# Evaluation of different trapping methods for the management of banana pseudostem weevil, *Odoiporus longicollis* Olivier (Coleoptera:Curculionidae) in Sugandhi banana under field conditions

Comment [h1]: Title suggestion- Evaluation of different trapping methods against banana pseudostem weevil, *Odoiporus longicollis* Olivier (Coleoptera:Curculionidae)

**Abstract:** The banana pseudostem weevil (BPW), *Odoiporus longicollis* Olivier (Coleoptera: Curculionidae), is a major internal borer pest of banana causing severe yield losses due to its concealed feeding habit within the pseudostem. Conventional chemical control is often ineffective against this pest. This study evaluated the efficacy of pheromone-assisted trapping methods and live pseudostem traps for BPW management under field conditions in Hosapete taluka, Vijayanagar district, Karnataka, during 2021–2022. Seventeen treatments involving different trap designs, synthetic aggregation pheromone lures and pseudostem-based traps were tested. Among all treatments, horizontally placed cut pseudostem traps at the plant base captured significantly higher numbers of weevils per trap per day (2.42) and per week (16.91), which was followed by vertical stump trap (0.74 and 5.17) and unsplit pseudostem traps (0.19 and 1.32) respectively. These effective treatments also corresponded with reduced BPW infestation in surrounding plants. In contrast, traps lacking host plant material or suboptimal designs showed negligible catches. The results underscore the importance of combining synthetic pheromones with live host cues for effective trapping. Pseudostem based traps, particularly the horizontal type demonstrated strong potential as a cost-effective component of integrated pest management (IPM) strategies for BPW in banana cultivation.

**Keywords:** Banana pseudostem weevil, trapping methods, pheromone lures, pseudostem pieces, vertical pseudostem trap, stump trap, integrated pest management



## INTRODUCTION:

Among the different constraints, the banana pseudostem weevil (BPW), *Odoiporus longicollis* Olivier (Coleoptera: Curculionidae) is one of the most important and monophagous pest in cultivation of bananas and plantains (Biswas & Bandyopadhyay, 2015). It is gaining significantly greater economic importance in small scale low-input cultivation systems in India and abroad places in the tropic and sub-tropics (Tiwari *et al*, 2006). Feeding by BPW resulting greater crop losses due to toppling at crown region, withering and delayed flowering, immature fruits and decreased bunch weight (Chowdhury, 2015). Depending upon the stage of the crop growth during which the pest attack and level of management practices pest can causes up to 90% yield loss and crop

Comment [h2]: Avoid to commence the sentence with 'among'. Add one or two line about importance of crop.

Comment [h3]: As per reference, this citation should be Biswas et al. (Cross check it) failure (Sivakumar *et al.,* 2014).Whereas, complete crop failure has been reported in Nendrans which is one of the susceptible cultivars. The weevil lay eggs in the outermost leafsheaths by making ovipositional injuries made by female's rostrum and the eggs were placed singly in the air chambers of leaf sheath. The emerged larvae feed on succulent tissue of pseudostem and also make tunnels in the core of the pseudostem. Under severe conditions, these tunnels may reach up to the peduncle and to the collar region of the bottom near the rhizome. This will hinder the flow of nutrients and minerals this leads to plant become more susceptible to topple and as a result, the bunched plants fall prematurely with little blow of wind and more yield losses (Chowdhury, 2015 & Sivakumar *et al.*, 2014). Although many of the chemicals recommended by the researchers, management of BPW is very difficult task by the farmers due its concealed feeding habit and life cycle (Sivakumar *et al.,* 2014). Further, in view of safety to the environment as well as health point of view, residue problems and in concern to the small -scale farmers use of pesticides to manage BPW is not frugal (Gold *et al.*, 1999) Banana cut pseudostem traps have been used for management and monitoring of the pest (Gold *et al.*, 2002).However, 5-15% of weevil population has been attracted by these traps in an area (Koppenhofer *et al.*, 1994). Funnel traps baited with aggregation pheromone lure of 2-methyl-4-heptanol combined with host plant extract trapped significantly more weevils (Palanichamy *et al.,* 2011). However, destruction of infested pseudostems by cutting them into small pieces and further manual collection of attracted adult weevils from cut pseudostem traps were found effective in reducing the infestation (Kung, 1955 and 1964), whereas, one week old cut banana pseudostem traps were attracted more adult banana weevils and reported 50 % reduction in weevil popualtion over a period of eleven months trapping and proved the cultural control method of weevil control is cost effective and ecofriendly **(**Koppenhofer *et al.* 1994). Traps such as disc-on-stump and longitudinal split pseudostem traps proved more effective in monitoring and reducing the pseudostem weevil population and in the cut area because of more exudation of plant fluids helps in luring more weevil population (Padmanabhan *et al.,* 2002). In addition, horizontal split and vertical cut pseudostem traps were most effective in trapping *C. sordidus and O. longicollis* adult weevils (Bulifu *et al.*, 2019), respectively. These previous ~~studies~~ findings witnessed that identification of the best attractant for *O. longicollis* is the foremost important criteria in developing successful insect traps. Since, BPW is an internal tissue borer, the penetration of insecticides in to the pseudostem and the target site of insect infestation may not be effective and practicable. One of the easy, economical and

