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ORIGINAL ARTICLE

A Review on Management of Mango Leafhoppers through Various Chemical Insecticides, Biopesticides and Entomopathogens

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ABSTRACT

Mango production is not up to the mark in our country due to the incidence of various insect pests. Of various pests, mango leafhoppers are the most destructive and economically important pests, which cause 25-60 per cent loss in yield. Initially Sulphur and Pyrethrum dusts were used to control mango leafhoppers. Later pyrophosphoramide, Endrin, Diazinon, Parathion, Endosulfan, Carbaryl, Dimethoate were used by various workers for management of hoppers in the field. Application of Parathion (0.02%), followed by Endosulfan and Carbaryl (0.1%) was found more effective than Dimethoate (0.1%). In another study 0.4% Carbaryl was reported to be better than Endosulfan (0.9%), Phosphamidon (0.09%), Fenitrothion (0.15%) and Malathion (0.25%) in dealing with these insects. Imidacloprid was effective in reducing the hopper population to almost zero. Dimethoate (0.03%) and carbaryl (0.10%) were reported to be the most effective insecticides, followed by lambda cyhalothrin (0.004%). Cartap hydrochloride (0.05%) and endosulfan (0.05%) were reported to remain effective only up to 7th day of the application, whereas neem (0.15%) was found least effective. The maximum per cent reduction in hopper population over untreated check was reported in the order of acephate > fenvalerate > marshal > applaud > etofenprox > RIL 18 > standard 2 > danitol. The superior efficacy of the new insecticides Imidacloprid 0.05% and Acetamiprid 0.005% were found effective to check the hopper populations up to 15 to 20 days; whereas among conventional insecticides Acephate 0.01% and Endosulfan 0.07% were found effective to check the hopper population up to 8-10 days only. Profenophos 0.05% and Thiodicarb were less effective against Mango hoppers. Among the biopesticides, M. anisoplae, V. lecanii, B. bassiana and NSKE, were reported equally effective in reducing the mango hopper population. Among the botanicals neem oil and pungam oil at 1% were found effective and superior to NSE 5%. Lecanicillium lecanii, an entomopathogen (1.15%WP) was found superior in controlling the mango hopper under field conditions.

Keywords: *Mango leafhoppers, Idioscopus clypealis, Amritodus atkinsoni, Insecticides, Biopesticides, Entomopathogens*

INTRODUCTION

Among seven continents of globe, mango, *Mangifera indica* (Linn.) is grown in 85 countries, of there, 63 developing countries produce more than 1000 metric tons mango per year. Asia and specifically India is most productive region of mango, which has the top position with 54% of 98% production of Asia (Srivastava, 1998; FAOSTAT, 2006). The decreased production of mango is due to the incidence of various insect pests. Of various pests, mango leafhoppers are the most destructive and economically important pests, which cause 25-60 per cent loss in yield (Hiremath and Hiremath, 1994). There are two species of mango leafhoppers, namely *Idioscopus clypealis* (Leth.) and *Amritodus atkinsoni* (Leth.), which are most abundant familiar in different parts of India (Dwivedi *et al.*, 2003). These hoppers damage mango crop by sucking the sap from tender shoots, leaves and inflorescence, which results in flowers shriveling, turning brown and ultimately affecting the fruit setting. In another way, hoppers also secrete honeydew, which attracts the development of sooty mould on leaves, branches and fruits in moist weather. On heavy infestation, mould covers whole plant with a black coating and prevents photosynthesis that results in dropping of immature fruits (Butani, 1993). Injury to fruits is also caused by insertion of ovipositor for egg laying by the female hoppers (Srivastava, 1997). It is feasible for gardeners and farmers of our country to reduce incidence of these hoppers and control them by using various insecticides. This review is an attempt to wrap up all the literature on management of mango leafhoppers through various chemical insecticides and biopesticides.

INITIAL ATTEMPTS

In the earlier times entomologist used sulphur dustings, kerosene oil, pyrethrum dust and smoke to control mango leafhoppers in mango orchards but did not achieve great success. Distant (1908) initiated the first ever chemical control of hoppers by using a mixture of soap, tobacco, sulphur and kerosine oil; however he could not obtain any fruitful results. Fletcher (1914) found that hopper infestation reduced considerably, if smoke is regularly produced in orchards. Ballard (1915) for the first time successfully controlled the hoppers by the use of fish oil soap. Hussain and Pruthi (1921) used sulphur and suggested 3 times sulphur dusting at fortnightly intervals during flowering to control mango leafhoppers. Kannan (1925) used pyrethrum dust for control of mango leaf hoppers.

