Original Research Article

Documentation of Pest Incidence and Pesticide Application Patterns in Banana with Special Emphasis on the Management of *Odoiporus longicollis* (Olivier) (Coleoptera: Curculionidae) in Selected Districts of Kerala

.

ABSTRACT

|  |
| --- |
| Banana (*Musa* spp.) is a major fruit crop extensively cultivated in tropical and subtropical regions. This study surveyed pest incidence, insecticide use patterns, and management practices for *O. longicollis* and associated pests in banana plantations of selected districts of Kerala and Tamil Nadu. Data were collected from 80 commercial banana farmers across eight major banana-growing districts through a structured questionnaire. The survey identified *O. longicollis* as the most prevalent chewing pest (87.5%), followed by *Cosmopolites sordidus* (82.5%) and *Spodoptera litura* (21.25%). Dominant sucking pests included *Aleurodicus rugioperculatus* (23.75%), *Aleurodicus dispersus* (18.75%), and *Pentalonia nigronervosa* (15%). Among insecticides from different groups chlorpyrifos (27.5%) was the most commonly used insecticide. The use of restricted insecticides, including monocrotophos and carbofuran, was also documented. Spraying on pseudostem and leaf axils (63.75%) was the primary application method, followed by sucker treatment (50%). Biopesticides such as neem oil, *Pseudomonas fluorescens*, *Beauveria bassiana*, and entomopathogenic nematodes were adopted minimally. About 55% of farmers followed a one-month spray interval from 4 months after planting (MAP) to 8 MAP, with 26.25% reporting control failures. Only 12.5% of the surveyed farmers practiced insecticide rotation, indicating gaps in resistance management awareness. |

*Keywords: Pest incidence, insecticide usage pattern, Odoiporus longicollis, Kerala, Tamil Nadu, banana plantations, pest management survey*

1. INTRODUCTION

 Banana (*Musa* spp.) is an economically important fruit crop extensively cultivated in tropical and subtropical regions worldwide and ranks as the fourth most important food crop globally, following rice, wheat, and maize (Thangavelu and Mustaffa, 2012). In Kerala and Tamil Nadu, banana is cultivated over an area of 47,540 hectares and 113,860 hectares, respectively, with an annual production of 477,520 tonnes in Kerala and 4,719,950 tonnes in Tamil Nadu, making a substantial contribution to the agricultural economy of both states (IndiaStat, 2024). Banana plantations support a diverse assemblage of insect species, which are broadly categorized as pests or non-pests based on their interaction with the crop and their potential to cause economic losses (Krishnan et al., 2019). Insect-induced damage can considerably diminish the marketability of bananas (Shankar et al., 2016).

 Among the insect pests associated with banana, the banana pseudostem weevil (*Odoiporus longicollis*) is considered one of the most serious pest, causing substantial reductions in both yield and productivity (Justin et al., 2008). Yield losses ranging from 10% to 90% have been reported, varying according to the stage of crop growth at the time of infestation and the effectiveness of the management practices adopted (Padmanaban and Sathiamoorthy, 2001). Presently, the management of this pest predominantly relies on chemical insecticides; however, numerous instances of control failures have been reported from various banana-growing regions. The indiscriminate and continuous use of insecticides against *O. longicollis* also raises the risk of developing insecticide-resistant pest populations, potentially jeopardizing future control efforts.

 In order to encourage the judicious and responsible use of pesticides, it is crucial to first assess and understand the prevailing patterns of pesticide use among banana growers. Considering the considerable trade value of banana in both domestic and international markets, the present field survey was undertaken to document pest details and pesticide use adopted by banana farmers across the major banana-producing districts of Kerala and neighbouring two districts of Tamil Nadu.