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practicable tools to reduce the BPW infestation in banana could be lure or attract weevils and kill them. In this background different trapping methods along with synthetic pheromone blends were tested to trap the weevils under field conditions in farmers field at Hosapete taluka of Vijayanagar district of North Karnataka during 2021 and 2022.

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## MATERIAL AND METHODS: -

This experiment was conducted in farmers' fields at Tungabhadra command area, Hospete taluk, Vijayanagar district during peak infestation of the pest i.e., September and October months of 2021 and 2022. The field was planted with variety Sugandhi (cul.AAB) at a spacing of 2.1 m X 2.1 m following all agronomic practices. The stage of the garden was 5th ratoon when the plants were flowering to fruiting stage. Totally there were 17 treatments replicated thrice, maintaining 1 trap per replication installed in randomized block design. The treatments comprised of different traps, pheromone lures and pseudostem pieces **(Table 1).** Lures were procured from Albero Green Organics Pvt. Ltd, Bangalore. The traps were separated by 10 m distance in the field and 15 m apart from the border.

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**Table 1. Different traps and lures used for the experiment against *O.longicollis***

| Treatments | Trap combinations with lures* |
|---|---|
| $T_1$ | Aerial bucket trap + lure-I |
| $T_2$ | White sticky cross vane trap +lure-I |
| $T_3$ | Aerial bucket trap + lure-II |
| $T_4$ | White sticky cross vane trap +lure-II |
| $T_5$ | Aerial bucket trap + lure-I+ cut pseudostem pieces |
| $T_6$ | Aerial bucket trap+ lure-II+ cut pseudostem pieces |
| $T_7$ | Aerial bucket trap+ cut pseudostem pieces |
| $T_8$ | Aerial bucket trap alone |
| $T_9$ | White sticky cross vane trap alone |
| T10 | Runway trap +lure-I |
| $T_{11}$ | Runway trap +lure-II |
| $T_{12}$ | Runway trap +lure-I+ cut pseudostem pieces |
| $T_{13}$ | Runway trap +lure-II+ cut pseudostem pieces |
| $T_{14}$ | Runway trap alone |
| $T_{15}$ | Cut pseudostem pieces (placed horizontally at the base of the plant) |
| $T_{16}$ | Vertical/stump pseudostem trap |
| $T_{17}$ | Pseudostem trap without splitting |

***Aggregation lure I: 2-methy l-4-heptanol**
*** Aggregation lure II: blends of diphenylamine, 1-hexadecene and hexadecane**

Aggregation pheromone lure of 2-methyl-4-heptanol (Lure-I) and blends of diphenylamine, 1-hexadecene and hexadecane (Lure-II) were evaluated in aerial bucket trap (Plate 1a), white sticky cross vane trap (plate 1b) and in runway trap respectively (Plate 1c) for attraction towards the source. These pheromones were evaluated alone and in combination with cut pseudostem pieces in the traps. The banana cut pseudostem trap as horizontally placed (Plate 1d), vertical/stump pseudostem trap (Plate 1e) and pseudostem trap without splitting (Plate 1f) were evaluated for their efficiency in attracting adult weevil.

Cut pseudostem traps were prepared from the stems of harvested banana plants. The banana stem was cut in to 30 cm length. The cut piece was split in to two halves of equal length and were placed horizontally over the soil at a distance of 1 ft from the base of the plant with cut section facing the soil with 1 cm gap by keeping two small stones at both the ends to facilitate movement of the weevils under the cut stem portion. Similarly, the vertical stump traps were prepared from the old stems by cutting them with a height of 80 cm from the ground level. Similarly, the aerial bucket traps were hanged to the bamboo stick of 3 feet height and soap solution was maintained up to 2 cm at the bottom to retain the trapped weevils (treatments having lure alone). White sticky cross vane traps were fixed to stick at a height of 3 feet. Similarly, runway traps were prepared by using small plastic buckets and thin metal rods and are buried in the soil. Vertical stump and cut pseudostem traps were changed at weekly interval up to two months. Treatments efficacy was studied by documenting the number of weevils trapped daily and weekly average. Similarly, observations were also made to record the infestation level by taking observations on five plants at the vicinity of the trap and the per cent infestation was worked looking in to the damage.

