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RESEARCH

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Population dynamics of Fall Army Worm [(*Spodoptera frugiperda*) J.E. Smith] (Lepidoptera: Nuctuidae) in maize-cassava intercrop using pheromone traps in Niger Delta Region

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Abstract

Background: This study was conducted to generate baseline information on population dynamics of Fall Army Worm (FAW) in cassava-maize intercrop for management technique. Maize (*Zea mays*) is Africa's most staple food crop with pest complex as major constraints to its production. The study was carried out at the Abuja Campus of the University of Port Harcourt, Faculty of Agriculture Teaching and Research Farm. A plot size of 3298 m^2 was cleared and ploughed; afterward, thirty six (36) ridges were made for the planting. Three varieties of maize grains (a hybrid Oba Super 98, white and yellow locals) were used for the study. Two cropping patterns (Sole maize and Cassava-Maize.-Intercrop) as main factor with a total of 18 sole and 18 intercrop plots and pheromone trap heights (at 1 m and 1.5 m) as sub-factor were used. The traps were mounted 18 days after planting and insect collection commenced at dawn the following day. FAW data in each trap were collected daily between 06.00 and 07.00 h. Maize cobs, fresh and dry weights, numbers of FAW exit holes, tunnels and tunnel lengths were recorded for both cropping patterns in each maize variety. Data were subjected to two-way analysis of variance.

Results: The results show higher mean value of FAW count in pheromone trap height placed at 1.5 m, and Oba super 98 maize variety intercropped with cassava had higher FAW count. There were significantly higher ($P < 0.05$) FAW exit holes in maize with pheromone trap height placed at 1.5 m, and maize-cassava intercrops had higher mean values of FAW exit holes. Number of tunnels and tunnel lengths (cm) due to FAW infestation were higher in maize varieties where pheromone traps were placed at 1.5 m.

Conclusion: Intercropping maize with cassava may suggest increase in FAW bionomics and the presence of abundant host which might increase a spike in its peak period of infestation. The presence of cassava in maize-cassava cropping pattern encourages feeding and/or oviposition of FAW on maize plant; therefore, an alternative cropping pattern should be encouraged in the region.

Keywords: Pheromone, *Spodoptera frugiperda*, Cropping pattern, Trap, Population dynamics

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Background

Population dynamics of various organisms particularly insects are of great concern since change in population size affects human, health, ecosystem services and the quality of aquatic and terrestrial life (Schowalter 2011). Insect population varies with response to changes in ecological conditions which is critical in determining species population (Schowalter 2011). Maize (*Zea mays*) is Africa's most staple food crop (FAO 2009; Ado et al. 2010) and ranks third after millet and sorghum in Nigeria (Uzozie 2001; FAO 2010). Pest is major constraints to its production and infestation starts from the field to store with varying levels of infestation depending on the agro-climatic conditions (Zakka et al. 2014), and the yield capability of maize is enormously influenced by insect invasion (Sosan and Daramola 1991; Ndemah and Schulthess 2002; Kfir et al. 2002).

Cassava (*Manihot esculenta*) is widely cultivated in tropical and subtropical areas for its tuberous root highly valued as sources of carbohydrates. Cassava has been accounted for to be a significant staple food in the diet of large proportion of people across the globe (Fauquet and Fargette 1990). Some of the general pest of cassava includes cassava mealy bugs, cassava green mites, variegated grasshopper, termites, whiteflies, cassava white scale and mite. These pests affects the leaves, stem and root of the plant (FAO 2013; IITA 2016).

The Fall Army Worm (FAW) *Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae) is a native to the Americas and a key pest of maize (*Z. mays* L.) (Abraham et al. 2017; Boaventura et al. 2020). It feeds in great numbers on the leaves, stems and reproductive regions of more than 350 plant species causing major damages to maize and a considerable number of other crops which includes cultivated grasses (such as rice, sorghum, sugarcane and wheat) vegetable crops and cotton throughout the Americas (Abraham et al. 2017; Ganiger et al. 2018). *S. frugiperda* is an invasive alien species in Africa particularly in Nigeria, Sao Tome, (Georgen et al. 2016) and subsequently in Benin and Togo (Nagoshi et al. 2017). FAW attacks major cereals in Nigeria but has much preference to maize and when left unchecked is capable of causing severe economic yield loss in maize (Day et al. 2017; Rwomushana et al. 2018).