2. material and methods

 A detailed survey was conducted based on the methodology of Awasthi and Sridharan, 2017 with minor modifications on the insect pest spectrum of banana plantation, pesticides used and insecticide usage pattern for controlling *O. longicollis.*  A survey was conducted among banana farmers in the districts of Thiruvananthapuram (TVM), Kollam (KLM), Alappuzha (ALP), Thrissur (TSR), Palakkad (PKD), and Kannur (KNR) in Kerala. Two neighboring districts of Tamil Nadu *viz*., Coimbatore (CBE) and Kanniyakumari (KKR) were also taken with the objective of comparing pesticide use patterns. Ten commercial banana farmers from each district were interviewed using a structured proforma designed to gather information on pest incidence, types of pesticides used, and insecticide use patterns. The study areas were selected based on the extent of cultivation of the crop in the state. The survey allowed multiple responses from each respondent wherever applicable. The objective and scope of the study was first explained to the banana farmers for their co-operation. The recorded data were converted to percentages prior to calculating mean values, and the results were presented using the tabular method based on percentages and averages.

|  |
| --- |
|  |
| **Fig 1. Locations of survey** |

3. results and discussion

**3.1 Pests observed during documentation studies in surveyed areas in districts of Kerala and Tamil Nadu**

 The survey conducted in banana plantations revealed the presence of several chewing and sucking pests affecting different parts of the plant, including the pseudostem, rhizome, and leaves (Table 1). Among the chewing pests recorded, *O. longicollis* was the most prevalent, with an incidence of 87.50%, followed by *C. sordidus* (82.5%) and *S. litura* (21.25%). The predominant sucking pests observed across the surveyed areas were *A. rugioperculatus* (23.75%), *A. dispersus* (18.75%), and *P. nigronervosa* (15%). In addition to insect pests, damage by non-insect pests was also documented in the surveyed fields. The occurrence of these pests aligns with previous reports of infestation by *C. sordidus* (Ostmark, 1974), *O. longicollis* (Visalakshi et al., 1989), *O. rhinoceros* (Sivakumar and Mohan, 2013), *S. litura* (Krishnan et al., 2019), *A. rugioperculatus* (Karthick et al., 2018), and *P. nigronervosa* (Harish et al., 2009). Notably, the detection of *R. ferrugineus* in banana plantations is indicative of a possible expansion in the host range of the red palm weevil, as recently reported by Kalita et al. (2023) and Gargi et al. (2024).

**Table 1. Details of pests observed during documentation studies in surveyed areas in districts of Kerala and Tamil Nadu**

|  |  |  |
| --- | --- | --- |
| **Types of pest** | **Particulars** | **Incidence of pest (%)\*** |
| **Common name** | **Scientific name** | **Family: Order** | **Part of crop infested** | **TVM** | **ALP** | **KLM** | **TSR** | **PKD** | **KNR** | **KKR** | **CBE** | **Mean±SD** |
| Chewing insects | Banana pseudostem weevil | *Odoiporus longicollis* (Olivier) | Curculionidae: Coleoptera | Pseudostem | 90 | 80 | 80 | 100 | 90 | 80 | 90 | 90 | 87.50±7.07 |
| Banana rhizome weevil | *Cosmopolitus sordidus* Germer | Curculionidae: Coleoptera | Rhizome | 80 | 90 | 80 | 90 | 90 | 70 | 70 | 90 | 82.50±8.86 |
| Red palm weevil | *Rhynchophorus ferrugineus* (Olivier) | Curculionidae: Coleoptera | Pseudostem | - | - | - | 10 | - | - | - | - | 1.25±3.54 |
| Rhinoceros beetle | *Oryctes rhinoceros* Linnaeus | Scarabidae: Coleoptera | Pseudostem | 30 | 10 | - | 40 | 40 | - | 10 | - | 16.25±17.68 |
| Tobacco caterpillar | *Spodoptera litura* Fabricius | Noctuidae: Lepidoptera | Leaf | 40 | 20 | 10 | 10 | 10 | 30 | 20 | 30 | 21.25±11.26 |
| Bihar hairy caterpillar | *Spilarctia obliqua* Walker | Erebidae: Lepidoptera | Leaf | - | - | - | - | - | 80 | - | - | 10.00±28.28 |
| Brown tussock moth |  *Olene mendosa* Hübner | Erebidae: Lepidoptera | Leaf | 10 | - | - | - | - | - | - | - | 1.25±3.54 |
| Banana slug caterpillar | *Miresa decedens* Walker | Limacodidae : Lepidoptera | Leaf | - | - | - | - | 20 | - | - | - | 2.50±7.07 |
| Sucking insects | Rugose Spiralling whitefly | *Aleurodicus rugioperculatus* Martin | Aleyrodidae: Hemiptera | Leaf | 20 | 10 | 20 | 30 | 10 | 10 | 40 | 50 | 23.75±15.06 |
| Spiralling whitefly | *Aleurodicus disperses* Russell | Aleyrodidae: Hemiptera | Leaf | 30 | 10 | 30 | 20 | 10 | 20 | 20 | 10 | 18.75±8.35 |
| Banana aphid | *Pentalonia nigronervosa*Coquerel | Aphididae: Hemiptera | Leaf | 20 | - | 10 | 20 | 10 | 20 | 10 | 30 | 15.00±9.26 |
| Cercopid  | *Phymatostetha deschampsi* Lethierry | Cercopidae: Hemiptera | Leaf | 10 | 20 | - | - | - | - | - | - | 3.75±7.44 |
| Non insect pests | Lesser bandicoot rat | *Bandicoota bengalensis* Gray | Muridae: Rodentia | Rhizome | - | 20 | 10 | - | - | - | - | - | 3.75±7.44 |
| Giant African Snail | *Achatina fulica* Ferussac | Achatinidae:Stylommatophora | Leaf | - | 20 | - | - | - | - | - | - | 2.50±7.07 |
| \*Out of 10 respondents/ districtMean of 80 farmersThiruvananthapuram (TVM), Kollam (KLM), Alappuzha (ALP), Thrissur (TSR), Palakkad (PKD), Kannur (KNR), Coimbatore (CBE), Kanniyakumari (KKR) |