INSECTICIDES USED FOR MANAGEMENT OF MANGO LEAFHOPPER

Later on scientists applied various chemical insecticides for successful management of mango leafhoppers in the field, which include Endrin, Diazinon, Endosulphan, Carbaryl, Dimethoate, Parathion and Malathion etc. De and Dutta (1955) suggested the use of pyrophosphoramide (Schradan), a systemic insecticide at 0.4% concentration against mango leafhoppers. Sen and Chaudhary (1961) suggested the use of Endrin (0.04%) to control mango leaf hoppers successfully. The field of Endrin treated trees was observed to be resistant, four times higher than that of untreated trees. Atwal (1963) recommended the use of Diazinon (0.2%) and Endrin (0.02%) sprays for leaf hoppers in Punjab. Chari *et al.* (1969) reported that under North Indian climatic conditions, application of Parathion (0.02%), followed by Endosulfan and Carbaryl (0.1%) was more effective than Dimethoate (0.1%).

Bindra *et al.* (1972) studied comparative efficacy of various chemicals against *Idioscopus clypealis* (Leth.) and found 0.4% Carbaryl to be better than Endosulfan (0.9%), Phosphamidon (0.09%), Fenitrothion (0.15%) and Malathion (0.25%) in dealing with these insects. Sathiyanandan *et al.* (1972) confirmed the superiority of Carbaryl for the control of leafhoppers. Butani (1974) suggested the spray of phosphamidon, Diazinon or Monocrotophos all at 0.03% and observed that these chemicals controlled the hopper infestation efficaciously. Prashad and Bagle (1979) reported that mango hoppers could also be controlled by spraying Fenvalerate (0.025%). Tandon and Lal (1979) and Tandon and Srivastava (1980) compared the efficacy of 0.12% permethrin with other conventional insecticides and found that the pyrethroid was quite effective in controlling the hoppers.

Yazdani and Mehto (1980) tested 8 insecticides against *Amritodus atkinsoni* (Leth.) and reported that Dimethoate at 0.5Kg/Hectare was 1.67 times more efficacious than Methyl parathion. Naseeruddin *et al.* (1982) found Fenvalerate (0.01%) and Permethrin (0.02%) to be highly effective. Patil (1982) also got excellent control of mango hoppers by spraying Permethrin (0.01%). Shah *et al.* (1983) evaluated effective dose of Monocrotophos for the control of mango leafhopper-*Amritodus atkinsoni* (Leth.), using injection method, as well as they compared it with foliar spraying method. Shukla and Prasad (1984) observed that systemic insecticides such as Dimethoate (0.05%), Monocrotophos (0.05%) and Phosphamidon (0.15%) were most effective, followed by synthetic pyrethroid like Permethrin (0.02%), Fenvalerate (0.02%) and Cypermethrin (0.02%) against hopper population. Datar (1985) worked on the synthetic pyrethroids in the control of mango hopper *Amritodus atkinsoni* (Leth.) and found the lowest hopper count in plants sprayed with Fenvalerate at 0.01%, followed by Bromphos ethyl, Carbaryl and Decamethrin. Kumar *et al.* (1985) worked on efficacy of some insecticides against hopper complex on mango and recorded that in laboratory Dimeton-S-methyl gave quick-down effect, followed by Monocrotophos and Carbaryl. Khaire *et al.* (1986) observed spectacular reduction in hopper population by spraying with 0.004% Fluvalinate followed by 0.01% Fenvalerate. Nachiappan and Baskaran (1986) worked on field evaluation of certain insecticidal sprays against mango leafhoppers and found that Endosulfan (0.035%), Phosalone (0.08%) and Carbaryl (0.01%) were more effective to control the population of mango leafhoppers. Chandrasekaran *et al.* (1988) evaluated 12 insecticides in the form of spray against *Idioscopus* spp. on mango. Monocrotophos, Phosphamidon, Dimethoate and Carbaryl, applied during the flowering period were observed to be effective. Shah *et al.* (1988) found 20 ppm permethrin and 10ppm Fenvalerate effective against *Amritodus atkinsoni* (Leth.). Hiremath and Hugar (1989) carried out field studies to determine the effect of Dimethoate,

Phosphamidon by injecting them during off season to control mango leafhoppers and found it effective.

Srivastava *et al.* (1993) tested Neem products against mango hoppers and reported that oil based Neem was more effective than the kernel based concentrate. Mishra and Chaudhary (1996) conducted field studies to determine the efficacy of Monocrotophos, Dimethoate, Quinalphos, Carbaryl and Endosulfan for the control of *Amritodus atkinsoni* (Leth.) in India. Verghese (1998) screened Imidacloprid for its efficacy against the mango hoppers-*Idioscopus nagpurensis* (Pruthi) and *Idioscopus niveosparsus* (Leth.). The results showed that imidacloprid was effective in reducing the hopper population to almost zero. In his next work Verghese (2000) tested lambdacyhalothrin, imidacloprid, and azadirachtin for the control of *Idioscopus niveosparsus* (Leth.). He conducted two experiments one each on mango varieties, Alphanso and Bangampalli at Bangalore. Results of both experiments showed that imidacloprid (0.2 - 0.8 ml/litre) and lambda-cyhalothrin (0.5 ml/litre) were effective and comparable with the standard monocrotophos (1 ml/litre).