**Results and Discussion: -**

The data pertaining to evaluation of different trapping methods during 2021 are presented in Table 2. The data showed significantly higher number of weevils trapped per day per trap in treatment $T_{15-}$ cut pseudostem pieces placed horizontally at the base of the plant (2.37) followed by $T_{16}$ -vertical or stump pseudostem trap (0.75) followed by $T_{17}$-pseudostem trap alone without splitting (0.03) which was statistically on par with rest of the treatments recorded almost zero and proved significantly ineffective in trapping the weevils (Table 2).Similarly, the data recorded per trap per week catches were significantly higher in $T_{15}$- cut pseudostem pieces placed horizontally at the base of the plant (16.55) followed by $T_{16}$-vertical or stump pseudostem trap (5.22) followed by $T_{17-}$ pseudostem trap alone without splitting (1.00) and $T_{12}$ - runway trap +lure-I+ cut pseudostem pieces (0.63) which was statistically on par with $T_4$ -white sticky cross vane trap +lure-II and $T_2$- white sticky cross vane trap +lure-1 were recorded 0.41 and 0.44 weevils per trap per week. Remaining treatments were significantly inferior in trapping the weevils.

**Table 2. Evaluation of different trapping devices and lures to trap the banana pseudostem weevil, 2021**

| Treatments | No of weevils/trap/day* | No of weevils/trap/week | Infestation (%)** |
|---|---|---|---|
| **$T_1$** -Aerial bucket trap + lure-I | 0.03 (0.73)$^{c}$ | 0.18 (0.83)$^{ef}$ | 49.63 (44.77)$^{d}$ |
| **$T_2$** - White sticky cross vane trap +lure-I | 0.06 (0.75)$^{c}$ | 0.44 (0.97)$^{de}$ | 51.85 (46.06)$^{d}$ |
| **$T_3$** -Aerial bucket trap + lure-II | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 48.89 (44.36)$^{cd}$ |
| **$T_4$** -White sticky cross vane trap +lure-II | 0.06 (0.75)$^{c}$ | 0.41 (0.95)$^{de}$ | 48.15 (43.94)$^{cd}$ |
| **$T_5$** -Aerial bucket trap + lure-I+ cut pseudostem pieces | 0.03 (0.73)$^{c}$ | 0.18 (0.83)$^{ef}$ | 48.89 (44.36)$^{cd}$ |
| **$T_6$** - Aerial bucket trap+ lure-II+ cut pseudostem pieces | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 48.89 (44.36)$^{cd}$ |
| **$T_7$** - Aerial bucket trap+ cut pseudostem pieces | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 48.89 (44.36)$^{cd}$ |
| **$T_8$**- - Aerial bucket trap alone | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 49.63 (44.79)$^{d}$ |
| **$T_9$** -White sticky cross vane trap alone | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 49.63 (44.79)$^{d}$ |
| **$T_{10}$** - Runway trap +lure-I | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 49.63 (44.79)$^{d}$ |
| **$T_{11}$** - Runway trap +lure-II | 0.03 (0.73)$^{c}$ | 0.18 (0.83)$^{ef}$ | 45.18 (42.23)$^{cd}$ |
| **$T_{12}$** - Runway trap +lure-I+ cut pseudostem pieces | 0.09 (0.77)$^{c}$ | 0.63 (1.06)$^{d}$ | 45.92 (42.66)$^{cd}$ |
| **$T_{13}$** - Runway trap + lure-II +cut pseudostem pieces | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{f}$ | 45.93 (42.66)$^{cd}$ |
| **$T_{14}$** - Runway trap alone | 0.00 (0.71 )$^{c}$ | 0.00 (0.71)$^{f}$ | 44.45 (41.80)$^{cd}$ |
| **$T_{15}$** - Cut pseudostem pieces (placed horizontally ) | 2.37 (1.69)$^{a}$ | 16.55 (4.13)$^{a}$ | 24.26 (29.50)$^{a}$ |
| **$T_{16}$** - Vertical/stump pseudostem trap | 0.75 (1.12)$^{b}$ | 5.22(2.39)$^{b}$ | 32.45 (34.71)$^{b}$ |
| **$T_{17}$** - Pseudostem Without splitting | 0.03 (0.80)c | 1.00 (1.22)$^{c}$ | 42.29 (40.56)$^{c}$ |
| **S. Em ±** | **0.03** | **0.05** | **1.41** |
| **CD at 5%** | **0.09** | **0.14** | **4.20** |

*Values the parentheses are √x + 0.5 transformed values and **Figures in parentheses are arc sine transformed values

In the field, the infestation of the weevils recorded nearby traps was significantly higher (42 to 49 %) compared to the fields where treatment $T_{15}$ and $T_{16}$ recorded mean infestation of 24.26 and 32.45 per cent, respectively.