**3.2 Pesticides commonly used in the surveyed banana plantations of the selected districts of Kerala and Tamil Nadu**

 The insecticides documented in the survey were categorized into various groups *viz*., organophosphates, carbamates, synthetic pyrethroids, nereistoxin analogues, phenyl pyrazoles, diamides, and oxadiazines (Table 2). Among the organophosphate group, chlorpyrifos (27.50%) emerged as the most frequently applied insecticide, followed by quinalphos (12.50%) and the restricted insecticide, monocrotophos (5.00%). Within the synthetic pyrethroids, lambda-cyhalothrin (8.75%) and cypermethrin (5.00%) were predominantly employed for pest management. Notably, the use of the restricted carbamate insecticide, carbofuran (2.50%), was also recorded in certain plantations. Farmers practiced insecticide rotation within the same cropping season, with combinations such as chlorpyrifos + quinalphos (12.50%) and chlorpyrifos + cartap hydrochloride (8.75%) being extensively adopted.

 These observations align with previous reports by Polidoro et al. (2008) from Costa Rica, where chlorpyrifos was documented as the most commonly used insecticide in plantain production systems. Similarly, Awasthi and Sridharan (2017), reported monocrotophos as the primary insecticide applied against banana pests, alongside chlorpyrifos, cypermethrin, and carbofuran. Corresponding trends were also observed in the study by Bhandari et al. (2023), which identified chlorpyrifos as the most frequently utilized insecticide, followed by cypermethrin in banana plantations. However, as per the Directorate of Plant Protection, Quarantine and Storage (2024), only carbofuran 3% CG, quinalphos 25% EC, and oxydemeton-methyl 25% EC hold approved label claims for application in banana, while the survey highlighted the continued use of several non-labelled pesticides in banana plantations.

 In the surveyed banana plantations, the principal fungicides in use were carbendazim (35%), mancozeb (26.25%), copper oxychloride (13.75%), while fluopyram was recorded as the nematicide applied for nematode management. Polidoro *et al*. (2008) reported that 84% of banana growers in their study area employed nematicides, and 22% utilized fungicides such as mancozeb, tridemorph, bitertanol, difenoconazole, and propiconazole. Similarly, Awasthi and Sridharan (2017) documented the application of fungicides including carbendazim, mancozeb, difenoconazole, propiconazole, tebuconazole, and copper oxychloride in banana plantations across Tamil Nadu.