Arora *et al.* (2003) studied comparative efficacy of various insecticides against mango hoppers. They evaluated endosulfan 35 EC, catlap hydrochloride 50 SP, lambda cyhalothrin 5 EC, neem 30 EC, carbaryl 50 WP and dimethoate 30 EC for the control of hoppers on Dashehri. And found that all these insecticides were effective in controlling the hopper population. Dimethoate (0.03%) and carbaryl (0.10%) were proved to be the most effective insecticides, followed by lambda cyhalothrin (0.004%). Cartap hydrochloride (0.05%) and endosulfan (0.05%) remained effective only up to 7th day of the application, whereas neem (0.15%) was found least effective. It could be concluded that dimethoate 30 EC (0.03%), carbaryl 50 WP (0.10%) and lambda cyhalothrin 5 EC (0.004%) could be recommended for the control of hoppers in mango orchards. Patel *et al.* (2003) reported the significant superiority of thiamethoxam 0.025% spray to two lower (25 and 37.5 g.a.i./ha) doses of thiamethoxam by having significant prevention of population build up of hopper after 3 days of spray against *Amritodus atkinsoni*. Kumar *et al.* (2005) reported that imidacloprid (0.005%), thiamethoxam (0.0084%), profenophos (0.1%) and lambda-cyhalothrin (0.003%) were effective in controlling hopper complex on Alphanso mango in South Gujarat. Jeyarani *et al.* (2006) studied the efficacy of certain newer insecticides against mango hoppers. The population of hoppers was significantly lower (<50 %) in all the insecticides treated plots as compared to untreated check. On 21st day after the first round of insecticide application, the reduction in the population of hoppers was maximum (84.62 %) in the trees treated with acephate 75 SP. Considering the efficacy of insecticides on 21st day after second round of insecticide application, the maximum per cent reduction over untreated check was in the order of acephate > fenvalerate > marshal > applaud > etofenprox > RIL 18 > standard 2 > danitol. Bhaskar *et al.* (2007) recorded imidacloprid 0.05% and acetamiprid 0.005% were highly effective with least number 0.74 and 1.26 of hoppers with more per cent reduction over control was 96.56 and 94.39 respectively. The next best insecticidal treatment was Acephate 0.1% (3.14 with 85.71 per cent reduction over control). Least effective insecticidal treatments were Endosulfan 0.07%, Thiodicarb 0.01% and Profenofos 0.05% with 59.97, 51.33, and 39.01 per cent reduction over control respectively. The superior efficacy of the new insecticides Imidacloprid 0.05% and Acetamiprid 0.005% were found effective to check the hopper populations up to 15 to 20 days. Whereas in conventional insecticides Acephate 0.01% and Endosulfan 0.07% were found effective to check the hopper population up to 8-10 days only. Profenophos 0.05% and Thiodicarb were less effective against Mango hoppers. Samanta *et al.* (2009) recorded lowest mean hopper population (4.53) and highest yield (180 fruits/tree & 72 kg/ tree) as well as highest cost-benefit ratio (2.89) in thiamethoxam 0.016% treatment followed by imidacloprid 0.01%. All the treatments were significantly superior in reducing hopper population as well as increasing yield as compared to untreated control.

Qureshi *et al.* (2011) reported that thiamethoxam and imidacloprid reduced the populations of nymphs and adults of mango leaf hoppers and scale insects. No significant difference was observed in mango production except for the higher rate (12 g/tree) of thiamethoxam, where fruit number was significantly higher than all other treatments. Ray *et al.* (2011) reported that module consisting imidacloprid was a most superior over all the treatments, followed by NSKE and endosulfan was found most effective in reducing hopper population (1.55 per panicle) with maximum fruit yield, 219.10 Kg/tree followed by the treatment module consisting the use of

thiamethoxam, azadirachtin and ethofenprox (3.55 hoppers per panicle) with fruit yield, 175.20 Kg/tree. All the treatment modules were significantly superior to the control in reducing mango hopper population. Ningthoujam and Kumar (2012) studied the Influence of monocrotophos, imidacloprid, dimethoate, carbaryl and endosulfan insecticides on mango hoppers and spiders on Mango. Imidacloprid was reported to reduce the hopper population. Monocrotophos and dimethoate were found to be highly toxic to spiders. Rathod and Borad (2013) observed that evaluated newer and conventional insecticides against mango hopper, *Amritodus atkinsoni* infesting mango and found the insecticides viz., imidacloprid (0.0053%), thiamethoxam (0.0075%), acetamiprid (0.005%) and fipronil (0.0075%) were found effective in checking the hoppers population. In their next work Ray *et al.* (2013) recorded on efficacy of pest management modules against mango hopper, *Amritodus atkinsoni,* Leth on mango.