Pheromones are volatile organic molecules produced and released by insect that evokes a behavioral response from individuals of a like species (Phillips 1997; Ayasse et al. 2001; Abd El-Ghany 2020). There are different behaviorally functional groups of pheromone released by insect for communication such as trail, aggregation, alarm, maturation and sex pheromone (Billen and Morgan 1998; Tillman et al. 1999; Abd El-Ghany 2020). Sex pheromones are attractants released mainly by female insect to attract males of same species for mating (Sufyan et al. 2013). They have been used in insect pest management for the identification of pest, mass trapping and mating disruption (Kloosterman and Mager 2014). Pheromone-baited traps such as a sticky board, bucket, funnel, Delta are used to catch insect pests both in the field and in storage (Kloosterman and Mager 2014). The study was aimed at generating baseline information for possible integrated management of FAW pest in cassava-maize intercropping pattern using pheromone traps placed at different heights.

Methods

Study area

The research was carried out at the Abuja Campus of the University of Port Harcourt, Faculty of Agricultural Science Teaching and Research farm located on latitude 4° 54′ 9 N and longitude 6° 55′ 13 E with an elevation of approximately 20 m above sea level and an annual rainfall ranging from 2000 to 2680 mm. The rainfall pattern was essentially bimodal with peaks in June and September while from April to August are periods of low precipitation. The mean monthly minimum and maximum temperatures ranged from 20 to 23 °C and 28 to 33 °C, respectively.

Land preparation/planting/agronomic practices

A plot size of 3298 m^2 was cleared and ploughed; afterward, thirty six (36) ridges were made for the planting. Three varieties of maize grains (an improved variety Oba Super 98 obtained from Agricultural Development Program (ADP), white and yellow locals purchased at Rumuokoro slaughter market all in Port Harcourt) were used for the study. Cassava variety TMS 1414 was planted at a distance of 1 m by 1 m and 2–3 maize seeds sown at a depth of 2–3 cm at a planting distance of 0.75 m × 0.25 m making a total of 20 plant stands on each ridge were used. Two cropping patterns (Sole maize and Cassava-Maize intercrop) as main factor with a total of 18 sole and 18 inter crop plots and pheromone trap heights (at 1.0 m and 1.5 m) as sub-factor were used. Each variety was replicated three times in a randomized complete block design (RCBD) experiment. The maize plants were thinned after 14 days to one plant per stand. Fertilizer was applied in split at a total of 60 kgN and 60 kgP_2O_5 ha^{-1} as recommended (ICAR 2006). Regular agronomic practiced was carried out as recommended by ADP Rivers State.

Mounting of pheromone traps

The sex pheromone of FAW was placed at the centre of a white triangular Delta trap with a sticky pad manufactured by Koppert Biological Systems Company, USA. The pheromone contained an active ingredient 97% (Z)-9-tetradecenyl acetate (z-9-14:Ac), 2% (Z)-7-dodecenyl acetate (Z7–12:Ac) and 1% (Z)-9-dodecenyl acetate (Z9–12:Ac), prepared by Russell IPM with batch number 69/5094, labeled and marketed with the trade name *S. frugiperda* PH-869-1PR. The traps were mounted at two different heights (1.0 m and 1.5 m) on a bamboo stick

18 days after planting and insect data collection commenced the following day up to the 35th day. Trap sticky bottom was changed every 7 days, while the lure was changed fortnightly.

Data collections

Data collection of the (FAW) caught by the pheromone-baited trap was done daily between 06.00 and 07.00 h, and all insects seen in each trap were counted and removed from the traps. Cobs were harvested at maturity, and fresh weights of the maize ear for each cropping pattern were weighed using electronic kitchen scale (Starfrit model 93016) and recorded. The cobs were left to dry for 25 days under an open shade and the dry weights of the ear, husk, cobs and empty cobs were taken using same scale. Numbers of FAW exit holes and tunnels found in the stems of the maize were counted and recorded. Tunnel lengths were measured using 30 cm rule and thread, and the values were recorded for both cropping patterns of the maize varieties.

Data analysis

The data collected were entered and stored in a spreadsheet of Microsoft Excel and subjected to analysis of variance (ANOVA), using SPSS Version 20.0 statistical packages. Significant means were separated using Tukey test, standard errors, and others for result interpretations.

