments significance, the data was analyzed for analysis of variance (ANOVA) by using Statistix 8.1 version. By LSD test were determined for mean values of thrips population at 5% probability level (Gomez *et al*., 1984).

Results and Discussion

Results presented in Table 1 showed mean population reduction of *Megalurothrips distalis* at 24 hours pre-treatment and 3, 7 and 14 days after spray which revealed that at all three locations before treatments applications no substantial differences in thrips population was observed during first application except where imidacloprid seed treatment and blue sticky traps were applied. Results showed that 3 days

Table 2: *Thrips population per flower difference at 24 h pre-treatment and 3, 7, and 14 days after spray (DAS) using different treatments at different locations during second spray.*

Treatments	Pre treatment			3 DAS			7 DAS			14 DAS		
	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3
T_1	4.60 cde	4.86 cde	5.20 bc	4.27 b	4.44 b	4.73 b	4.18 b	4.39 b	4.60 b	4.09 b	4.33 b	4.49 b
T_2	5.02 abc	5.31 abc	5.54 abc	2.47 c	2.59 c	2.87 c	1.53 c	1.62 c	1.84 c	1.82 f	1.94 e	2.09 f
T_3	5.13 ab	5.38 ab	5.67 ab	2.02 d	2.14 d	2.33 d	1.35 c	1.45 cd	1.71 cd	3.07 c	3.24 c	3.58 c
T_4	4.76 bcde	5.03 bcd	5.22 bc	0.80 fg	0.87 fg	1.11 ef	1.42 c	1.53 c	1.80 cd	2.53 d	2.71 d	2.93 de
T_5	4.55 de	4.86 bcde	5.02 cd	0.58 gh	0.71 gh	1.00 ef	0.98 d	1.09 e	1.49 cde	1.67 f	1.83 e	2.04 fg
T_6	4.49 ef	4.78 de	4.96 cd	2.07 d	2.24 d	2.49 cd	1.25 cd	1.33 cde	1.49 cde	1.58 fg	1.69 ef	1.89 fg
T_7	4.55 de	4.86 cde	5.02 cd	1.58 e	1.73 e	2.07 d	1.00 d	1.13 e	1.44 de	2.89 c	3.04 c	3.29 cd
T_8	4.49 ef	4.73 de	4.96 cd	0.40 hi	0.47 hi	0.80 ef	1.04 d	1.18 de	1.49 cde	2.25 e	2.42 d	2.58 e
T_9	4.11 f	4.36 e	4.56 d	0.20 i	0.27 i	0.69 f	0.62 e	0.70 f	1.13 ef	1.26 h	1.40 f	1.69 fg
T_{10}	4.93 abcd	5.24 abcd	5.49 abc	0.93 f	1.07 f	1.20 e	0.47 e	0.58 f	0.87 f	1.31 gh	1.49 f	1.64 g
T_{11}	5.36 a	5.57 a	5.91 a	4.95 a	5.11 a	5.29 a	4.76 a	4.94 a	5.15 a	4.67 a	4.85 a	4.98 a
$LSD_{0.05}$	0.44	0.52	0.62	0.3	0.31	0.44	0.3	0.3	0.38	0.28	0.33	0.4

Means with the similar letter(s) in each column and rows for interaction, in column for locations and in rows for treatments are not statistically different from each other at P=0.05 by LSD Test, DAS = Days After Sowing, Location 1 = Farmer Field, 36/TDA, Bhakkar, Location 2 = Arid Zone Research Institute, Bhakkar, Location 3 = Farmer Field,Kotla Jam, Bhakkar.

after spray, density of *M. distalis* was considerably higher in control plots in comparison to all other tested treatments which were significantly different from each other's. The lowest thrips population was observed in the T_9 followed by T_8, and T_{10} treated plots. The results (Table 1) exhibited that 7 days after spray, thrips population trend was close to those observed at 3 days after spray in the treated and control plots but the thrips population was much lower as compared to 3 days after spray. These results also depicted that thrips density in the T_9 differed not only significantly from the untreated (control) treatment but also with the rest of all other tested treatments, except T_{10} treatment. Results showed that 14 days after spray thrips population increased in all plots. After the second round of treatments application, the population pattern of thrips between experimental plots was the same as after first spraying (Table 2).