The results showed that module 4 (first spray at panicle emergence with Spinosad, second spray of Thiamethoxam after 21 days of 1st spray and third spray (need based) of Neem Azal when fruits were at pea size) was found to be most effective in reducing (5.13 hoppers/panicle/week, 63%) mango hopper population. This was followed by module 3 (first spray of Thiamethoxam at panicle emergence, second spray of Profenophos after 21 days of 1st spray and third spray (need based) of Carbaryl when fruits were at pea size) (5.84 hoppers / panicle/week, 58%). While maximum (113.68 / 100 panicle) fruit set per 100 panicle at marble stage was recorded in module 4. Considering yield and cost-benefit ratio against management of mango hopper, module 4 (88.20 kg/tree, 49%) was found most economical and it was followed by module 3 (80.38 kg/tree, 45%).

RECENT EXPERIMENTS

In the last decade various workers tested newer chemical insecticides along with biopesticides and entomopathogens for successfully managing the mango leafhoppers. The chemical insecticides include acephate, thiamethoxam, imidacloprid, lambda cyhalothrin, acetamaprid, buprofezin, pymetrozine, spinosad, abamectin and acetamiprid etc. Among the biopesticides, *M. anisoplae, V. lecanii, B. bassiana* and NSKE were reported equally effective in reducing the mango hopper population. The botanicals tested during the experiments, included limonene, neem oil and pungam oil at 1% and found effective in managing the mango leafhoppers. The efficacy of the entomopathogenic fungus *Lecanicillium lecanii* 1.15%WP in managing the mango hopper was also found superior. Kaushik *et al.* (2014) reported that the imidacloprid was most effective and significantly superior in reducing the hopper population (97.6%) as well as increasing fruit yield (the highest yield being 79.10 kg tree-1) followed by carbaryl with reduction in hopper population of 88.31% and fruit yield of 67.05 kg tree-1. The respective values for reduction in hopper population in endosulfan, thiodicarb, monocrotophos and profenophos were 87.16, 83.73, 82.54 and 77.35 per cent and those for mango fruit yield being 63.62, 55.70, 52.70 and 49.25 kg tree-1. Azadirachtin was least effective among insecticides with 65.21% reduction in hopper population and fruit yield of 43.28 kg tree-1. Bana *et al.*, (2015) worked on Integrated Pest Management modules against mango hopper.

The lowest population (3.81 hoppers /twig or panicle) was recorded in Module-V [first spray of acephate at panicle emergence stage followed by second spray (21 days after first spray) with spinosad and third need based spray of carbaryl] and it was at par with Module-III (4.35 hoppers /twig or panicle) [first spray of thiamethoxam at panicle emergence stage followed by second spray (21 days after first spray) of profenophos and third need based spray of carbaryl] and module IV [first spray of spinosad at panicle emergence stage followed by second spray (21 days after first spray) with thiamethoxam and third need based spray of Neem Azal] (4.91 hoppers/twig or panicle). There was significant difference in fruit drop indicating lowest fruit drop in M-III (41.12 %) which was at par with M V (41.77 %) and M-I (42.45%). Fruits set at harvest stage were highest in M-V (244 /100 panicles) which was at par with M-III (236.75 / 100 panicles). Sarode and Mohite (2016) evaluated newer insecticides for control of mango hoppers, the studies revealed that imidacloprid was found to be most effective in reducing mango hopper which was on par with thiamethoxam and lambda cyhalothrin. Among the biopesticides, M. anisoplae, V. lecanii, B. bassiana and NSKE, were reported equally effective in reducing the mango hopper population.

Chaudhari *et al.* (2017) tried some pesticides, entomopathogens and botanicals and found that imidacloprid 17.8 SL @ 0.007% was proved to be the best pesticide treatments with maximum mortality of the hoppers. Thiomethoxam 25 WG @ 0.0025% was the next best pesticide. Malathion 0.075% was found least effective among chemicals pesticides tested. Among the botanicals neem oil and pungam oil at 1% were found effective and superior to NSE 5%. *Lecanicillium lecanii*, an entomopathogen (1.15%WP) was found superior in controlling the mango hopper under field conditions.