 In the surveyed banana plantations, pesticides of biological control employed for pest management included neem oil (11.25%), *Pseudomonas fluorescens* (13.75%), *Beauveria bassiana* (3.75%), and entomopathogenic nematodes (EPN) (2.5%). Earlier studies by Mgenzi (2005) and Bagamba et al. (2006) reported that the application of neem-based products was well accepted among banana farmers for pest control. According to Aguilar et al. (2014) some farmers reported that adopting a purely organic approach was effective in managing pests in their banana fields, while others believed it fell short in reducing pest populations and improving productivity. In contrast, the survey by Okonya et al. (2019) documented the complete absence of chemical pesticide use for pest management in banana cultivation systems in Rwanda and Burundi, where farmers predominantly relied on non-chemical approaches.

**Table 2. Pesticides commonly used in the surveyed banana plantations of the selected districts of Kerala and Tamil Nadu**

|  |  |
| --- | --- |
| **Particulars** | **Farmer’s response/ district (%)** |
| **Pesticides** | **TVM** | **KLM** | **ALP** | **TSR** | **PKD** | **KNR** | **CBE** | **KKR** | **Mean±SD** |
| **Insecticide** |
| **Single insecticide** |
| Chlorpyrifos | 10 | 40 | 20 | 40 | 50 | 20 | 20 | 20 | 27.50±13.89 |
| Quinalphos | 10 | 10 | 20 | 10 | 20 | 20 | - | 10 | 12.50±7.07 |
| Monocrotophos | - | - | - | - | - | - | 20 | 20 | 5.00±9.26 |
| Carbofuran | 10 | - | - | - | - | - | - | 10 | 2.50±4.63 |
| Cypermethrin | 10 | - | - | - | - | 10 | - | 20 | 5.00±7.56 |
| Lambda cyhalothrin | 10 | - | 10 | 10 | 10 | 20 | - | 10 | 8.75±6.41 |
| Bifenthrin | - | - | 10 | - | - | - | - | - | 1.25±3.54 |
| Cartap hydrochloride | 10 | 10 | - | - | - | - | - | - | 2.50±4.63 |
| Fipronil | - | - | - | - | - | - | 20 | - | 2.50±7.07 |
| Flubendiamide | - | - | - | 10 | - | - | - | - | 1.25±3.54 |
| Indoxacarb | - | - | - | 10 | - | - | - | - | 1.25±3.54 |
| **More than one insecticide/ field**  |
| Chlorpyrifos + Quinalphos | 30 | 20 | 10 | 20 | 10 | 10 | - | - | 12.50±10.35 |
| Chlorpyrifos+ Monocrotophos | - | - | - | - | - | - | 20 | 10 | 3.75±7.44 |
| Chlorpyrifos + Cartap hydrochloride | 10 | 20 | 10 | - | 10 | 10 | 10 | - | 8.75±6.41 |
| Chlorpyrifos+ Cypermethrin | - | - | 10 | - | - | 10 | - | - | 2.50±4.63 |
| Chlorpyrifos + Fipronil | - | - | - | - | - | - | 10 | - | 1.25±3.54 |
| **Botanicals** |  |
| Neem oil | 20 | 10 | 10 | 20 | 10 | 10 | - | 10 | 11.25±6.41 |
| **Fungicides** |  |
| Carbendazim | 40 | 50 | 20 | 40 | 30 | 20 | 40 | 40 | 35±10.69 |
| Mancozeb | 40 | 40 | 20 | 30 | 20 | 10 | 20 | 30 | 26.25±10.61 |
| Copper oxychloride | 20 | 10 | - | 10 | 20 | 10 | 10 | 30 | 13.75±9.16 |
| Fosetyl Aluminium | - | - | - | - | - | - | 10 | - | 1.25±3.54 |
| Tebuconazole | - | - | - | - | - | - | 10 | - | 1.25±3.54 |
| Nematicide |  |
| Fluopyrum | - | - | - | - | - | - | 10 | - | 1.25±3.54 |
| **Microbial Biopesticides** |  |
| *Pseudomonas flourescens* | 10 | 30 | 20 | 30 | 10 | 10 | - | - | 13.75±11.78 |
| *Beauveria bassiana* | 10 | 10 | - | 10 | - | - | - | - | 3.75±5.18 |
| EPN | - | - | - | 20 | - | - | - | - | 2.50±7.07 |
| EPN= Entomopathogenic Nematodes\*Out of 10 respondents/ districtMean of 80 farmersThiruvananthapuram (TVM), Kollam (KLM), Alappuzha (ALP), Thrissur (TSR), Palakkad (PKD), Kannur (KNR), Coimbatore (CBE), Kanniyakumari (KKR) |