The results (Table 3) reflect a mean comparison of results relating to the effect of treatments on the density and the percent decline of thrips at various post-treatment periods. Results (Table 4) demonstrated that the lowest thrips population was found in T_9, followed by T_8, T_{10} and T_5, respectively with 1.71, 2.11, 2.19 and 2.25 thrips per flower population, respectively. Seed treatment with imidacloprid and installation of blue sticky traps alone were found to be minimally effective, resulting in 3.94 thrips per flower population. This was followed by treatments T3 and T2, which resulted in 3.01 and 2.83 thrips per flower population, respectively, compared to 4.73 thrips per flower in the control (untreated) group. All the other treatments showed intermediate response in controlling thrips on mungbean ranging from 2.58 to 2.33 per flower population. It was observed from these findings that T_9, when imidacloprid seed-treatment + blue sticky traps and spray of chlorfenapyr, were applied collectively, was found to be the most efficient and it resulted in lowest thrips per flower population at all the experimental localities and was statistically at par with each other. Variations have been observed to exist, between other treatments, in various locations. The impact of imidacloprid seed treatment+blue sticky traps was lowest at all the experimental sites. The imidacloprid seed-treatment + blue sticky trap and application of acephate (T_8), exhibited a noteworthy impact on the thrips densities after T_9. On all observation dates, after each application of blue sticky traps, the thrips population remained close to ETL, but exerted a considerable effect against the control. Results (Table 5) exhibited that maximum yield 1970.1 kg/ha of mungbean, was recorded in T_9, followed by that in T_5, T_8, T_4 and that in T_{10}, with 1941.6, 1840.7, 1800 and 1627.3 kg/ha, respectively and were statistically different from each other. The installation of imidacloprid seed treatment+blue sticky traps exhibited 1001.6 kg/ha yields and was considerably different from control however, did not

Table 3: *Thrips (Megalurothrips distalis L.) per flower density along with the percent reduction on mungbean, Vigna radiate L. as affected by diverse treatments, at different intervals after sowing.*

Treatments	38 DAS		45 DAS		49 DAS		53 DAS	
	Population	% reduction	Population	% reduction	Population	% reduction	Population	% reduction
T_1= Imida seed treatment+ Sticky trap	2.21 c	0.40	3.27 b	0.24	3.62 b	0.16	3.95 b	0.14
T_2=*B. bassiana* 7.5%	3.58 ab	0.04	4.22 a	0.02	2.33 c	0.46	1.65 c	0.64
T_3= NSE 5%	3.55 ab	0.05	4.23 a	0.01	1.92 d	0.56	1.45 cde	0.69
T_4=Acephate	3.48 b	0.07	4.20 a	0.02	0.87 fg	0.80	1.53 cd	0.67
T_5=Chlorfenapyr	3.61 ab	0.03	4.23 a	0.01	0.70 gh	0.84	1.20 f	0.74
T_6=T_1+T_2	2.27 c	0.39	3.33 b	0.22	2.01 d	0.53	1.37 def	0.70
T_7=T_1+T_3	2.21 c	0.41	3.31 b	0.23	1.55 e	0.64	1.19 f	0.74
T_8=T_1+T_4	2.28 c	0.39	3.28 b	0.24	0.61 h	0.86	1.26 ef	0.73
T_9=T_1+T_5	2.24 c	0.40	3.30 b	0.23	0.37 i	0.91	0.89 g	0.81
T_{10}=T_2+T_3	3.67 ab	0.01	4.24 a	0.01	1.01 f	0.77	0.67 g	0.86
T_{11}=Control	3.72 a	0.00	4.29 a	0.00	4.31 a	0.00	4.62 a	0.00
LSD	0.23		0.24		0.17		0.22	

60 DAS		67 DAS		71 DAS		75 DAS		82 DAS	
Population	% reduction	Population	% reduction	Population	% reduction	Population	% reduction	Population	% reduction
4.38 b	0.14	4.89 d	0.13	4.48 b	0.13	4.39 b	0.11	4.30 b	0.11
2.16 g	0.58	5.30 abc	0.06	2.64 c	0.48	1.67 c	0.66	1.95 g	0.60
3.63 c	0.29	5.40 ab	0.04	2.17 d	0.58	1.51 d	0.70	3.30 c	0.32
2.92 e	0.42	5.01 cd	0.11	0.93 fg	0.82	1.59 cd	0.68	2.72 e	0.44
1.91 h	0.62	4.82 d	0.14	0.77 g	0.85	1.18 f	0.76	1.85 gh	0.62
1.90 h	0.63	4.74 d	0.15	2.27 d	0.56	1.36 e	0.73	1.72 h	0.64
3.35 d	0.34	4.81 d	0.14	1.79 e	0.65	1.19 f	0.76	3.07 d	0.36
2.59 f	0.49	4.72 d	0.16	0.56 h	0.89	1.24 ef	0.75	2.41 f	0.50
1.65 i	0.68	4.34 e	0.23	0.39 i	0.93	0.82 g	0.84	1.45 i	0.70
1.69 hi	0.67	5.22 bc	0.07	1.06 f	0.79	0.64 h	0.87	1.48 i	0.69
5.09 a	0.00	5.61 a	0.00	5.12 a	0.00	4.95 a	0.00	4.83 a	0.00
0.24		0.33		0.17		0.15		0.15	