Sharanabasappa *et al.* (2018) conducted a field experiment on the efficacy of different insecticides against mango leafhoppers and reported that dinotefuron 20 SG was the best the treatment causing significant mortality of nymphs and adults, followed by imidacloprid 70 WG and acetamaprid 20 SP against leafhoppers. The next best insecticides were buprofezin 25 SC, thiamethoxam 25 WG, and imdidacloprid 17.8 SL. Mohapatra *et al.* (2019) tested various insecticides against mango leafhopper *Amritodus atkinsoni* (Leth.). Of the eight evaluated insecticides thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, thiamethoxam 25 WG and acephate 50% + imidacloprid 1.8% SP were found the most effective in reducing the incidence of *A. atkinsoni*. However, buprofezin 15% + acephate 35% WP, acetamiprid 20 SP and buprofezin 25 SC were found mediocre in their effectiveness. Ferdous and Jahan (2020) evaluated efficacy of four insecticides viz., pymetrozine, spinosad, abamectin and acetamiprid and three botanicals viz., karanj oil, limonene and neem seed kernel extract against the mango hopper *Idioscopus clypealis*,. Pymetrozine was found to be most effective against both nymphs and adults of hoppers, followed by acetamiprid. Among botanicals, limonene was the most effective.

Prashanthi *et al.* (2021) conducted an experiment to evaluate the efficacy of nine insecticides viz., Dinotefuron 20 SG @ 0.3 g/l, Buprofezin (15%) + Acephate (35%) WP @ 2.5 g/l, Flonicamid 50 WG @ 0.4 g/l, Imidacloprid (40%) + Ethiprole (40%) 80 WG @ 0.6 g/l, Lambda Cyhalothrin 5 EC @ 2.0 ml/l, Spinosad 480 SC @ 0.3 ml/l, Thiamethoxam (12.6%) + Lambda Cyhalothrin (9.5%) 247 ZC @ 1.0 ml/l, Pymetrozine 50 WG @ 0.6 g/l, Imidacloprid 17.8 SL @ 0.3 ml/l along with an untreated control. Pooled efficacies of these treatments revealed that Imidacloprid (40%) + Ethiprole (40%) 80 WG @ 0.6 g/l and Thiamethoxam (12.6%) + Lambda Cyhalothrin (9.5%) 247 ZC @ 1.0 ml/l have resulted in 95.68 and 94.88 per cent reduction of leafhopper population over control (ROC), respectively and were proved to be the most effective treatments followed by Buprofezin (15%) + Acephate (35%) WP @ 2.5 g/l (92.54 % ROC). Rajkumar *et al.* (2022) studied the efficacy of the different insecticides and bio-rationals on mango leafhoppers. The total ten treatments were selected including biorationals, which were Pymetrozine 50 WG 0.6 g, Thiamethoxam 25 WG 2 g, Dinotefuran 20 SG 0.2 g, Flonicamid 50 WG 0.4 g, Tolfenpyrad 15 EC 1.5 ml, *Lecanicillium lecani* 1x108 cfu/1g, *Beauveria bassiana* 1 x 108 cfu / 2g, Azadirachtin 1500 ppm 2 ml, Lambda cyhalothrin 5 EC 0.5 ml and Untreated check. In the year 2015-16 most effective insecticide was tolfenpyrad 15 EC causing 92.34% reduction leafhopper population, followed by flonicamide 50 WG causing 89.84% reduction, dinotefuran 20 SG with 88.30% reduction in hopper population. Azadirachtin (70.91% reduction), *B. bassiana* (69.15% reduction) and *L. lecanii* (69.10%reduction) were found to be least effective. Similarly, during the next year, tolfenpyrad 15 EC (91.48%), followed by flonicamid 50 WG (91.08%) and dinotefuran 20SG (88.25%) were found effective in reducing the hopper population. *B. bassiana* (71.50%), *L. lecanii* (69.94%) and azadirachtin (69.25%) were proved to be least effective. Hence, the insecticide tolfenpyrad 15 EC @ 1.5 ml per litre of water found promising in effective management of mango leafhoppers. Arya *et al.* (2023) evaluated various chemical pesticides, entomopathogens, and botanicals against mango leafhoppers and reported that imidacloprid 17.8 SL with the concentration of 0.007% showed the best results. The next most effective treatment was NSKE 5%. The botanical treatment of NSKE (Neem Seed Kernel Extract) caused high mortality of hoppers. The efficacy of the entomopathogenic fungus *Lecanicillium lecanii* 1.15%WP in managing the mango hopper was also found superior.