## Standardization of BPW trapping techniques during 2022

Correspondingly the data on number of weevils/ trap/day and number of weevils/trap/weeks with √ x+0.5 values and per cent infestation for the second season (2022) are presented in Table 3. The data indicated that significantly more number of

**Comment [h10]:** CV value should also mention in table weevils trapped per day per trap was in $T_{15}$-cut pseudostem pieces placed horizontally at the base of the plant (2.46) which was followed by $T_{16}$ - vertical or stump pseudostem trap (0.73), $T_{17}$- pseudostem trap alone without splitting (0.23) which was statistically on par with $T_4$ -White sticky cross vane trap +lure-II (0.07) and $T_{12}$- runway trap +lure-I+ cut pseudostem pieces (0.10) trapping methods. Other treatments recorded almost zero and proved significantly ineffective in trapping the weevils (Table 3).

**Table 3. Evaluation of different trapping devices and lures to trap the banana pseudostem weevil, 2022**

| Treatments | No. of weevils/trap/day* | No. of weevils/trap/week | Infestation (%)** |
|---|---|---|---|
| **$T_1$** -Aerial bucket trap + lure-I | 0.05 (0.74)[d] | 0.33 (0.91)[def] | 42.97(40.93)[c] |
| **$T_2$** - White sticky cross vane trap +lure-I | 0.05 (0.74)[d] | 0.37 (0.93)[de] | 48.89 (44.36)[cde] |
| **$T_3$** -Aerial bucket trap + lure-II | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 51.85 (46.06)[f] |
| **$T_4$** -White sticky cross vane trap +lure-II | 0.07 (0.76)[cd] | 0.52 (1.01)[de] | 48.89 (44.36)[cde] |
| **$T_5$** -Aerial bucket trap + lure-I+ cut pseudostem pieces | 0.02 (0.72)[d] | 0.15 (0.80)[fg] | 47.41 (43.50)[cde] |
| **$T_6$** - Aerial bucket trap+ lure-II+ cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 48.15 (43.93)[cde] |
| **$T_7$** - Aerial bucket trap+ cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 51.11 (45.64)[cde] |
| **$T_{8-}$** - Aerial bucket trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cde] |
| **$T_9$** -White sticky cross vane trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cde] |
| **$T_{10}$** - Runway trap +lure-I | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cde] |
| **$T_{11}$** - Runway trap +lure-II | 0.02 (0.72)[d] | 0.18 (0.82)[efg] | 47.41(43.51)[cde] |
| **$T_{12}$** - Runway trap +lure-I+ cut pseudostem pieces | 0.10 (0.78)[cd] | 0.71 (1.10)[d] | 45.92 (42.66)[cde] |
| **$T_{13}$** - Runway trap +lure-II + cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)g | 46.67 (43.09)[cde] |
| **$T_{14}$** - Runway trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 48.15 (43.94)[cde] |
| **$T_{15}$** - Cut pseudostem pieces (placed horizontally ) | 2.46 (1.72)[a] | 17.26 (4.21)[a] | 22.96 (28.63)[a] |
| **$T_{16}$** - Vertical/stump pseudostem trap | 0.73 (1.11)[b] | 5.11 (2.36)[b] | 34.37 (35.88)[b] |
| **$T_{17}$** - Pseudostem Without splitting | 0.23 (0.83)[c] | 1.63 (1.46)[c] | 45.18 (42.24)[cd] |
| **S. Em ±** | **0.02** | **0.04** | **1.20** |
| **CD at 5%** | **0.07** | **0.12** | **3.60** |

*Values in the parentheses are $\sqrt{x} + 0.5$ transformed values and **Figures in the parentheses are arc sine transformed values

Likewise, the observations recorded for per trap per week catches showed significantly more number of weevils trapped in treatment $T_{15}$ i.e, cut pseudostem pieces placed horizontally at the base of the plant (17.26) followed by next $T_{16}$- vertical or stump pseudostem trap (5.11), $T_{17}$- pseudostem trap alone without splitting (1.63), $T_{12}$ - runway trap +lure-I+ cut pseudostem pieces (0.71) was statistically on par with $T_4$ -white sticky cross vane trap +lure-II, $T_2$ -white sticky cross vane trap +lure-I and $T_1$ -aerial bucket trap with lure-I trapped 0.52, 0.37 and 0.33 average number of weevils per trap per week, respectively. Remaining treatments were significantly inferior and failed in trapping the weevils. Correspondingly, the per cent infestation of the weevils recorded near the vicinity of the traps was significantly higher (42.97 to 51.85 percent) compared to the fields where treatment $T_{15}$ and $T_{16}$ recorded lower infestation of 22.96 and 34.37 per cent, respectively.