Means with the similar letter(s) in each column are not statistically different from each other at P=0.05 by LSD test, DAS= Days after sowing

Table 4: *Means comparison of the thrips (Megalurothrips distalis L.) population per flower on mungbean in different treatments and localities.*

Treatments	Locality x treatment **			Localities mean **	
	Location 1	Location 2	Location 3	Thrips population/ flower	% reduction
T_1= Imida seed treatment+ sticky trap	3.71 f	3.95 e	4.17 d	3.94 b	0.17
T_2 = *B.bassiana*7.5%	2.65 jk	2.81 i	3.04 h	2.83 d	0.39
T_3 = Neem seed Extract 5%	2.82 i	2.98 h	3.24 g	3.01 c	0.36
T_4 = Acephate	2.41lmno	2.56 kl	2.78 ij	2.58 e	0.45
T_5 = Chlorfenapyr	2.07stu	2.23 pqr	2.45 lmn	2.25 fg	0.51
T_6 = T_1+T_2	2.16 rs	2.32 nopq	2.51 klm	2.33 f	0.51
T_7 = T_1+T_3	2.30 opqr	2.48 lm	2.72 ij	2.50 e	0.48
T_8 = T_1+T_4	1.92 u	2.08 st	2.32 nopq	2.11 h	0.56
T_9 = T_1+ T_5	1.54 v	1.67 v	1.94 tu	1.71 i	0.63
T_{10} = T_2+ T_3	2.00 tu	2.17 qrs	2.37 mnop	2.19 gh	0.53
T11 = Control	4.52 c	4.73 b	4.93 a	4.73 a	0.00
LSD at 5%	0.15			0.09	

Means with the similar letter(s) in each column and rows for interaction, in column for locations and in rows for treatments are not statistically different from each other at P=0.05 by LSD Test, DAS = Days After Sowing, Location 1 = Farmer Field, 36/TDA, Bhakkar, Location 2 = Arid Zone Research Institute, Bhakkar, Location 3 = Farmer Field,Kotla Jam, Bhakkar

Table 5: *Means comparison of treatments effect on yield (kg/ha) of mungbean at different locations.*

Treatment	Interaction			Means for localities
	Location 1	Location 2	Location 3	
T_1 = Imida seed treatment+ sticky trap	1074.7 o	984.0 p	946.0 pq	1001.6 j
T_2 = EPF	1411.9 gh	1304.0 jk	1264.5 kl	1326.8 g
T_3 = Neem seed Extract	1322.7 j	1211.0 mn	1171.3 n	1235.0 i
T_4 = Acephate	1904.2 bc	1767.7 de	1728.0 e	1800.0 d
T_5 = Chlorfenapyr	2048.5 a	1908.0 bc	1868.3 c	1941.6 b
$T_6 = T_1+T_2$	1458.0 g	1347.7 ij	1308.0 jk	1371.3 f
$T_7 = T_1+T_3$	1377.5 hi	1271.3 kl	1231.6 lm	1293.5 h
$T_8 = T_1+T_4$	1946.4 b	1807.7 d	1768.0 de	1840.7 c
$T_9 = T_1+ T_5$	2068.0 a	1941.0 b	1901.3 bc	1970.1 a
$T_{10} = T_2+ T_3$	1725.4 e	1598.3 f	1558.3 f	1627.3 e
T_{11} = Control	908.0 qr	880.7 r	879.0 r	889.2 k
LSD at 5%	47.76			27.58
Means for Localities	1567.8 a	1456.5 b	1420.4 c	
LSD at 5%	14.40			

