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Review article

A BRIEF REVIEW ON ABUNDANCE AND MANAGEMENT OF MAJOR INSECT PESTS OF BRINJAL (*SOLANUM MELONGENA* L.)

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INTRODUCTION

Brinjal (*Solanummelongena*L.) occupies a distinct place in the realm of vegetable crops. It is a bushy plant, commonly known as egg plant. It is one of the most popular and important vegetable crops grown in India and many parts of the world. It is native of Indian sub-continent, with India as the probable centre of origin (Gleddie*et al.*, 1986). In the world, brinjal occupies an area of 1.72 m ha with a production of 43.17 m MT with an average productivity of 25 MT per ha (FAOSTAT, 2011). In India brinjal is grown throughout the year in almost all parts of the country. Although brinjal is widely grown, it is subjected to severe damage by different insect pests leading to significant loss in yield. There are 26 insect pests species and few non insect pest species infesting brinjal of which the shoot and fruit borer, *Leucinodesorbonalis* (Guen.); whitefly, *Bemisiatabaci* (Genn.); leafhopper, *Amarascadevastans* (Distant); epilachna beetle, *Henosepilachna vigintioctopunctata* (Fab.); aphid, *Aphis gossypii* (Glover.); mealy bug, *Centroccocusinsolitus* (Guen.); lace wing bug, *Urentiushystricellus* (Richt.) and non insect pest, red spider mite, *Tetranichusmacfurlanei*(Andre)cause severe damage, necessitating initiation of control measures quite frequently(Vevai,1970). Infestation due to leafhopper, whitefly and shoot and fruit borer results in about 70-92 per cent loss in yield of brinjal (Rosaiah, 2001). Dhankar*et al.* 1997 recorded 63 per cent yield loss due to shoot and fruit borer alone.As brinjal is a vegetable crop and harvesting of fruits is done at regular short intervals, safer and effective insecticides are needed for controlling the insect pest complex. At present synthetic pyrethroids are regularly used for the control of shoot and fruit borer and their indiscriminate use, leading to whitefly, aphid and mite resurgence is well documented (Reddy and Srinivas, 2005). The present day need emphasizes not only the use of different groups of chemicals that are eco-friendly but also give satisfactory control of insect pest population by their novel mode of action. Information on the seasonal incidence of the insect pests in brinjal ecosystem and their management, particularly in this agro-climatic situation in the recent past, is meagre. The available literature related to the present study has been reviewed under the followingheads.

1. Abundance of insect pests and their natural enemies in brinjal.

2.Bio-efficacy of certain insecticides and eco-friendly chemicals alone and in combinations against major insect pests of brinjal

Abundance of insect Pests and their Natural Enemies in Brinjal.

Whitefly and leafhopper

Sucking pests like whiteflies and leafhoppers cause severe damage to the crop particularly during early vegetative growth stage. The magnitude and severe population outbreaks are greatly influenced by both abiotic and biotic factors that cause seasonal variations. Besides brinjal, these pests also attack other malvaceous crops like okra and cotton.Ghosh and Senapati (2003) investigated the seasonal abundance of leafhopper infesting brinjal in West Bengal, India during 1996-98 and reported that the highest leafhopper population (4.63 per leaf) was recorded in April-May and the lowest (0.50 per leaf) was in mid July. Further Ghosh*et al.* (2004) identified*B. tabaci* on aubergine cv. Pusa purple long, highest population was observed during the 32^{nd} standard week.