CONCLUSION

In the beginning Entomologists tried smoke, Sulphur and Pyrethrum dusts for management of mango leafhoppers. Later workers tested various chemical insecticides like pyrophosphoramide,

Endrin, Diazinon, Parathion, Endosulfan, Carbaryl, Dimethoate for management of hoppers in the mango orchards. Application of Parathion (0.02%), followed by Endosulfan and Carbaryl (0.1%) was found more effective than Dimethoate (0.1%). In another study 0.4% Carbaryl was reported to be better than Endosulfan (0.9%), Phosphamidon (0.09%), Fenitrothion (0.15%) and Malathion (0.25%) in dealing with these insects. Imidacloprid was effective in reducing the hopper population to almost zero. Dimethoate (0.03%) and carbaryl (0.10%) were reported to be the most effective insecticides, followed by lambda cyhalothrin (0.004%). Cartap hydrochloride (0.05%) and endosulfan (0.05%) were reported to remain effective only up to 7th day of the application, whereas neem (0.15%) was found least effective. Profenophos 0.05% and Thiodicarb were found less effective against Mango hoppers. Among the biopesticides, *M. anisoplae*, *V. lecanii*, *B. bassiana* and NSKE, were reported equally effective in reducing the mango hopper population. Among the botanicals neem oil and pungam oil at 1% were found effective and superior to NSE 5%. *Lecanicillium lecanii*, an entomopathogen (1.15%WP) was found superior in controlling the mango hopper under field conditions.

REFERENCES

1. Arora, R. K., Tandon, V. K., & Koul, V. K. (2003). Comparative efficacy of various insecticides against hoppers on mango (*Mangifera indica* L.). *Pestology, 27*(9), 21–24.
2. Arya, A., Kumar, R., Kumar, P., Chauhan, S., & Ahad, I. (2023). Evaluation of different bio pesticides against mango hoppers in Eastern Uttar Pradesh. *Biological Forum, 15*(10), 408–414.
3. Atwal, A. S. (1963). Insect pests of mango and their control. *Punjab Horticultural Journal, 3*(2), 234–258.
4. Ballard, E. (1915). Mango hopper control experiments. *Agricultural Journal of India, 10*(4), 395–398.
5. Bana, J. K., Ghoghari, P. D., Kalaris, G. B., Saxena, S. P., & Shah, N. I. (2015). Efficacy of IPM modules against mango hopper complex. *Indian Journal of Entomology, 77*(4), 320–322.
6. Bhaskar, L., Vijaya, L., Manjunath, J., & Gopal, A. V. (2007). Evaluation of new insecticides against mango hoppers *Amritodus atkinsoni* L. *Pestology, 31*, 33–34.
7. Bindra, O. S., Sandhu, G. S., Verma, G. C., & Sekhon, S. S. (1972). Studies on the control of mango hoppers *Idioscopus clypealis* (Leth.) and *Idiocerus atkinsoni* (Leth.). *Abstracts of Third Symposium on Subtropical and Tropical Horticulture*, 83.
8. Butani, D. K. (1974). Insect pests of fruit crops and their control: Mango. *Pesticides, 8*(3), 36–41.
9. Butani, D. K. (1993). *Mango pest problems*. Periodical Expert Book Agency.
10. Chandrasekaran, S., Kuttalam, S., & Irulappan, I. (1988). Field evaluation of certain insecticides against mango hopper (*Idioscopus* spp.). *South Indian Horticulture, 36*(3), 146–147.
11. Chari, S. N., Seshadri, H. S., & Patel, H. K. (1969). Control of mango hoppers. *Pesticides, 3*(12), 33–35.
12. Chaudhari, A. U., Sridharan, S., & Singh, S. S. D. (2017). Management of mango hopper with newer molecules and biopesticides under ultra high density planting system. *Journal of Entomology and Zoology Studies, 5*(6), 454–458.
13. Datar, V. V. (1985). Synthetic pyrethroids in the control of mango hoppers (*Amritodus atkinsoni* Leth.). *Pesticides, 19*(2), 13–14.
14. De, R. K., & Dutta, D. K. (1955). Effect of commercial pyrophosphoramide (Schradan), a systemic insecticide on mango hoppers (*Idiocerus atkinsoni* L.). *Indian Journal of Entomology, 12*(4), 165–172.
15. Distant, W. L. (1908). *The fauna of British India including Ceylon and Burma: Rhynchota (Vol. IV)*. Taylor and Francis.
16. Dwivedi, S. C., Singh, S. M. R., & Katiyar, R. R. (2003). Seasonal incidence of insect pest associated with mango crop. *Annals of Plant Protection Sciences, 11*(1), 159–162.
17. FAOSTAT. (2006). *Year production book of Food and Agriculture Organization of the United Nations*. http://faostat.fao.org/site/567/default.aspx#ancor
18. Ferdous, M. G., & Jahan, M. (2020). Efficacy of insecticides and botanicals against the mango hopper *Idioscopus clypealis*. *Indian Journal of Entomology, 82*(1), 13–15.
19. Fletcher, T. B. (1914). *Some South Indian insects and other animals of importance*. Government Press.
20. Hiremath, S. C., & Hiremath, I. G. (1994). Studies on seasonal incidence and nature of damage of mango hoppers. *Bulletin of Entomology, 35*(1), 78–83.
21. Hiremath, S. C., & Hugar, P. (1989). Effects of injecting systemic insecticides into mango during off season on the mango hopper population. *Madras Agricultural Journal, 76*(11), 638–640.
22. Hussain, M. A., & Pruthi, H. S. (1921). Preliminary note on winter spraying against mango hopper (*Idiocerus* spp.). In *Proceedings of the IVth Entomological Meeting, Pusa (Bihar)* (pp. 148–152).
23. Jeyarani, S., Chandrasekaran, M., & Chinniah, C. (2006). Bio-efficacy of certain newer insecticides against mango hoppers. *Agricultural Science Digest, 26*(3), 200–202.
24. Kannan, K. K. (1925). Report of the entomologist. *Annual Report of the Agricultural Department, Mysore*, 10–12.
25. Kaushik, D. K., Sharma, S., Sharma, D., & Baraiha, U. (2014). Efficacy of insecticides against hopper complex on Langra mango in Chhattisgarh. *Pesticide Research Journal, 26*(1), 6–11.
26. Khaire, V. A., Naik, R. L., Kolhe, D. S., Patil, J. D., & Meher, B. B. (1986). Efficacy of some synthetic pyrethroids against mango hoppers. *Pestology, 10*(10), 12–13.