Means with the similar letter(s) in each column and rows for interaction, in column for locations and in rows for treatments are not statistically different from each other at P=0.05 by LSD Test, DAS = Days After Sowing, Location 1 = Farmer Field, 36/TDA, Bhakkar, Location 2 = Arid Zone Research Institute, Bhakkar, Location 3 = Farmer Field,Kotla Jam, Bhakkar

show a positive effect on mungbean yield. In addition, all of the other tested treatments resulted intermediate results in case of mungbean yield. Comparable tendency was noted between the treatments and localities interaction, with a little difference. However, there was somewhat different impact on localities. The maximum mungbean yield was observed at the experiments sown in the Location 1 which was significantly different from that of experiments harvested in other localities. While, the research area of Location 3 exhibited minimum yield and it was significant different with other localities. The experimental area of location 2 showed an intermediate yield response. This disparity may be due to variation in the soil nutrients. It was found from this experiment that combination of imidacloprid seed treatment + blue sticky trap and spray of chlorfenapyr were observed to be very efficient followed by spray of chlorfenapyr and imidacloprid seed treatment + blue sticky trap and acephate spray. This study revealed that the tested seed treatment+blue sticky trap, bio-insceticides, chemical insecticides and their possible combinations were highly effective against mungbean thrips. Chemical control, is a key component of IPM program to combat insect pests losses (Sarfraz *et al.*, 2005; Soomro *et al.*, 2008; Nadeem *et al.*, 2016) so majority of the farmers prefer this control method. Present results suggested that in comparison to all other tested approaches chlorfenapyr and acephate 75% in combination of imidacloprid seed treatment+blue sticky traps were proved to be more successful which gave considerable reduction of thrips population. There is no documented material to relate this research from Pakistan. However, many researchers worked on chemical insecticides alone to control thrips densities. These results are in conformity with Hossain *et al.* (2018) findings that for the thrips control, chlorfenapyr gave very good efficiency as compared to spraying of azadirachtin which exhibited less effectiveness in reducing thrips population. The combination of chlorfenapyr with imidacloprid seed treatment and blue sticky traps was found to be effective in managing the thrips population on mungbean. This combination, leveraging the seed treatment's effectiveness and chlorfenapyr's control, provided the best results. Furthermore, the blue sticky traps were effective in capturing a greater number of thrips, enhancing the overall efficacy of the treatment. Due to this reason they improved the insecticide's activity and eliminated more thrips than other treatments. Likewise Din *et al.* (2016) observed that chlorfenapyr 36 SC is better than imidacloprid 200 SL which corroborated the present research results. Furthermore, Babar *et al.* (2016) stated that acephate 75 SP had the highest mortality percentage 24 and 72 hours after treatment. Based on two spray applications of different pesticides at three different locations, the results showed that combination of chlorfenapyr and imidacloprid seed treatment + blue sticky traps was found more efficient followed by combination

of acephate and imidacloprid seed treatment + blue sticky trap treatment and combination of *B.bassiana* 7.5% and neem seed extract which results 63, 56 and 53% reduction over control respectively while, imidacloprid seed treatment+ blue sticky trap alone proved least effective with 17% reduction over control. These findings are in confirmatory with Shah *et al.* (2017) who found that acephate pesticide showed 37.39% overall thrips reduction which is superior to other tested insecticides and with the control plot (11.50%). Similarly, Khaliq *et al.* (2016) found that acephate was the best as compared to other pesticides. The outcomes of Din *et al.* (2015) favors our findings that acephate 75SP was most effective. The results are in consistency with the Iqbal *et al.* (2013) and Pachundkar *et al.* (2013) who found that acephate had highest control of thrips density. In the present research Neem Seed Extract (NSE) showed more than 69% and 70% reductions (Table 3) in the thrips population up to 7 days after spray which is in the line of Kadri and Goud (2010) who observed that neem extracts in onion cause noteworthy reduction of thrips. Similarly, toxicity of neem against thrips were found by Mishra *et al.* (2016). Our results showed that all tested chemical insecticides, bio pesticides and their possible combinations were effective in controlling thrips in mungbean crop which are in agreement with Subramanian *et al.* (2010). The present study concluded that chemical pesticides were most efficient against thrips, followed by biopesticides which are in agreement with Mandi and Senapati (2009). The pathogenicity of *B. bassiana* against thrips was verified and concluded that they caused good mortality by different scientist (Jacobson *et al.*, 2001; Yankova and Markova, 2017). Similarly, Palthiya *et al.* (2017) reported that *B. bassiana* can reduce thrips population by 65% to 87% when used as a foliar spray. More recently Bayu and Prayogo (2018) also reported similar results. When entomopathogen *B. bassiana* 7.5% was applied in combination with neem, the 53% protection over control were considerably superior in all the treatments than their individual result which was 39 and 36%, respectively (Table 4) indicating compatibility among these major biopesticides. Further when the neem seed extract spray in combination of *B. bassiana* entomopathogenic fungi, the mortality rate was quickened and ending up with the 86% and 87% percent mortality after seven days of the treatment application during first and second spray application (Table 3). Based on the results obtained it is clear that combination of different treatments ended with more mortality percentage which is greater than their separate effects which indicates the presence of clear synergetic activity especially in case of neem, and entomopathogenic fungi *B. bassiana* @ 7.5% which is in line with of Otieno *et al.* (2016). The inhibition of certain susceptible isolates of *B. bassiana* by azadirachtin has also been observed (Depieri *et al.*, 2005; Mohan *et al.*, 2007) which demonstrated that certain neem concentrations are well-matched and synergistic when combined with EPFs. Halder *et al.* (2017) reported that all the tested entomopathogenic fungi (EPF) including *B.bassiana* were compatible with neem against insect pests of vegetables. The present outcomes are in accord with the Subbulakshmi *et al.* (2012) who found that nimbecidine neem based formulation worked well with EPF including *B. bassiana.* The significant rise in neem activity and EPF mixtures was due to the probable stabilizer and synergistic result of neem (Halder *et al.*, 2012, 2013). It is evident from our research that when used in mixture of neem seed extract, and *B. bassiana* give maximum protection against thrips in mungbean which would benefit farmers by lowering the cost of thrips management. The findings of the experiments on mortality strongly support the use of combined bio pesticides as a new method for IPM.