They concluded that the whitefly population was significantly and negatively correlated with average temperature, non-significantly and negatively with average humidity and weekly rainfall.Singh *et al.* (2005) identifiedpeak population of leafhopper was recorded on the 1^{st} week of November, coincided with the presence of 22.57 ˚C average temperature and 69.0 per cent relative humidity. In another study, Samal and Patnaik (2008) reported that the aubergine leafhopper activity under Odisha condition peaked at 55-65 days and 40-50 days after planting during winter 2006-07 and summer 2007 respectively. Muthukumar and Kalyanasundarm (2003b) found that *B. tabaci* observed from the first WAT and persisted throughout the season. They reported that the leafhopper had a negative association with minimum temperature and rainfall. Naik*et al.* (2009) reported that the peak incidence was recorded during the third week of February 2006 and which the incidence had non-significant relationship with abiotic factors. Patil and Mehta (2008) during 2003 and 2004 revealed that leafhopper (*A. biguttulabiguttula*) appeared first during both years on brinjal.In a detailed study, Hasan*et al.* (2008) recorded*B. tabaci* peak population was seen on the 60 day old crop in 2005 and 2006, while the lowest was on the 30 day old crop. Population density was higher (3.2 - 6.7 adults per leaf). *B. tabaci* followed a regular distribution, while aggregated distribution was also recorded when the population was low in 2005.Yadav*et al.* (2007) found that maximum population of leafhopper was observed during 2005 in the second week of September on 8-week-old plant. The highest whitefly population was observed during 2005 in the week of September on 9-week-old plants.Anitha and Nandanhalli (2008) identified leafhopper and whitefly populations on kharif crop started appearing from the first week of August 2006. Peak leafhopper incidence was noticed during the last (19.43 leafhopper per 3 leaves) week of October 2006 while peak whitefly incidence was noticed during the fourth week October with 6.43 whiteflies per 3 leaves.Meena*et al.* (2010) found that leafhoppers (2.0 and 2.4 leafhoppers per plant) started in first week of August and was being active till harvesting in both the years, its population reached at maximum (15.2 and 16.4 leafhoppers per plant) in fourth week of September in 2002 and 2003. Incidence of whitefly and leafhopper populations on cotton posed economic damage in cotton during recent Leafhopper attained its peak during 4^{th} week of September. The whitefly attained its peaks in the 2^{nd} week of August and 3^{rd} week of September during respective years. They observed that leafhoppers and whitefly showed positive correlation with all the abiotic factors (Purohit*et al.*, 2006). Prasad *et al.* (2008) revealed that the peak incidence of leafhopper was recorded from the 37 to 47^{th} standard week (mid September to November). It was the 44^{th} to 48^{th} standard week (November) for whiteflies (*B. tabaci*).

Epilachna beetle, *H. Vigintioctopunctata* (Fab.)

Abiotic factors influence on the incidence of spotted leaf beetle *H. vigintioctopunctata*in brinjal revealed that the pest population was more in the month of February (24.2) and March (27.4) in the southern part of the country. A significant positive correlation with relative humidity, maximum temperature and wind velocity and negative correlation with rainfall was observed in relation to insect population (Raghuraman and Veeravel, 1999). However, in North Indian conditions Ghosh and Senapathi (2002) reported that epilachna beetle in terai region was found active from April to middle of October on brinjal and the highest population was recorded (8.14 beetles per plant) during middle of September. Bharadiya and Patel (2005) also reported that the incidence of leaf eating beetle,*H. vigintioctopunctata* on brinjal was recorded from the fourth week of August onwards and reached the peak average count of 1.3 per plant in the 3^{rd} week of September.Population ofepilachna beetle showed significant positive correlation with average temperature, relative humidity and weekly rainfall, *H. vigintioctopunctata*damaged brinjal from first week after transplantation. Its incidence peaked from 7 to 9 weeks after transplantation, with 23.70 - 27.60 adults per three leaves. It was higher (21.80 - 27.60 beetles per three leaves) during March - April but declined thereafter. It was positively associated with maximum temperature (Muthukumar and KalyanaSundaram, 2003b). Anandhi*et al.* (2008) revealed that incidence first noticed from the 20th week after transplanting (third week of January) with an average population of 0.27 brinjalhadda beetle per plant in 2004-05. In 2005-06, the incidence started earlier, i.e., first week of November, with an average population level of 2.85 brinjalhadda beetle per plant. The hadda beetle population reached the peaks in the third week of February in 2004-05. It attained its peaks in the third week of November during 2005-06. The beetle incidence showed negative correlation with the maximum and minimum temperatures and was positively correlated to all other abiotic factors. In the subsequent years, the pest population was positively correlated to the maximum relative humidity and wind velocity while negatively correlated to all other abiotic factors.Under severe cold conditions like in Japan the over wintered adults of *H. vigintioctopunctata*appeared in early May, adults of the first generation in late June and early July and of the second generation in August (Takeda *et al.*, 1980). Further, Hirano *et al.* (1985) reported that in Japan the over wintered adults of *H. vigintioctopunctata*appeared in potato fields, and began to oviposit in May.