Results

Pheromone trap placed at 1.5 m trapped had more FAW (Table 1). Oba super 98 maize variety intercropped with cassava had higher FAW counts which was followed by white maize variety planted as a sole crop both at pheromone trap height of 1.5 m, while the least FAW counts were found in Oba super 98 maize variety in a sole cropping pattern at pheromone height of 1.5 m. The result also shows mean number of FAW exit holes in maize cultivated as sole and intercropped with cassava with pheromone traps placed at 1.0 m and 1.5 m heights. There were significantly higher FAW exit holes in maize variety with pheromone traps height at 1.5 m, conversely, local maize varieties (white and yellow) cultivated in cassava intercropping pattern had higher exit holes, and the least was in sole yellow local variety.

Severity of damage as a result of Fall Army Worm infestation in MCi cultivated in Niger Delta Region under two pheromone trap heights as a means of determining population dynamic is shown in Table 2. The number of tunnels and tunnel lengths (cm) due to FAW infestation

Table 1 Fall Army Worm counts and Exit holes in Maize-Cassava intercrop cultivated in Niger Delta Region using two pheromone traps

Infestation level	Pheromone trap height	Sole Maize variety			Cassava-Maize variety Intercrop			Mean ± SD
		OBA Super 98	White Maize	Yellow Maize	OBA Super 98	White Maize	Yellow Maize	
FAW count	1 m	1.00 ± 0.48	0.20 ± 0.27	1.00 ± 0.43	0.80 ± 0.45	0.60 ± 0.43	0.60 ± 0.23	0.52 ± 0.21
	1.5 m	0.00 ± 0.00	1.20 ± 0.55	0.60 ± 0.23	2.20 ± 0.71	1.00 ± 0.48	0.60 ± 0.33	0.68 ± 0.11
	Mean ± SD	0.50 ± 0.47	0.70 ± 0.45	0.80 ± 0.35	1.50 ± 0.61	0.80 ± 0.18	0.60 ± 0.04	
Exit holes of FAW	1 m	4.33 ± 1.31	5.33 ± 1.41	7.87 ± 1.70	3.60 ± 1.32	7.93 ± 1.50	7.27 ± 1.58	5.51 ± 1.21
	1.5 m	2.87 ± 0.79	3.00 ± 0.65	0.6 ± 0.11	10.40 ± 2.97	18.60 ± 4.65	22.93 ± 2.01	9.17 ± 1.26
	Mean ± SD	3.60 ± 1.04	4.17 ± 1.00	4.23 ± 1.30	7.00 ± 1.32	13.27 ± 1.70	15.10 ± 1.71	

Table 2 The mean ± SD effect of cropping pattern and maize variety on the number of tunnels and tunnels length caused by Fall Army Worm on maize cultivated in the Niger Delta Region of Nigeria under two pheromone trap heights as a means of determining population dynamics

Damage level	Pheromone trap height	Sole Maize variety			Cassava-Maize variety Intercrop			Mean ± SD
		OBA Super 98	White Maize	Yellow Maize	OBA Super 98	White Maize	Yellow Maize	
No. of tunnel	1 m	1.73 ± 0.17	3.07 ± 0.74	3.33 ± 0.47	1.60 ± 0.67	3.73 ± 1.35	3.13 ± 1.09	2.33 ± 1.19
	1.5 m	1.80 ± 0.47	2.40 ± 0.45	0.67 ± 0.30	4.67 ± 1.09	5.80 ± 1.31	5.80 ± 1.41	2.83 ± 0.95
	Mean ± SD	1.77 ± 0.32	2.73 ± 0.84	2.00 ± 0.39	3.13 ± 0.79	4.77 ± 1.83	4.47 ± 175	4.21 ± 0.23
Tunnel length	1 m	4.89 ± 1.38	7.06 ± 2.57	7.45 ± 1.76	4.83 ± 1.90	7.61 ± 2.44	4.12 ± 1.55	5.65 ± 1.04
	1.5 m	5.57 ± 1.65	7.63 ± 1.46	3.75 ± 1.35	12.31 ± 1.63	11.88 ± 2.75	12.27 ± 2.94	8.42 ± 2.21
	Mean ± SD	5.23 ± 1.52	7.35 ± 1.02	5.60 ± 1.56	8.57 ± 1.27	9.75 ± 2.52	8.20 ± 1.75	7.21 ± 1.13