Out of eleven different treatments, the significant superiority preferably towards the control of thrips and yield was found in chlorfenapyr and acephate combination with imidacloprid seed treatment + blue sticky traps applications (Tables 4 and 5). The present research found that at all tested locations the yield of mungbean in chemical insecticides as well as botanicals treated plots was substantially higher than in control plots (Table 5). Similar findings were observed by Hossain *et al.* (2018) while installing white sticky trap + chlorfenapyr + emamectin benzoate spray and got highest mungbean yield. Similarly, Hossain (2014) reported that highest yield 1933 kg/ha was achieved from white sticky trap in combination with voliam flexi sprayed plots while testing different IPM practices in mungbean. Furthermore, Singh and Singh (2015) reported that by adoption of IPM module insect pest density in mungbean can be reduced which ultimately enhanced the yield.

Conclusions and Recommendations

The population of thrips in mungbean reached the economic threshold level 45 days after sowing,

specifically during the flowering stage, across three locations. Consequently, it is recommended to increase the frequency of scouting to at least twice a week during this critical phase. Imidacloprid seed treatment is suggested for managing *M. distalis* in mungbean. Monitoring insect populations using blue sticky traps at the onset of the flowering stage proved beneficial for early detection of infestations. When *M. distalis* infestation reached the economic threshold level, chlorfenapyr at 100 ml/acre was the most effective treatment. To preserve an eco-friendly ecosystem for beneficial insects and human health, it is imperative to use comparatively safer insecticides according to the economic threshold level during the mungbean cropping season. Additionally, the application of botanicals and selective insecticides has shown promise in pest management and increasing mungbean yields.

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Novelty Statement

These findings offer a practical integrated pest management approach to control thrips for local farmers to maintain an eco-friendly ecosystem for beneficial fauna and flora.

Author's Contribution

Muhammad Nadeem: Conducted Research and wrote manuscript.
Jamshaid Iqbal: Conceptualized and designed the study.
Muneer Abbas: Reviewed manuscript and publication.
Niaz Hussain, Muhammad Tariq Javeed and Abdul Ghaffar: Conducted comprehensive reviews.
Muhammad Irshad and Muhammad Aslam: Proof read manuscript.
Gul Rehman: Identified the Scope of study.
Shahar Yar Ahsan: Managed article and incorporated corrections.

Conflict of interest

The authors have declared no conflict of interest.

References

Adilakshmi, A., D. Korat and P. Vaishnav. 2008. Bio-efficacy of some botanical insecticides against pests of Okra. Karnataka J. Agric. Sci., 21(2): 290-292.

Afzal, M., M. Sharif, A. Raza, A. Tasneem and M. Bashir. 2000. Comparative efficacy of some traditional and non-traditional insecticides against whitefly (*Bemisia tabaci* Genn.) on Mung-85 (*Vigna radiata* L.). Pak. Entomol., 22(1/2): 47-49.

Anjum, M., Z. Ahmed and C.A. Rauf. 2006. Effect of Rhizobium inoculation and nitrogen fertilizer on yield and yield components of mungbean. Int. J. Agric. Biol. (Pak.), 8(2): 238-240.