**3.3 Information on insecticide use against *O. longicollis* in banana plantations of Kerala and Tamil Nadu**

 In the surveyed banana plantations, the most commonly adopted method for insecticide application was spraying on the pseudostem and leaf axil (63.75%), followed by sucker treatment (50.00%), soil incorporation (26.25%), and leaf axil filling alone (3.75%) (Table 3). These findings are consistent with the observations of Awasthi and Sridharan (2017), who reported that spraying was the predominant method of pesticide application, which was supplemented by practices such as sucker treatment, pseudostem injection, and whorl application of chemical. They further noted that labour-intensive techniques like pseudostem injection and swabbing of the pseudostem were less frequently practiced due to operational constraints. Similarly, Henriques et al. (1997), in their review of pest management strategies in Latin America, identified both aerial and manual spraying as the principal methods for insecticide application in infested fields, alongside cultural practices like dipping susceptible plant parts in insecticide solutions. In addition, Barraza et al. (2011) recognized aerial spraying of pesticides in banana plantations as a significant factor contributing to pesticide exposure among populations residing in proximity to these agricultural areas.

 A substantial proportion of banana farmers (78.75%) accessed technical information pertaining to improved agricultural practices predominantly through government agencies, followed by progressive farmers (17.50%) and pesticide dealers (11.25%). With respect to insecticide application schedules, 55.00% of the respondents adhered to a one-month interval from 4 months after planting (MAP) to 8MAP, whereas 26.25% followed a two-month interval during the same period. Furthermore, 50.00 % of the surveyed farmers adopted the incorporation of insecticides at the time of planting either as sucker treatment or soil incorporation. Conversely, Tiwari et al. (2006) reported that farmers depended on other farmers, followed by pesticide dealers, government agencies and radio for technical help on crop protection. Awasthi and Sridharan (2017) documented a different trend wherein a majority of banana cultivators (46.25%) relied on private agro-pesticide dealers for technical advisory services, followed by agricultural officers and scientists (42.92%). Their study further revealed that pesticide applications were predominantly carried out at three-month intervals (48.33%), while 30.83% of farmers practiced need-based applications and 6.25% adhered to a two-month interval schedule.