The first generation adults emerged late in June or early in July. The adults then moved to the fields of brinjal, tomato and other crops and oviposit mainly on brinjal. The second generation adults emerged in late July or in early August. Raj and Lakshmann (1980) reported that the damage caused by this beetle to egg plant in Madurai region was greater on the crop planted in January than that planted in December. The attack by the pest could be minimised by advancing the planting date to late November or early December.

Brinjal shoot and fruit borer (BSFB)

Shoot and fruit borer in brinjal is the major pest causing severe losses to marketable yield throughout the country. A moderate range of temperature coupled with high humidity was found to be favourable for the borer. Brinjal crop planted during March to September recorded a higher level of shoot (3.4 - 10.62%) and fruit damage (53.39 - 61.23%) than the crops planted during remaining months (Tripathi and Senapathi 1998).Singh *et al.* (2000) revealed that *L. orbonalis*infested the crop shoots during the end of August (73.33%), which peaked (86.66%) in the third week of September with an intensity of 2.09 per plant.The shoot damage ranged between 30.23 and 36.23%, while fruit damage ranged 37.51 to 42.23 % from May to July. Maximum and minimum temperature, evaporation and sun shine hours had positive association with shoot damage, while relative humidity had negative influence. Murthy (2001) found that the pest was relatively more during September month on potato shoot under protected condition.Infestation of *L. orbonalis* in brinjal shoots started in the first week of August and remained up to second week of October, with peak in second week of September in both the years. Infestation in shoots decreased after fruit setting and completely disappeared thereafter. The infestation in fruits was recorded in the second week of September and remained up to third week of October. The infestation increased gradually and reached maximum in the first week of October (63.09% on number basis and 51.45% on weight basis). The infestation of fruit borer started declining and persisted only up to third week of October. The effect of abiotic factors on *L. orbonalis* revealed that maximum temperature had positive significant effect on fruit infestation; whereas, negative significant correlation was computed between borer infestation and minimum temperature. Relative humidity had positive significant effect on shoot and fruit borer. Rainfall had no effect on shoot and fruit borer infestation (Naqvi*et al.*, 2009). Bharadiya and Patel (2005) reported that the activity of shoot and fruit borer, *L. orbonalis*, on shoots started in the first week of September (4.9% incidence) and reached the peak level (17.1%) before migrating to fruits by fourth week of October. Dhamdhere*et al.* (1995) found that pest commenced from 45 and 55 days after transplanting of brinjal seedlings in summer and kharif season, respectively and continued up to harvest. The infestation in summer and kharif season ranged from 7.56 to 23.55 and 17.24 to 30.87 on shoots and 10.06 to 25.27 and 23.34 to 47.75 per cent fruits number and weight basis, respectively.Tripathi*et al.* (1996) revealed that highest incidence of the pest on shoots was noticed in 46th standard week (8.05 %) and lowest in 31st standard week (0.98 %). The highest fruit damage occurred at low mean temperature of 19.4 ˚C and 61 per cent relative humidity. The extent of damage on weight basis ranged between 4.03 and 57.01 per cent and followed a similar trend as on number basis.Anil Kumar *et al.* (1997) observed that infestation by the pest was significantly affected by temperature than other environmental factors.The peak shoot (15.71%) and fruit infestation (71.09% by weight) were recorded during the last week of June and first week of July, respectively. Singh *et al.*, (2009) observed that shoot infestationduring 4th week of August, 2008 and the incidence had non-significant relationship with temperature, relative humidity and rainfall but significant relationship with coccinellids and spiders. In another study Singh *et al.* (2011) observed that incidence of shoot and fruit borer was started in the month of April and continued till the end of the June. The peak period of the pest on shoot was recorded in the first week of June (29.45%) and fourth week of May (25.24%) during the first and second cropping seasons respectively. However, the incidence of the pest on fruit was highest during the second week of June, 2003 (67.16%) and third week of June, 2004 (72.25%). The correlation study revealed that average temperature and relative humidity showed significant positive association while average sunshine observed significant negative association with the infestation of the pest on brinjal.