Anonymous, 2019-20. Pakistan Economic Survey.

Babar, T.K., H. Karar, M. Hasnain, M. Arshad, A.A. Ahmad and M. Akram. 2016. Field evaluation of new insecticides against cotton thrips (*Thrips tabaci* lind.) in district Multan. Pak. Entomol., 38(1): 7-13.

Bashir, M., S. Mughal and B. Malik. 1991. Assessment of yield in lentil due to insect pests and virus in urd bean, *Vigna mungo* (L.). Pak. J. Bot., 23(1): 40-142.

Bayu, M. and Y. Prayogo. 2018. Field efficacy of entomopathogenic fungi *Beauveria bassiana* (Balsamo) for the management of mungbean insect pests. IOP Conf. Ser. Earth Environ. Sci., pp. 1-9. https://doi.org/10.1088/1755-1315/102/1/012032

Chadha, M., 2010. Short duration mungbean: A new success in south Asia. APAARI.

Chhabra, K., and B. Kooner. 1985. Problem of flower shedding caused by thrips, *Megalurothrips distalis* (Karny), on summer mungbean, *Vigna radiata* (L.) Wilczek, and its control. Int. J. Pest Manage., 31(3): 186-188. https://doi.org/10.1080/09670878509370978

Depieri, R.A., S.S. Martinez and A.O. Menezes. 2005. Compatibility of the fungus *Beauveria bassiana* (Bals.) Vuill. (Deuteromycetes) with extracts of neem seeds and leaves and the emulsible oil. Neotrop. Entomol., 34(4): 601-606. https://doi.org/10.1590/S1519-566X2005000400010

Dilawari, V. and G. Dhaliwal. 1993. Host plant resistance to insects: Novel concepts. Advances in host plant resistance to insects. New Delhi

(India): Kalyani Publishers. pp. 393-422.

Din, M., M.K. Nadeem, M. Ali, M.Q. Waqar, M.A. Ali and N. Masood. 2015. Efficacy of some insecticides against cotton thrips (*Thrips tabaci* Lind.) under natural field conditions. J. Environ. Agric. Sci., 5: 1-3.

Din, N., M. Ashraf and S. Hussain. 2016. Effect of different non-chemical and chemical measures against onion thrips. J. Ent. Zool. Stud., 4(5): 10-12.

Gomez, K.A., K.A. Gomez and A.A. Gomez. 1984. Statistical procedures for agricultural research. John Wiley & Sons.

Halder, J., A. Rai and M. Kodandaram. 2013. Compatibility of neem oil and different entomopathogens for the management of major vegetable sucking pests. Natl. Acad. Sci. Lett., 36(1): 19-25. https://doi.org/10.1007/s40009-012-0091-1

Halder, J., C. Srivastava, S. Dhingra and P. Dureja. 2012. Effect of essential oils on feeding, survival, growth and development of third instar larvae of *Helicoverpa armigera* Hubner. Natl. Acad. Sci. Lett., 35(4): 271-276. https://doi.org/10.1007/s40009-012-0043-9

Halder, J., D. Kushwaha, A. Rai, A. Singh and B. Singh. 2017. Potential of entomopathogens and neem oil against two emerging insect pests of vegetables. Indian J. Agric. Sci., 87(2): 220-224. https://doi.org/10.56093/ijas.v87i2.67634

Helweg, C., B.B. Mogensen, P.B. Sørensen, T. Madsen, R. Bossi, D. Rasmussen and S. Petersen. 2003. Fate of pesticides in surface waters, laboraty and field experiments. Pestic. Res., 68: 55-60.

Hossain, M.A., 2014. Development of IPM practices for the control of flower thrips and pod borers in mungbean (*Vigna radiata* L.). Bull. Inst. Trop. Agric. Kyushu Univ., 37(1): 85-92.

Hossain, M.A., M. Sarker and M. Azam. 2018. Evaluation of some integrated management approaches against flower thrips and pod borers of mungbean (*Vigna radiata* L.). Jahangirnagar Univ. J. Biol. Sci., 7(1): 55-64. https://doi.org/10.3329/jujbs.v7i1.37974

Hossain, M., J. Ferdous, M. Sarkar and M. Rahman. 2004. Insecticidal management of thrips and pod borer in mungbean. Bangladesh J. Agric. Res., 29(3): 347-356.