**Table 3. Information on insecticide use against *O. longicollis* in banana plantations of Kerala and Tamil Nadu**

|  |  |
| --- | --- |
| **Particulars** | **Farmer’s response/ district (%)** |
| **TVM** | **KLM** | **ALP** | **TSR** | **PKD** | **KNR** | **CBE** | **KKR** | **Mean±SD** |
| **Method of application of insecticide** |  |
| Sucker treatment | 40 | 80 | 60 | 50 | 40 | 60 | 60 | 10 | 50.00±20.70 |
| Soil incorporation | 30 | 50 | 40 | 40 | 20 | 30 | - | - | 26.25±18.47 |
| Spraying on pseudostem and leaf axil | 40 | 80 | 60 | 60 | 60 | 70 | 70 | 70 | 63.75±11.88 |
| Leaf axil filling | 10 | - | - | - | - | - | 10 | 10 | 3.75±5.18 |
| **Source of technical information** |  |
| Government Agencies(KB/ KVK/ VFPCK/SAUs) | 80 | 100 | 90 | 100 | 80 | 90 | 40 | 50 | 78.75±22.32 |
| Pesticide retailers/dealers | 20 | - | - | 10 | 10 | - | 20 | 30 | 11.25±11.26 |
| Other progressive farmers | 30 | 20 | 10 | 20 | - | 10 | 30 | 20 | 17.50±10.35 |
| Media | - | - | - | - | - | - | 20 | 10 | 3.75±7.44 |
| **Stage of crop and frequency of pesticide application** |  |
| At the time of planting | 60 | 50 | 50 | 60 | 40 | 50 | 60 | 30 | 50.00±10.69 |
| 1 -3 MAP | 10 | 0 | 0 | 10 | 0 | 10 | 30 | 20 | 10.00±10.69 |
| 1 month interval from 4 MAP to 8 MAP | 60 | 50 | 30 | 70 | 40 | 50 | 80 | 60 | 55.00±16.04 |
| 2 months interval from 4 MAP to 8 MAP | 30 | 40 | 50 | 10 | 30 | 30 | - | 20 | 26.25±15.98 |
| Need based application | - | - | - | - | - | - | - | 10 | 1.25±3.54 |
| \*Out of 10 respondents/ districtMean of 80 farmersKB= Krishibhavan, KVK= Krishi Vigyan Kendra, VFPCK= Vegetable and Fruit Promotion Council Keralam, SAU= State Agricultural University, MAP=Months After PlantingThiruvananthapuram (TVM), Kollam (KLM), Alappuzha (ALP), Thrissur (TSR), Palakkad (PKD), Kannur (KNR), Coimbatore (CBE), Kanniyakumari (KKR) |

**3.4 Farmers’ responses on control failures, insecticide rotation and rate of application against *Odoiporus longicollis* in selected districts of Kerala and Tamil Nadu**

Approximately 26.25% of the surveyed banana farmers reported pest management failures despite adopting control measures, while only 12.5% of the respondents practiced insecticide rotation as a resistance management strategy (Table 4). Additionally, it was observed that nearly 55% of the banana farmers applied insecticides at dosages exceeding the recommended levels. These findings align with the observations of Henriques et al*. (*1997) and Awasthi and Sridharan (2017), who reported indiscriminate and excessive use of pesticides among banana growers, irrespective of the control methods employed. Conversely, Gurbuz et al. (2023) documented a trend of safer pesticide practices, with reduced quantities and frequency of applications in banana field in Somalia, which was attributed to the implementation of Integrated Pest Management (IPM) training programmes among local farmers.

**Table 4. Farmers’ responses on control failures, insecticide rotation and rate of application against *Odoiporus longicollis* in selected districts of Kerala and Tamil Nadu**

|  |  |
| --- | --- |
| **Particulars** | **Farmer’s response/ district (%)** |
| **TVM** | **KLM** | **ALP** | **TSR** | **PKD** | **KNR** | **CBE** | **KKR** | **Mean±SD** |
| **Control Failures** |
| Report of control failures | 40 | 20 | 10 | 30 | 20 | 10 | 50 | 30 | 26.25±14.08 |
| **Insecticide rotation** |
| Practice of insecticide rotation | 10 | 20 | 30 | - | 10 | 20 | 10 | - | 12.50±10.35 |
| **Rate of application of insecticide** |
| Recommended dose | 30 | 50 | 40 | 40 | 40 | 50 | 10 | 10 | 33.75±15.98 |
| Above recommended dose | 70 | 50 | 40 | 50 | 30 | 30 | 90 | 80 | 55.00±22.68 |
| Below recommended dose | - | - | 20 | 10 | 30 | 20 | - | 10 | 11.25±11.25 |
| \*Out of 10 respondents/ districtMean of 80 farmersThiruvananthapuram (TVM), Kollam (KLM), Alappuzha (ALP), Thrissur (TSR), Palakkad (PKD), Kannur (KNR), Coimbatore (CBE), Kanniyakumari (KKR) |