The pooled analysis data of two years 2021 and 2022 is presented in Table 4. The trapping data was computed to determine the efficiency of the traps to lure the banana pseudostem weevil. The number of weevils trapped/trap/day was 0.00 to 0.10 in treatments from $T_1$ to $T_{14}$ with synthetic aggregation pheromones. The treatment $T_{15-}$ placing cut pseudostem pieces horizontally at the base of the plant and $T_{16-}$ vertical/ stump pseudostem trapping methods attracted significantly higher number of weevils/day/trap i.e., 2.42 and 0.74 weevils trapped/trap/day, respectively.



**Table 4. Pooled data on evaluation of different trapping devices and lures to trap the banana pseudostem weevil, 2021 and 2022**

| Treatments | No. of weevils/trap/day* | No. of weevils/trap/week | Infestation (%)** |
|---|---|---|---|
| **$T_1$** -Aerial bucket trap + lure-I | 0.04 (0.73)[d] | 0.26 (0.87)[ef] | 46.30 (42.85)[cd] |
| **$T_2$** - White sticky cross vane trap +lure-I | 0.06 (0.75)[cd] | 0.41 (0.95)[e] | 50.37 (45.21)[cd] |
| **$T_3$** -Aerial bucket trap + lure-II | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 50.37 (45.21)[d] |
| **$T_4$** -White sticky cross vane trap +lure-II | 0.07 (0.75)[cd] | 0.46 (0.98)[de] | 48.52 (44.15)[cd] |
| **$T_5$** -Aerial bucket trap + lure-I+ cut pseudostem pieces | 0.03 (0.72)[d] | 0.17 (0.82)[fg] | 48.15 (43.93)[cd] |
| **$T_6$** - Aerial bucket trap+ lure-II+ cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 48.52 (44.15)[cd] |
| **$T_7$** - Aerial bucket trap+ cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 50.00 (45.00)[cd] |
| **$T_{8-}$** - Aerial bucket trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cd] |
| **$T_9$** -White sticky cross vane trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cd] |
| **$T_{10}$** - Runway trap +lure-I | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 49.63 (44.79)[cd] |
| **$T_{11}$** - Runway trap +lure-II | 0.03 (0.72)[d] | 0.18 (0.83)[f] | 46.30 (42.87)[cd] |
| **$T_{12}$** - Runway trap +lure-I+ cut pseudostem pieces | 0.10 (0.77)[cd] | 0.67 (1.08)[d] | 45.92 (42.66)[cd] |
| **$T_{13}$** - Runway trap +lure-II+ cut pseudostem pieces | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 46.30 (42.88)[cd] |
| **$T_{14}$** - Runway trap alone | 0.00 (0.71)[d] | 0.00 (0.71)[g] | 46.30 (42.88)[cd] |
| **$T_{15}$** - Cut pseudostem pieces (placed horizontally ) | 2.42(1.71)[a] | 16.91 (4.17)[a] | 23.61 (29.07)[a] |
| **$T_{16}$** - Vertical/stump pseudostem trap | 0.74 (1.11)[b] | 5.17 (2.38)[b] | 33.41 (35.30)[b] |
| **$T_{17}$** - Pseudostem Without splitting | 0.19 (0.83)[c] | 1.32 (1.34)[c] | 43.74 (41.40)[c] |
| **S. Em ±** | 0.03 | 0.04 | 0.13 |
| **CD at 5%** | 0.08 | 0.11 | 3.70 |

*Values in the parentheses are $\sqrt{x + 0.5}$ transformed values and **Figures in parentheses are arc sine transformed values

Likewise, the pooled data on number weevils per trap/week indicated significantly maximum number of weevils registered in treatments $T_{15}$-placingcut pseudostem pieces horizontally at the base of the plant (16.91) followed by$T_{16}$ -vertical/ stump pseudostem trap (5.17) and $T_{17}$ -pseudostem trap alone withoutsplitting (1.32) trapping methods. The number of weevils trapped/trap/week was 0.00 to 0.67 in treatments from $T_1$ to $T_{14}$ with synthetic aggregation pheromones. The per cent infestation of BPW was much lower i.e., 23.61 and 33.41 in treatments $T_{15}$ and $T_{16,}$ respectively (Table 4).