on the stem of different maize varieties cultivated under maize-cassava intercrop with pheromone traps heights at 1.0 m and 1.5 m indicated that the highest number of stem tunnels and tunnel length were recorded in maize-cassava intercrop cropping pattern, while number of tunnels and tunnel length of FAW in maize intercropped with cassava were higher in maize varieties where pheromone traps were placed at 1.5 m. Significantly, higher number of FAW tunnels were recorded in yellow and white maize intercropped with cassava, while the least number of FAW tunnel was recorded in sole yellow maize where pheromones traps were placed at 1.5 m height. Similar results were obtained for FAW tunnel length.

Table 3 shows that maize fresh weights (g) of different maize varieties cultivated in a maize-cassava intercrop technique under FAW infestation in Niger Delta region at two pheromone trap heights were higher in maize varieties with a pheromone traps placed at 1.5 m and the least in maize-cassava intercropped with pheromone traps placed at 1.0 m. The result also shows that Oba super 98 intercropped with cassava had higher maize fresh weight, while sole white maize recorded the least fresh weight. Interaction between maize varieties and pheromone heights showed that yellow maize intercropped with cassava with pheromone trap height at 1.5 m had the highest fresh weight followed by white maize in the same cropping pattern and pheromone trap height, while yellow maize in cassava intercrop had the least fresh weight followed by sole maize cultivated where pheromone trap was placed at 1.5 m.

Table 4 shows the results of the various yield and yield components of maize intercropped with cassava and pheromone traps placed at two different heights to traps to determining FAW population dynamics. Maize ear weight was significantly higher in maize cultivated where pheromone traps were placed at 1.5 m. Yellow maize intercropped with cassava had higher ear weight followed by Oba super 98 both cultivated under intercrop pattern and pheromones traps placed at 1.5 m height, while the least maize ear weight was recorded in a sole maize with pheromone trap placed at 1.5 m. Interaction between maize variety and pheromone heights shows that yellow maize intercropped with cassava had higher ear weight followed by white maize in the same cropping

Table 3 The mean ± SD effect of cropping pattern and maize variety on the fresh weight of maize cob cultivated in the Niger Delta Region of Nigeria under two pheromone heights as a means of determining FAW population dynamics

Infestation	Pheromone trap height	Sole Maize variety			Cassava-Maize variety Intercrop			Mean ± SD
		OBA Super 98	White Maize	Yellow Maize	OBA Super 98	White Maize	Yellow Maize	
Fresh weight	1 m	119.33 ± 26.16	92.67 ± 8.89	80.13 ± 13.12	176.33 ± 15.72	15.13 ± 7.28	6.67 ± 2.01	82.13 ± 14.31
	1.5 m	81.13 ± 14.43	13.60 ± 3.44	43.60 ± 21.00	62.93 ± 14.26	191.20 ± 16.44	212.40 ± 28.89	102.21 ± 12.17
	Mean ± SD	105.23 ± 18.30	53.13 ± 15.17	61.87 ± 17.31	119.63 ± 19.49	103.17 ± 14.36	109.53 ± 15.45	

Table 4 Yield and yield components of dry maize grains in maize-cassava cropping pattern infested by Fall Army Worm cultivated in the Niger Delta Region of Nigeria under two pheromone heights as a means of determining population dynamics