Hossain, M., S. Yesmin, M. Islam, M. Hossain and M. Jahan. 2021. Physiological attributes of mungbean (*Vigna radiata* L.) influenced by different sources of nutrients (NPK) in Madhupur tract region of Bangladesh. J. Sci. Technol. Environ. Infirmat., 11(1): 736-748. https://doi.org/10.18801/jstei.110121.74

Iqbal, J., M. Nadeem and MWU Hassan. 2013. Comparative efficacy of some insecticides against sucking insect pests on mungbean, *Vigna radiata* (L.) Wilczek. Gomal Univ. J. Res., 29(1): 31-37.

Jacobson, R., D. Chandler, J. Fenlon and K. Russell. 2001. Compatibility of B*eauveria bassiana* (balsamo) vuillemin with amblyseius C*ucumeris oudemans* (Acarina: Phytoseiidae) to control F*rankliniella occidentalis* pergande (Thysanoptera: Thripidae) on cucumber plants. Biocontr. Sci. Technol., 11(3): 391-400. https://doi.org/10.1080/09583150120055808

Kadri, S.W. and K.B. Goud. 2010. Efficacy of newer molecules of insecticides and botanicals against onion thrips, *Thrips tabaci* (Lindeman) (Thysanoptera: Thripidae). Karnataka J. Agric. Sci., 19(3): 539-543.

Khaliq, A., M. Afzal, A.A. Khan, A.M. Raza, M. Kamran, H.M. Tahir, M.A. Aqeel and M.I. Ullah. 2016. Management of *Thrips tabaci* (Thysanoptera: Thripidae) through agronomic practices in onion field plots. Pak. J. Zool., 48(6): 1675-1680.

Khattak, M.K., S. Ali and J.I. Chishti. 2004. Varietal resistance of mung bean (*Vigna radiata* L.) against whitefly (Bemisia tabaci Genn.), jassid (Amrasca devastans Dist.), and thrips (*Thrips tabaci* Lind). Pak. Entomol., 26(1):9-12.

Khetan, S., 2000. Microbial pest control. CRC Press. https://doi.org/10.1201/9781482270631

Lal, S., 1985. A review of insect pests of mungbean and their control in India. Int. J. Pest Manage., 31(2): 105-114. https://doi.org/10.1080/09670878509370960

Lopes, R.B., R.A. Laumann, M.C. Blassioli-Moraes, M. Borges and M. Faria. 2015. The fungistatic and fungicidal effects of volatiles from metathoracic glands of soybean-attacking stink bugs (Heteroptera: Pentatomidae) on the entomopathogen *Beauveria bassiana*. J. Invert. Pathol., 132: 77-85. https://doi.org/10.1016/j.jip.2015.08.011

Mandi, N. and A. Senapati. 2009. Integration of chemical botanical and microbial insecticides

for control of thrips, *Scirtothrips dorsalis* Hood infesting chilli. J. Plant Prot. Sci., 1(1): 92-95.

Mishra, D., G. Pathak, R. Tailor and A. Deshwal. 2016. On farm trial: An approach for management of thrips in onion. Indian Res. J. Ext. Educ., 7(1): 66-67.

Mohan, M.C., N.P. Reddy, U.K. Devi, R. Kongara and H.C. Sharma. 2007. Growth and insect assays of *Beauveria bassiana* with neem to test their compatibility and synergism. Biocontr. Sci. Technol., 17(10): 1059-1069. https://doi.org/10.1080/09583150701714551

Nadeem, M., M.A. Shah and J. Iqbal. 2016. Management of thrips in mungbean crop using neem oil (*Azadirachta indica* A. Juss) and different insecticides. Gomal Univ. J. Res., 32(1): 1-8.

Otieno, J.A., P. Pallmann and H.M. Poehling. 2016. The combined effect of soil-applied azadirachtin with entomopathogens for integrated management of western flower thrips. J. Appl. Entomol., 140(3): 174-186. https://doi.org/10.1111/jen.12242

Pachundkar, N., P. Borad and P. Patil. 2013. Evaluation of various synthetic insecticides against sucking insect pests of cluster bean. Int. J. Sci. Res. Publ., 3(8): 1-6.

Palthiya, R., R. Nakat and S. Jadhav. 2017. Efficacy of entomopathogenic fungi against thrips on Okra. Int. J. Pure Appl. Biosci., 5(4): 1931-1935. https://doi.org/10.18782/2320-7051.5746

Panchabhavi, K. and M. Kadam. 1990. Avoidable loss in yield due to insect pests at different stages of growth in pigeonpea (*Cajanus cajan*). Indian J. Agric. Sci., 60(11): 742-743.