27. Kumar, D., Roy, C. S., Yazdani, S. S., Hameed, S. F., & Khan, Z. R. (1985). Efficacy of some insecticides against hopper complex on mango (*Mangifera indica* L.). *Pesticides, 19*(11), 42–43.

28. Kumar, S., Raghvani, B. R., & Bhatt, R. I. (2005). Bio-efficacy of newer insecticides against hopper complex in Alphonso mango in humid tropics of South Gujarat. *Journal of Applied Zoological Research, 16*(1), 64–66.

29. Mishra, D. N., & Chaudhary, A. K. S. (1996). Field evaluation of some modern insecticides for the control of mango leaf hopper *Amritodus atkinsoni* (Leth.). *Environment and Ecology, 14*(2), 299–300.

30. Mohapatra, A. R., Thumar, R. K., Parmar, D. J., & Bhagora, J. K. (2019). Bio-efficacy of different insecticides evaluated against hopper, *Amritodus atkinsoni* Lethierry infesting mango. *International Journal of Chemical Studies, 7*(6), 1684–1689.

31. Nachiappan, R. M., & Baskaran, P. (1986). Field evaluation of certain insecticidal sprays against mango leaf-hoppers. *Pesticides, 20*(1), 41–44.

32. Naseeruddin, S. H., Laxminarayan, K., & Rao, K. P. (1982). Evaluation of various insecticides for the control of mango hopper (*Idioscopus* spp.). *All India Coordinated Fruit Improvement Project Technical Document, 17*, 461–466.

33. Ningthoujam, K., & Kumar, M. G. (2012). Influence of insecticides on mango hoppers and spiders in mango orchard. *Annals of Plant Protection Sciences, 20*(2), 341–343.

34. Patel, N. C., Kher, R. H., Chavda, A. J., & Patel, J. R. (2003). Bio-efficacy of thiamethoxam (Actara 25 WG) in comparison to conventional insecticides against hopper, *Amritodus atkinsoni* Leth. infesting mango. *Indian Journal of Entomology, 65*(3), 315–318.

35. Patil, P. D. (1982). Chemical control of mango hoppers (*Idioscopus* spp.). *All India Coordinated Fruit Improvement Project Technical Document, 17*, 467–471.

36. Prasanthi, S. J., Chalam, M. S. V., Devaki, K., & Naidu, M. G. (2021). Evaluation of efficacies of newer insecticides against mango leafhoppers. *The Pharma Innovation Journal, 10*(10), 385–391.

37. Prashad, V. G., & Bagle, B. G. (1979). Control of mango hopper *Idioscopus clypealis* (Leth.) by new insecticides. *Pestology, 3*(3), 11–14.

38. Qureshi, M. S., Thistleton, B., Syeda, S. S., Hearnden, M., & Queshi, M. H. (2011). Managing mango leafhoppers and other associated species affected through systemic insecticides in mango orchards at Darwin, Australia. *Pakistan Journal of Entomology, 26*(2), 81–87.