Bio-efficacy of certain Insecticides against major Insect Pests of Brinjal

Efficacy on Whitefly and Leafhopper

Kumar *et al.*(2001) reported that efficacy of certain insecticide mixtures and their constituent insecticides against *A biguttulabiguttula* on brinjal separately, data revealed that amongst the treatments triazophos 0.05% was found to be least effective (). Among treatments triazophos (0.05%) exerted superior control (75.22%) of whiteflies. The mixed formulation of insecticides namely deltamethrin + triazophos (0.1%) recorded 65.48% reduction of whitefly population over control.

Naik*et al*. (2009) found thiamethoxamshow the high efficacy against whiteflies and leafhoppers and they also showed that combination effect of azadirachtin with other chemicals give better control of sucking pests and shoot and fruit borer. Sarangdevot*et al.* (2006) reported that two sprays of neem oil @ 10 ml per litre of water were effective against aphids, leafhoppers and whiteflies on brinjal.Foliar sprays of Thiamethoxam 25 WG @ 0.025% recorded 67.55 per cent mean reduction of whitefly population on brinjal (Balaji, 2002).Studies conducted by Sharma and Lal (2002) reported that thiamethoxam was superior to other treatment against both the leafhopper and whitefly. After one day of first spray of thiamethoxam 25 WG, the whitefly population was reduced by 94.06% on brinjal. Mhaske and Mot (2005) reported that higher doses of Imidacloprid (18 and 22.5 g per ha and thiamethoxam 25 and 50 g per ha) were effective against leafhopper and whitefly on brinjal.In a study from Tamil Nadu Muthukumar and Kalyanasundaram (2003a) reported that reduction of population was highest with 0.05 % Triazophos (70.99 %) and Profenofos(50.19 %) recorded. Fruit yield was highest on plots treated with Triazophos (19.34 t per ha). However, Chandrasekaran and Balasubramanian (2002) reported that neem formulation, TNAU, neem oil 60 EC was effective in bringing down the aphid population on green gram from 48.80 to 54.00 per cent by seventh day after treatment which was statistically on par with neemazal- f treatment, neem oil and garlic.Ghosh*et al*. (2002) reported that neem oil @ 2.5 ml per litre provided good control of whitefly and leafhopper population (64.37% and 65.34% respectively) on brinjal.Dhawan and Simwat (2002) reported that thiamethoxam foliar spray @ 25 g a.i. per ha was significantly better than Oxydemeton methyl and was at par with Imidacloprid in controlling the cotton leafhopper. However, Patil*et al.* (2009) evaluated the efficacy of various insecticides against sucking pests of cotton, at ARS, Dharwad. They reported that all the insecticides were found to give effective control of leafhoppers, aphids, and thrips. Fipronil 40% + Imidacloprid 80 WG 40% were better than Imidacloprid 200 SL.

Krishnakumar*et al.* (2001) reported that thiamethoxam 25 WG @ 0.4 g per litre gave significantly superior control of leafhopper on Mango. However thiamethoxam @ 0.4 g per litre was on par with imidacloprid seed treatment 12 ml per kg of seed. Also, Murugan and Ramachandran (2001) concluded that spraying actara 25 WG @ 50 and 100 a.i. per ha two times, once at the beginning of flowering and second at full bloom stage checked mango hoppers infestation. Dey*et al*. (2005) reported that all the insecticides treated plots showed significantly superior control of whiteflies and leafhoppers. The two foliar sprays of Imidacloprid 200 SL, viz., 100 and 125 ml per ha provided excellent control of aphids, thrips, leaf hoppers up to 15 days after spraying.Dhanalakshmi and Mallapur (2008) found Imidacloprid 200 SL at 5.0 ml per litre and acetamiprid 20 SP at 0.2g per litre were the most effective against aphids, leafhopper (*A. biguttulabiguttula*), followed by Spinosad 45 SC at 0.1 ml per litre.Nath and Sinha (2010)reprted both neonicotinoids (thimethoxam and acetamiprid) were effective against whitefly and leaf hopper. At one day after spraying (DAS), 35% Triazophos + 1% Deltamethrin and 50% Chlorpyrifos + 5% Cypermethrin were both effective against leafhopper.