Maize data	Pheromone trap height	Sole Maize variety			Cassava- Maize variety Intercrop			Mean ± SD
		OBA Super 98	White Maize	Yellow Maize	OBA Super 98	White Maize	Yellow Maize	
Ear weight	1 m	40.87 ± 15.95	29.13 ± 13.68	29.27 ± 11.68	69.80 ± 17.65	2.40 ± 2.15	2.20 ± 3.03	28.54 ± 11.28
	1.5 m	38.00 ± 7.51	4.47 ± 1.68	14.00 ± 9.24	17.40 ± 2.85	76.87 ± 12.30	93.67 ± 13.34	40.93 ± 13.16
	Mean ± SD	39.43 ± 6.73	16.80 ± 5.68	21.63 ± 6.46	43.60 ± 12.25	39.63 ± 11.73	47.93 ± 12.19	
Husk weight	1 m	10.80 ± 3.23	11.60 ± 2.42	9.87 ± 9.40	19.27 ± 6.27	1.40 ± 2.92	0.87 ± 0.47	8.28 ± 3.89
	1.5 m	15.87 ± 2.98	1.27 ± 0.26	6.07 ± 2.84	8.80 ± 2.03	21.53 ± 11.49	31.47 ± 2.85	13.87 ± 3.79
	Mean ± SD	13.33 ± ± 2.12	6.43 ± 1.54	7.97 ± 3.62	14.03 ± 5.65	11.47 ± 2.71	16.17 ± 2.16	
Cob weight	1 m	30.07 ± 12.10	17.53 ± 9.62	19.47 ± 1.66	50.53 ± 2.89	1.00 ± 0.30	1.33 ± 0.64	19.72 ± 6.94
	1.5 m	22.13 ± 10.15	3.20 ± 1.30	7.93 ± 4.67	8.60 ± 4.65	55.33 ± 17.27	62.20 ± 13.48	26.98 ± 18.80
	Mean ± SD	26.1 ± 11.63	10.37 ± 2.96	13.70 ± 7.14	29.57 ± 11.27	28.17 ± 16.79	31.77 ± 18.56	
Empty cob weight	1 m	12.80 ± 3.72	10.27 ± 3.86	9.07 ± 2.47	15.87 ± 3.84	1.00 ± 0.30	0.73 ± 0.84	8.21 ± 3.66
	1.5 m	11.00 ± 2.15	1.40 ± 0.58	6.00 ± 2.23	3.87 ± 1.60	21.20 ± 11.45	23.80 ± 11.47	11.21 ± 1.17
	Mean ± SD	11.90 ± 2.94	5.83 ± 1.72	7.53 ± 1.35	9.87 ± 2.72	11.10 ± 3.88	12.27 ± 3.66	

pattern, and the least was recorded in yellow maize with a pheromone trap placed at 1.0 m height. Similar results were recorded for husk weight. Interaction effect of pheromone trap heights and maize variety under different cropping pattern shows that yellow maize intercropped with cassava with pheromone trap height of 1. 5 m had higher cob weight which was closely followed by white maize under same cropping pattern, and the least cob weight was recorded in white maize intercropped with cassava but with pheromone traps placed at 1.0 m which was followed by yellow maize in the same cropping pattern. Similar results were obtained for empty cob weight.

Discussion

The utilization of the pheromone trap in this investigation to determine FAW population dynamics was a suitable tool as propounded by Knodel and Petzoldt (1995) and Nandagopal et al. (2008) that pheromone is an excellent tool for monitoring pest populations, suppressing and timing of management procedures Thomas 2008). It also enhances the ability for early detection, establishing baseline data for action thresholds/decision support, mapping pest distribution, quarantine inspection, estimation of population dynamics, prevalence (Nandagopal et al. 2008) and reconnaissance and exploration (Mc Grath et al. 2018). Cruz et al. (2010) stated that utilizing pheromone is the best method for settling on the number of pesticide applications.

Fall armyworm is a key pest of maize (Abraham et al. 2017). This was affirmed in this investigation as adult FAW were caught in critical numbers. Rojas et al. (2004) revealed that traps get just adult male moths; however, the plant harm is caused by hatchlings and that it is not sufficient to just include moth numbers in the snares and disregard different factors, for example, temperature and harvest development stage and even common control. Likewise, that trap catches are also connected with wind speed and temperature, and contrarily, associated with relative moistness. The burrowing of the fall army worm into the stem of the maize plants results in exit holes on the stems and thus leading to severe damage thereby reducing movement of nutrient in the plants vascular system especially the photosynthate and minerals (Shana 2016). The result indicating higher FAW exit holes and tunnel length in maize varieties cultivated under maize cassava intercrop (MCi) with a pheromone trap placed at 1.5 m shows the degree of severity of damage suffered under the cropping pattern. This could be attributed to the presence of cassava which may have served as an alternative host (FAO 2018) and modified microclimate thus making it suitable for continuous breeding (Cabi 2017) especially at larval stage where they burrow into soil causing damages to seedlings (Cruz 1995). However, the result was at variance with Afrin et al. (2017) that aphid infestation in intercropped mustard seed and attributed it to improved biodiversity and communications among plants and arthropods thereby creating a conducive agro-ecological system which may enhance proper nutrient uptake, high compensatory mechanism and ability to withstand insect pest infestation (Echezona and Nganwuchu 2006). The variation could also be due to suitability of cropping system in the management of insect pest and selection of best companion crops (Afrin et al. 2017). Intercropping maize with cassava may suggest increase in FAW bionomics although Adeniyan et al. (2014) expressed its advantage of having high total productivity per unit land area. FAW is a generalist feeder and can thrive on large group of plants families (Yu et al. 2003; Rojas et al. 2004; Wychkhuys and O'Neil 2006) and the presence of abundant host might increase a spike in its peak period of infestation (Vonny and Thomas 2009).