39. Rajkumar, M., Katti, P., Prabhuraj, A., Kotikal, Y. K., Ashoka, J., Mulge, R., & Beladhadi, R. V. (2022). Evaluation of efficacy of newer molecules on mango leafhopper. *The Pharma Innovation Journal, 11*(10), 1436–1442.

40. Rathod, S. T., & Borad, P. K. (2013). Bioefficacy of newer and conventional insecticides against mango hopper *Amritodus atkinsoni* (Leth.). *Pesticide Research Journal, 25*(1), 77–79.

41. Ray, S. N., Kumari, K., & Singh, S. N. (2011). Management of mango hopper *Idioscopus clypealis* (Homoptera: Cicadellidae) with some insecticides and biopesticides. *Pesticide Research Journal, 23*(1), 114–115.

42. Ray, S. N., Saha, T., & Nithya, C. (2013). Field efficacy of pest management modules against mango hopper *Amritodus atkinsoni* (Leth.) on Langra mango in zone III of Bihar. *Annals of Plant Protection Sciences, 22*(1), 10–13.

43. Samanta, A., Gosh, A., Hembram, T. K., Patra, S., & Somchowdhury, A. K. (2009). Efficacy of insecticides against mango hoppers and fruit yield. *Annals of Plant Protection Sciences, 17*(1), 225–274.

44. Sarode, B. R., & Mohite, P. B. (2016). Seasonal incidence and biorational management of mango hopper (*Amritodus atkinsoni* L.). *Journal of Agriculture and Veterinary Sciences, 9*(1), 29–31.

45. Sathiyanandan, V. K., Gowder, B. R., & Santhanaraman, T. (1972). Control of mango hoppers (*Idiocerus* sp.). In *Proceedings of the Third International Symposium on Subtropical and Tropical Horticulture* (pp. 83–84).

46. Sen, A. C., & Chaudhari, D. P. (1961). Control of mango hopper *Amritodus atkinsoni* (Leth.). *Indian Agriculturist, 5*(1), 85–86.

47. Shah, A. H., Jhala, R. C., Patel, G. M., & Patel, S. H. (1983). Evaluation of effective dose of monocrotophos for the control of mango hopper *Amritodus atkinsoni* (Leth.) (Cicadellidae: Homoptera) by injection method and its comparison with foliar application method. *Gujarat Agricultural Research Journal, 9*(1), 14–18.

48. Shah, A. H., Jhala, R. C., Patel, Z. P., & Patel, R. L. (1988). Efficacy of synthetic pyrethroids against mango hoppers at lower doses. *Acta Horticulturae, 221*, 602–606.

49. Sharanabasappa, Pavithra, H. B., Maruthi, M. S., & Nagarajappa, A. (2018). Efficacy of different newer insecticides against mango leaf hoppers. *Journal of Entomology and Zoology Studies, 6*(1), 834–837.

50. Shukla, R. P., & Prasad, V. G. (1984). Evaluation of some insecticides against mango hopper *Idioscopus clypealis* (Leth.) (Homoptera: Cicadellidae). *Indian Journal of Agricultural Sciences, 54*(8), 677–681.

51. Srivastava, R. P. (1997). *Mango insect pest management* (1st ed.). International Book Distribution Co.

52. Srivastava, R. P. (1998). *Preface – Mango cultivation*. International Book Distribution Co.

53. Srivastava, R. P., Singh, R. P., Haseeb, M., & Abbas, S. R. (1993). Evaluation of formulated neem (*Azadirachta indica*) extracts against mango hopper *Idioscopus nitidulus* and *Amritodus atkinsoni* (Leth.). In *Neem and Environment* (Vol. 1, pp. 527–534).

54. Tandon, P. L., & Lal, B. (1979). Studies on the chemical control of the mango hopper *Idioscopus clypealis* (Leth.). *Pest Control, 21*(1), 6–7.

55. Tandon, P. L., & Srivastava, R. P. (1980). Protect your mango crop from mango hoppers. *Farm Digest, 13*(2), 5–7.

56. Verghese, A. (1998). Effect of imidacloprid (insecticide) on mango hoppers *Idioscopus* spp. (Homoptera: Cicadellidae). *Pest Management in Horticultural Ecosystems, 4*(2), 70–74.

57. Verghese, A. (2000). Effect of imidacloprid, lambda-cyhalothrin and azadirachtin on the mango hopper *Idioscopus niveosparsus* Leth. (Homoptera: Cicadellidae). *Acta Horticulturae, 509*(2), 733–736.

58. Yazdani, S. S., & Mehto, D. N. (1980). A note on the control of mango hopper *Amritodus atkinsoni* (Leth.) at Dholi. *Indian Journal of Entomology, 42*(2), 275–276.