Efficacy on of Various Insecticides Shoot and Fruit Borer

Chatterjee*et al.* (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with spinosad 2.5 SC (50 g a.i. ha^{-1}).Singh *et al.* (2009) was observed that Profenofos @ 0.1% and Spinosad @0.01% were most effective in reduction of shoot infestation of *L. orbonalis* besides recording higher brinjal fruit yield. Among the nine treatments tested, Profenofos was the most effective followed by Spinosad individually and their combinations in reducing the population as well as in giving higher yield.

Profenofos 50 EC @ 1000, 1500, 2000, 4000 ml per ha, Endosulfan 35 EC @ 1200 ml per ha, Chlorpyriphos 20 EC @ 1250 ml per ha and carbaryl 50 WP (4 g per litre) gave significant reduction of brinjal shoot and fruit borer as compared to control. Profenofos @ 1000 ml per ha proved effective in reducing incidence of the pest and it was almost on par with other higher dosages. The yield data also showed that profenofos recorded higher yield compared to other insecticides (Prasad kumar*et al*., 2006).Mishra *et al*. (2007), granular application of carbofuran @ 1.5 kg a.i. per ha at 10 days of planting followed by spray of triazophos @ 0.5 kg a.i. per ha, cypermethrin @ 0.150 kg a.i. per ha, azadirachtin @1500 ppm per ha and imidacloprid @ 0.025 kg a.i. per ha in sequence at 10-15 days interval after 40 days of planting was the most effective schedule in managing brinjal shoot and fruit borer.Mandal*et al.* (2008) found that the treatment pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was best for the management of this borer. Anjali(2006) revealed that cypermethrin (0.007%) and carbaryl (0.02%) were at par with each other and were significantly superior to all other treatments in terms of percent shoot damage, fruit damage on number and weight basis and on yield basis.

However, Deshmukh*et al.* (2006), amongst newer insecticides, cartap hydrochloride 50 SP at 0.1% was found most effective in reducing shoot infestation (4.20%) and fruit infestation (23.72% on number basis and 25.30% on weight basis) and in increasing aubergine fruit yield (78.73 q per ha. Sharma *et al.* (2009) found that the main crop, border cropped with either baby corn or radish or guar along with two foliar sprays of spinosad @ 75 g a.i. per ha was very effective in minimizing the fruit borer incidence. Brinjal bordered with radish followed by foliar spray of thiamethoxam @ 20 g a.i. per ha followed by abamectin @ 15 g a.i. per ha and emamectin benzoate @ l0g a.i. per ha gave highest yield viz., 17.128 MT per ha and 26.350 MT per ha, respectively. Dutta*et al.* (2007) revealed that Proclaim 5 SG (Emamectin benzoate) showed moderate level of efficacy providing 62.8% reduction of BSFB population over control it is concluded that this pest might have developed resistance against the tested insecticides. Islam *et al.* (2004) found that Fenvalerate (0.02%) was the best treatment followed by carbofuran 3 G at 0.5 kg a.i per ha, removal and destruction of infested plant parts, neem oil at 0.2% concentration, neem leaf extract at 1:1 ratio and dipel at 0.15 per cent concentration. Radhika*et al.* (1997) found that application of 0.1% triazophos on need basis (when > 20% of the fruits was infested by the pest) produced the highest fruit yield and the highest return. Jena *et al.* (2006) revealed that application of carbaryl, cartap hydrochloride [cartap], endosulfan, diflubenzuron, azadirachtin and chlorpyrifos at 1.0, 0.5, 0.7, 0.07, 0.075 and 0.4 kg a.i. per ha at 30, 45, 60, 75 and 90 days after transplanting (DAT), respectively, reduced shoot and fruit infestation, and gave the highest fruit yield (196.61 quintal per ha) and benefit cost ratio (3.76:1). However Mishra *et al.* (2004)found that triazophos gave the lowest average fruit borer incidence (14.36%) and the highest average fruit yield (20.75 q per ha).

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