The number of tunnels and tunnel lengths due to FAW infestation on maize stem in both cropping systems with pheromone traps placed at two different heights may suggest the degree of damage attributed to FAW on the different maize varieties. Therefore, the infestation expressed in either tunnel length or number or both may have translated to grain yield loss as observed by Chouraddi and Mallapur (2017) as an important parameter for assessing intensity of damage, dead hearts and stunting growth to maize (Mohyuddin and Attique 1978). Such loss attributed to FAW infestation could potentially reduce crop yields by 21–53% in tropical African countries (Maes 2018) and could translate to over $13 billion loss in the continent (All Africa 2018; Kebede 2018; Tamakloe 2018). However, the results showing higher yield and yield performance of maize in MCi above sole cropping pattern concurs with Ibrahim (1998) that intercrop improves agronomic practices and is the dominant cropping pattern among peasant farmers in Nigeria and reduces risk aversion, extensive and intensive use of resources (land and labor), greater return per unit land area, reduction in pest and diseases and the possible improvement of soil fertility and complements resources in time and space among different species (Guo et al. 2016). Although Adeniyan et al. (2014) reported an increase in plant population density of maize intercropped with cassava may lead to lodging percentage and reduced stalk diameter, average cob weight, dry matter yield and grain yield although it may lead to increase agronomic parameters such as height at tasseling and height at harvest.

Spodoptera frugiperda in the study were observed on maize plants 24 h after the traps were set, indicated their presence around the maize crops as soon as the maize start forming whorls. Similar observation was made by Bokonom et al. (2003) that FAW larvae feed on young whorls, ears and tassels causing substantial damage to maize crops; also Harrison (1984) reported that plants at the early whorl stage and younger were preferred by FAW for oviposition and maize plants infested early in their development were less tolerant than plants infested later. Seshu-Reddy and Sun (1991) found a linear relationship between infestation and yield loss and that the extent of loss increased with earlier infestation. Ric (2004) advocated control measures where the egg masses are present on 5% of the plants or when 25% of the plants show damage symptoms and live larvae are still present. Since severe attack may lead to huge loss by the farmers (Barlow and Kuha 2012). Cruz and Turpin (1983) and Cruz et al. (1996) reported that, when 20% of maize plants in the mid-whorl stage of growth were infested with fall armyworm egg masses, yield reduced by 17–18%.

Conclusion

The pheromone trap was effective in the trapping of fall army worm (FAW), and its use in this agroecology zone for effective monitoring FAW invasion will be effective and economically if integrated in the management of FAW on maize plant. Pheromone traps in maize should be mounted at height range of 1.5 m for adequate catch during FAW surveillance and monitoring. Maize-Cassava intercrop system which has been a long tradition in the region should be revisited with caution since cassava plant was shown to significantly attract FAW for feeding and/or oviposition on maize plant; therefore, an alternative cropping pattern should be encouraged in the region.

Abbreviations

FAW: Fall Army Worm; ADP: Agricultural Development Programme; MCi: Maize-Cassava intercrop.

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Authors' contributions

NJAC and UZ conceived and performed the research; RBB read the manuscript and revised the final version and KEB supplied the pheromone and traps. All authors read and approved the final manuscript.

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Availability of data and materials

The pheromone contained an active ingredient 97% (Z)-9-tetradecenyl acetate (z-9-14:Ac), 2% (Z)-7-dodecenyl acetate (Z7–12:Ac), and 1% (Z)-9-dodecenyl acetate (Z9–12:Ac), prepared by Russell IPM with batch number 69/5094, labeled and marketed with the trade name *Spodoptera frugiperda* PH-869-1PR and can be obtained under the label details.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

We have no competing interests.

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