4. Conclusion

This survey highlights the dominance of *O. longicollis* and associated pests in banana plantations across Kerala and two districts of Tamil Nadu, with extensive reliance on chemical insecticides, notably organophosphates like chlorpyrifos. The frequent application of insecticides at one-month intervals, limited adoption of insecticide rotation, and occasional use of restricted molecules reflect potential risks for pest resurgence, environmental contamination, and resistance development. Although biopesticides have made inroads into pest management practices, their usage remains minimal. These findings highlight the urgent need for farmer education on integrated pest management (IPM) strategies, rational insecticide use, and resistance management to ensure sustainable banana production and safeguard agro-ecosystem health.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) here by declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**DISCLAIMER (ETHICAL ISSUES)**

Authors here by declare that, this research article is original work submitted compiling all the guidelines, there is no deviation from any ethical issues.

References

Aguilar, C. H., Zapico, F. L., Namocatcat, J., Fortich, A. & Bojadores, M. (2014). Farmers' perceptions about banana insect pests and integrated pest management systems in banana plantations in SOCSARGEN [South Cotabato, Saranggani and General Santos City] area, Mindanao Philippines. *Philippine Journal of Crop Science (Philippines)*, 63(5). 22-27.

Awasthi, N. S., & Sridharan, S. (2017). Documentation of pest management practices among banana growers in major banana growing districts of Tamil Nadu. *International Journal of Plant Protection*, 10(1), 63-68.

Bagamba, F., Karamura, E., Gold, C.S., Barekye, A., Blomme, G., Tushemereirwe, W.K. & Tinzaara, W. (2006). Socioeconomic assessment of pest management practices in Lwengo sub-county, Uganda. In: Blomme, G., Gold, C.S. & Karamura, E. (eds.) *Farmer-participatory testing of integrated pest management options for sustainable banana production in Eastern Africa: Proceedings of the workshop held in Seeta, Uganda, 8–9 December 2003*. Montpellier, France: The International Network for the Improvement of Banana and Plantain (INIBAP), pp. 17–25.

Barraza, D., Jansen, K., de Joode, B.V.W., & Wesseling, C. (2011). Pesticide use in banana and plantain production and risk perception among local actors in Talamanca, Costa Rica. *Environmental Research*, 111(5), 708-717.

Bhandari, G., Chiaia-Hernández, A.C., Atreya, K., Geissen, V., & Singh, S.P. (2023) Knowledge and practices of commercial banana farmers related to pesticide use in Chitwan district, Nepal; a cross-sectional study and meta-analyses. *Environmental Monitoring and Assessment*, 195(12), p.1490.

Directorate of Plant Protection, Quarantine & Storage. (2024). *Major uses of insecticides (registered under the Insecticides Act, 1968) as on 30.11.2024*. Department of Agriculture & Farmers Welfare, Government of India. Retrieved from <https://ppqs.gov.in/sites/default/files/mup_insecticide_30.11.2024_0.pdf>

Gargi, C., Paul, A., Anitha, N., Manu, C.R., Alex, S., & Sheena, A. (2024).First report of the occurrence of red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) on banana in Kerala, India. *Insect Environment*, 27(1), 24–26.

Gurbuz, I.B., Abdullahı, A.M., & Ozkan, G. (2023). Integrated pest management practices in Somalia to reduce pesticide use in banana production. *Erwerbs-Obstbau*, 65(5), 1793-1801.

Harish, S., Kavino, M., Kumar, N., & Samiyappan, R. (2009). Differential expression of pathogenesis-related proteins and defense enzymes in banana: interaction between endophytic bacteria, Banana bunchy top virus and *Pentalonia nigronervosa*. *Biocontrol Science and Technology*, *19*(8), 843-857.

Henriques, W., Jeffers, R. D., Lacher Jr, T.E., & Kendall, R. J. (1997). Agrochemical use on banana plantations in Latin America: perspectives on ecological risk. *Environmental Toxicology and Chemistry*, 16(1), 91-99.

IndiaStat. 2024. State-wise area, production and productivity of banana in India (2023-2024). Available at: <https://www.indiastat.com/> (Accessed on: 7 May, 2025).