Reddy, G.V., Z. Zhao and R.A. Humber. 2014. Laboratory and field efficacy of entomopathogenic fungi for the management of the sweetpotato weevil, *Cylas formicarius* (Coleoptera: Brentidae). J. Invert. Pathol., 122: 10-15. https://doi.org/10.1016/j.jip.2014.07.009

Sarfraz, M., L. Dosdall and B. Keddie. 2005. Spinosad: A promising tool for integrated pest management. Outlooks Pest Manage., 16(2): 78-84. https://doi.org/10.1564/16apl09

Shah, Z.H., H.A. Sahito, T. Kousar, M.M. Rind, F.A. Jatoi and W.M. Mangrio. 2017. Integrated pest management of cotton Thrips, *Thrips tabaci* (Lindeman, 1889) through Selected Pesticides under Vitro Conditions. Int. J. Res. Stud. Zool., 3(4): 76-83. https://doi.org/10.20431/2454-941X.0304011

Shelton, A., J. Zhao, B. Nault, J. Plate, F. Musser and E. Larentzaki. 2006. Patterns of insecticide resistance in onion thrips (Thysanoptera: Thripidae) in onion fields in New York. J. Econ. Entomol., 99(5): 1798-1804. https://doi.org/10.1093/jee/99.5.1798

Siegwart, M., B. Graillot, C. Blachere Lopez, S. Besse, M. Bardin, P.C. Nicot and M. Lopez-Ferber. 2015. Resistance to bio-insecticides or how to enhance their sustainability: A review. Front. Plant Sci., 6: 1-19. https://doi.org/10.3389/fpls.2015.00381

Singh, P. and S. Singh. 2015. Comparative evaluation of IPM module and farmer's practices in Mungbean, *Vigna radiata* (L.) Wilczek against major insect pests. Int. J. Agric. Environ. Biotechnol., 8(1): 215-218. https://doi.org/10.5958/2230-732X.2015.00027.3

Sohail, K., S. Jan, A. Usman, S.F. Shah, M. Usman, M. Shah and A. Mehmood. 2015. Evaluation of some botanical and chemical insecticides against the insect pests of Okra. J. Entomol. Zool. Stud., 3(2): 20-24.

Soomro, A., G. Seehar, M. Bhanger and N. Channa. 2008. Pesticides in the blood samples of spray-workers at agriculture environment: The toxicological evaluation. Pak. J. Anal. Environ. Chem., 9(1): 1-6.

Subbulakshmi, N., S. Ramarathinam, J. Anburaj, C. Sundaravadivelan, T. Kuberan, P. Kumar, T. Starlin and S. Marimuthu. 2012. Compatibility of neem based oil nimbicidine with entomopathogenic fungi. Int. J. Appl. Biores., 4: 12-15.

Subramanian, S., M. Muthuswami, R. Krishnan, A. Thangamalar and P. Indumathi. 2010. Bioefficacy of botanicals and insecticides against mulberry thrips, *Pseudodentrothrips mori* Niwa. Karnataka J. Agric. Sci., 23(1): 47-50.

Sujatha, B. and T. Bharpoda. 2017. Evaluation of insecticides against sucking pests grown during Kharif. Int. J. Curr. Microbiol. Appl. Sci., 6(10): 1258-1268. https://doi.org/10.20546/ijcmas.2017.610.150

Venugopal R.N., A. Reddy and D. Reddy. 1990. Relative toxicity of some insecticides to cotton whitefly, *Bemisia tabaci* Genn. Short communication. Indian J. Plant Prot. (India), 18(1): 97-100.

Wakil, W. and T. Schmitt. 2015. Field trials on the efficacy of *Beauveria bassiana*, diatomaceous earth and Imidacloprid for the protection of wheat grains from four major stored grain insect pests. J. Stored Prod. Res., 64: 160-167. https://doi.org/10.1016/j.jspr.2014.10.008

Yankova, V. and D. Markova. 2017. Effectiveness of some pathogenic control agents against pests in greenhouse vegetable crops. New knowl. J. Sci., 6(3): 131-138.

Zacharia, J.T., 2011. Ecological effects of pesticides, pesticides in the modern world-risks and benefits, Dr. Margarita Stoytcheva (Ed.), ISBN: 978-953-307-458-0, InTech. Tech, Available from: http://www. intechopen.com/books/pesticides-in-the-modern-world-risks-and-benefits/ecological-effects-of pesticides