The comprehensive data suggests that the treatments placing cut pseudostem pieces horizontally at the base of the plant and vertical / stump pseudostem trap trapping methods were significantly superior in trapping the weevils and lower per cent infestation (Plate 2 a&b and Fig. 1). However, the superiority of these treatments may be attributed the host plant volatiles (semio-chemicals) as these volatiles released from the cut pseudostem area that attracts the weevils towards the food source and acting as attractant property. In other way these traps are utilized for monitoring the activity and the trapped weevils are collected manually daily and killed. Further, split pseudostems have added advantage as these may also be used to deliver the entomopathogenic fungi such as *B. bassiana* and *M.anisopliae*. Overall, these treatments could be advantageously used to manage the BPW, as these are ecofriendly, economical and most convenient to the farmers for better utilization of pseudostems after harvest.



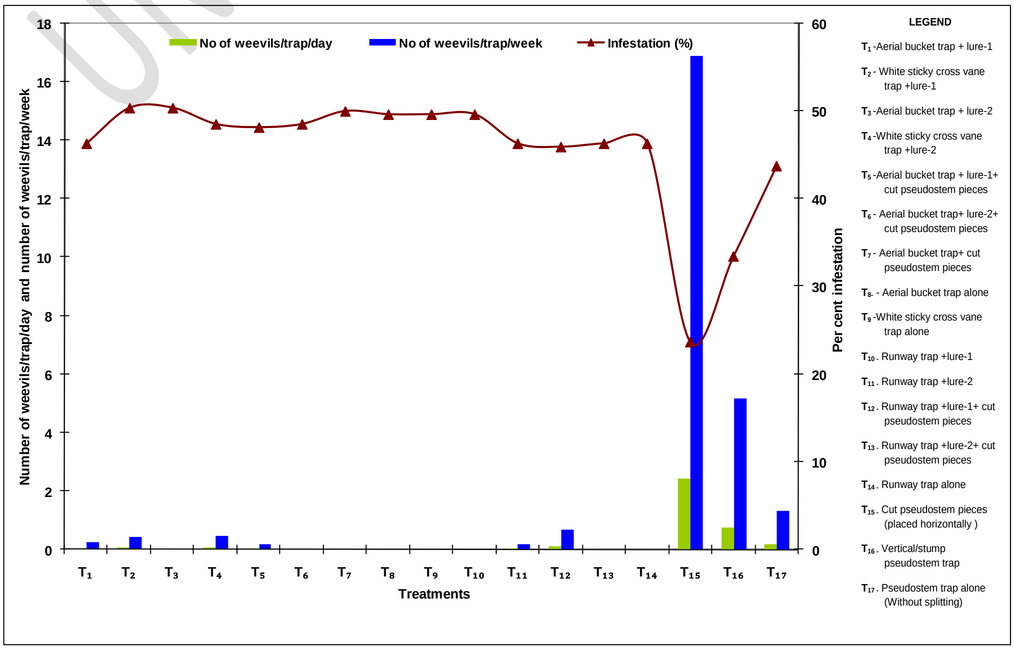

**Fig. 1: Evaluation of different trapping devices and lures to trap the BPW**

A. Aerial bucket trap

B. White sticky cross vane trap

C. Runway trap

D. Banana cut pseudostem trap

D. Pseudostem trap without splitting

E. Vertical/stump pseudostem trap

**Plate 1. Different traps used for evaluation against banana pseudostem weevil, *O. longicollis***

A. Cut pseudostem trap — Weevils trapped (Ventral view)

B. Vertical/ Stump pseudostem trap — Weevils trapped (Dorsal view of the trap)

**Plate 2. Weevils trapped in different trapping techniques**



To support the current findings related to traps using aggregation pheromones, there is limited documented literature under field conditions, with only one or two studies addressing this approach. In contrast, numerous researchers have investigated the use of live pseudostem traps, and their findings have been published in scientific journals. The present results are discussed in relation to these earlier studies. For instance, adult weevils were more strongly attracted to freshly cut pseudostem traps, where they were manually collected and killed, effectively reducing pseudostem weevil infestations (Kung, 1955; 1964). Koppenhöfer *et al*. (1994) demonstrated that one-week-old cut banana pseudostem traps were more attractive to adult banana weevils and resulted in a 50% reduction in the weevil population through trapping. Similarly, Gold *et al*. (2001) used split pseudostem traps for both monitoring and managing pseudostem weevils in Uganda. Supporting the present findings, Padmanabhan *et al*. (2002) reported that disc-on-stump and longitudinally split pseudostem traps were more effective for monitoring and reducing weevil populations, likely due to greater exudation of plant fluids that attract the weevils. However, contrary to these results, Palanichamy *et al*. (2011) found that funnel traps baited with a combination of aggregation pheromone (2-methyl-4-heptanol) and host plant extract captured significantly more weevils than traps using either component alone. They concluded that semiochemical-based trapping plays a significant role in weevil management and holds great potential for use in mass trapping or as part of integrated pest management (IPM) strategies.