Justin, C., Leelamathi, M., & Nirmaljohson, S. B. (2008). Bionomics and management of the pseudostem weevil, *Odoiporus longicollis* Oliver (Coleoptera: Curculionidae) in banana–A review. *Agricultural Reviews*, 29(3), 185 192.

Kalita, B., Bhattacharyya, B., Das, P.P.G., Gogoi, I., Hazarika, J., & Borkataki, S. (2023). First report of red palm weevil, *Rhynchophorus ferrugineus* on banana cultivar ‘AsomiyaMalbhog’ in Assam, India. *Pest Management in Horticultural Ecosystems*, 29(1), 166-168.

Karthick, K. S., Chinniah, C., Parthiban, P., & Ravikumar, A. (2018). Newer report of Rugose Spiraling Whitefly, Aleurodicus *rugioperculatus* Martin (Hemiptera: Aleyrodidae) in India. *International Journal of Research Studies in Zoology*, *4*(2), 12-16.

Krishnan, J.U., Jayaprakas, C.A., Harish, E.R., & Rajeswari, L.S. (2019). Banana (*Musa* spp.)-an unseen umbrella crop? Insect diversity on *Musa* spp. in the Indo-Pacific region. *Oriental Insects*, 54(3), 433-445.

Mgenzi, S.R.B., Mkulila, S.I., Blomme, G., Gold, C.S., Ragama, P.E., Karamura, E.B. & Nkuba, J.M. (2005). The effect of pest management practices on banana pests in the Kagera region of Tanzania. In: Blomme, G., Gold, C.S. & Karamura, E.B. (Eds.), *Farmer-participatory testing of integrated pest management options for sustainable banana production in Eastern Africa*. Proceedings of the workshop held in Seeta, Uganda, 8–9 December 2003. Montpellier, France: International Plant Genetic Resources Institute, pp. 43–52.

Okonya, J.S., Petsakos, A., Suarez, V., Nduwayezu, A., Kantungeko, D., Blomme, G., Legg, J.P., & Kroschel, J. (2019). Pesticide use practices in root, tuber, and banana crops by smallholder farmers in Rwanda and Burundi. *International Journal of Environmental Research and Public Health*, 16(3), p.400.

Ostmark, H.E. (1974). Economic insect pests of bananas. *Annual Review of Entomology*, 19, 161–176.

Padmanaban, B., & Sathiamoorthy, S. (2001). Banana stem weevil, *Odoiporus longicollis*. *Musa* Pest Fact Sheet No.5, INIBAP, France.

Polidoro, B. A., Dahlquist, R. M., Castillo, L. E., Morra, M. J., Somarriba, E., & Bosque-Pérez, N. A. (2008). Pesticide application practices, pest knowledge, and cost-benefits of plantain production in the Bribri-Cabécar Indigenous Territories, Costa Rica. *Environmental Research*, *108*(1), 98-106.

Shankar, U., Singh, A.K., Mondal, A. (2016). Integrated pest management in banana. In: Abrol DP (ed) Integrated pest management in the tropics. New India Publishing Agency, New Delhi, pp 329–349

Sivakumar, T., & Mohan C. (2013). Occurrence of rhinoceros beetle, *Oryctes rhinoceros* (L.), on banana cultivars in Kerala. *Pest Management in Horticultural Ecosystems*. 19(1):99–101.

Thangavelu, R., & Mustaffa, M. M. (2012). Current advances in the *Fusarium* wilt disease management in banana with emphasis on biological control. *Plant Pathology*, 273-298.

Tiwari, S., Thapa, R. B., Gautam, D. M. & Shrestha, S. K. (2006). Survey of banana stem weevil, *Odoiporus longicollis* (Oliv.)(Coleoptera: Curculionidae) in Nepal. *Journal of the Institute of Agriculture and Animal Science*, 27, 127-131.

Visalakshi A, Nair, G. M, Beevi, S. N., Amma, A.M.K. (1989). Occurrence of *Odoiporus longicollis* Oliver (Coleoptera: Curculionidae) as a pest of banana in Kerala. *Entomon*. 14 (3–4), 367–368.