On the contrary, Bulifu *et al*. (2019) evaluated various trapping systems for managing *Odoiporus longicollis* and found that horizontal split and vertical cut pseudostem traps were the most effective for capturing adults of both *Cosmopolites sordidus* and *O. longicollis*. Similarly, Manikannan *et al*. (2020) demonstrated that longitudinally split banana pseudostem traps are effective for both monitoring and mass trapping of banana weevils in field conditions. Tumuhaise *et al*. (2003) reported that applying *Beauveria bassiana* formulated with cracked maize to split pseudostem and corm traps resulted in 50% and 60% mortality of weevils, respectively. Further, Irulandi *et al*. (2012) evaluated pseudostem traps smeared with *B. bassiana* (25 g/trap) and observed a 56.75% reduction in *O. longicollis* infestation. In the present study, emphasis was placed on the use of horizontal split pseudostem traps and vertical stump traps for the attraction and capture of banana pseudostem weevils. These trapping systems not only facilitate pest population monitoring but also hold promise as delivery mechanisms for entomopathogenic fungi, contributing to the sustainable and eco-friendly management of *O. longicollis* within an Integrated Pest Management (IPM) framework.

The present investigation was conducted to evaluate the efficacy of two synthetic aggregation pheromonesnamely, 2-methyl-4-heptanol (L-I) and a blend comprising diphenylamine, 1-hexadecene, and hexadecane (L-II)in attracting weevils under field conditions. These pheromones were tested using three different trap designs namely aerial bucket traps, white sticky cross vane traps, and runway traps. The lures were evaluated both individually and in combination with cut pseudostem pieces as additional attractants. The study revealed that white cross vane traps baited with pheromone lures did attract weevils, the insects were observed to escape after initial contact, indicating a failure in trap retention. In another scenario, traps containing the aggregation pheromone lure and pseudostem pieces attracted only a small number of weevils, averaging between 1 to 3 individuals per trap. This suggests that there was a measurable attraction to the source but effective retention of the weevils within the trap was not achieved. Furthermore, traps baited with synthetic pheromone lures alone, pseudostem pieces alone or their combination failed to attract any weevils in certain instances. This lack of efficacy could be attributed to several factors, may include Inefficient trap design, Improper trap positioning, Inadequate lure concentration, Unsuitable trap height etc., of these parameters are likely contributing to the low capture rates and poor retention observed during the field trials. The results underscore the importance of optimizing both chemical lures and mechanical trap design to enhance weevil attraction and successful trapping under real-world conditions.

As a part of trap and lure standardization Riedler and Loher (1980) conducted an experiment and reported to reduce the variability in performance of traps which supports the present findings. On the contrary, Tinzaara *et al.* (2005) reported insights into the factors influencing trap efficiency are essential for developing effective pheromone trapping systems. Hence, there is a need to optimize and establish pheromone trapping plans including the trap design, trap height, trap placement (e.g., trap height, position and density) and influence of weather (e.g., temperature, wind speed and rainfall) on trap catches, effect of pheromone release rate and continuity of synthetic pheromone on attraction of weevils. Mass trapping is appropriate for weevils because of their long life cycle and adult longevity and reliance on aggregation pheromone and host volatiles. This ultimately reduces the amount of insecticides required for the control and due to its specificity also increases the efficiency of beneficiary insects in the field. In addition, the pheromone traps can be used for monitoring the population trends of *O. longicollis* and for evaluating the effects of control measures. The results of the present study finally open up the possibility that these aggregation pheromones can be used in development of mass trapping techniques as a viable alternative for the management of banana pseudostem weevil, *O. longicollis*. However, before arriving the conclusion further studies can be suggested such as large-scale cage and field trapping studies.

**Conclusion:**

This study evaluated various trapping methods for managing Banana Pseudostem Weevil (BPW) in Sugandhi banana cultivation. Among the different methods tested, horizontally placed cut pseudostem traps and vertical stump traps proved most effective due to the attractant properties of host plant volatiles. These eco-friendly and low-cost traps not only helps in monitoring but can also serve as carriers for biocontrol agents like *B. bassiana* and *M. anisopliae*. While pheromone traps showed mixed results, their combination with host plant materials enhanced weevil attraction. Traps baited with aggregation pheromone *2 - methyl - 4 - heptanol*, alone or in combination with host plant extracts have shown significantly higher catches when pheromone and host plant are used together than either alone. However, Trap design, placement, moisture, and their maintenance significantly influenced effectiveness. Further research on optimal trap density, integration with other control strategies and region-specific factors will enhance the practical utility of these methods for sustainable BPW management in Sugandhi banana cultivation.

**Compliance with ethical standards**

**Conflict of interest:** Authors do not have any conflict of interests to declare.

**Ethical issues**: None.

**Declaration of generative AI and AI-assisted tech-nologies in the writing process**

During the preparation of this work the author(s) used Grammarly (free version) to improve the language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.



**REFERENCES:**

Biswas, D, Banerjee., A. & Bandyopadhyay., B., (2015). Studies on incidence pattern of banana pseudostem weevil, *Odoiporus longicollis* Oliv. under Gangetic tracts of West Bengal. *J Crop Weed*, 11, 161.

Bulifu., Qiang. Li., Haiyan. Qiu., Liangde. Tang., Xin. Zhang. & Kui. Liu., (2019). *Int. J. Trop. Insect Sci*., **7**(3), 47-54.

Chowdhury., S.K., (2015). Study on major insect pests and major diseases of banana of Malda, West Bengal, India. *Indian J Appl Res*, 5, 607.

Gold, C.S, Okech, S.H. & Nokoe, S., (2002). Evaluation of pseudostem trapping as a control measure against banana weevil, Cosmopolites sordidus (Coleoptera: Curculionidae) in Uganda. *Bull Entomol Res*, 92, 35.

Gold, C. S., Pena, J. E. & Karamura, E. B., (2001). Biology and integrated pest management for the banana weevil, *Cosmopolite ssordidus* (Germar) (Coleoptera:Curculionidae), *Int. Pest Manage.Rev.*, 6, 79-155.

Irulandi, S., Aiyanathan, E. A.K. & Bhuvaneswari, S. B. S., (2012). Assessment of biopesticides and insecticide against pseudostem weevil *Odoiporus longicollis* Oliver in red banana. *J. Biopest*,5, 68-71.

Koppenhofer, A.M., Seshu, Reddy, K.V. & Sikora, R.A., (1994). Reduction of banana weevil populations with pseudostem traps. *Int J Pest Manage*, 40, 300.

Kung, K. S., (1955). The banana stem borer weevil *O. longicollis* Oliv. *In Taiwan. J. Agric. Taiwan*, 4,80-113.

Kung, K.S., (1964). Ecological studies on banana stem borer weevil *Odoiporus longicollis* Olivo. *J. Agric. Taiwan,* 11, 137-160.

ManiKannan., Padmanaban., B., Kammatterikunnu. A., Narayanan. B. & Subbaraya. Uma., (2020). Examining the trapping efficiency of different coloured light emitting diodes in combination with the host plant for monitoring and managing banana weevils. *Curr. Sci.*, 119, 10.

Palanichamy, S., Padmanaban, B., Mohamed, M.I.F. & Mustaffa, M.M., (2011). A simple and low cost semiochemical based trapping method for the management of banana pseudostem weevil, *Odoiporus longicollis* Olivier (Coleoptera: Curculionidae). *Adv. Appl. Sci. Res.,* 2 , 69.

Padmanaban, B. & Sathiamoorthy, S., (2002). Present status of banana stem weevil in India. *Global conference on banana and plantain,* Bangalore. 178.

Riedler, H. & Loher, W., (1980). Circadian control of oviposition in the codling moth, *Laspeyresia pomonella* (Lepidoptera: Olethreutidae). *Ent. Exp. Appl.,* **27**,38-49.

Sivakumar. T., Jiji, T. & Sheela, M.S., (2014). Report of banana pseudostem weevil (*Odoiporus longicollis* Olivier) infestation on leaf petiole. *Entomon*, 39, 111.

Tinzaara, W., Gold, C. S., Dicke, M., Van Huis, A. & Ragama, P. E., (2007). Host plant odours enhance the responses of adult banana weevil to the synthetic aggregation pheromone Cosmolure. *Inter. J. Pest Manag.,* **53**, 127 – 137.

Tiwari, S, Thapa, R.B., Gautham, D.M. & Shrestha, S.K., (2006). Survey of banana stem weevil, *Odoiporus longicollis* (Oliv.) (Coleoptera: Curculionidae) in Nepal. *J Inst Agric Anim Sci*, 27, 127.

Tumuhaise, V., Nankinga, C. M., Gold, C. S., Kyamanywa, S., Tushemereirwe, W. K., Ragama, P., Moore, D., Gowen, S. R., Moore, D. & Gowen, S. R., (2003). Kairomone trapping for delivery of *Beauveria bassiana* to control the banana weevil, Cosmopolites sordidus (Germar). *African Crop Science Conference Proceedings,* 6: 346-351.