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COMPARATIVE EVALUATION OF NUTRIENT COMPOSTION AND FALL ARMYWORM INFESTATION IN ORGANIC AND INORGANIC MAIZE PRODUCTION SYSTEMS IN NDUME, SOUTH EASTERN NIGERIA.

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ABSTRACT

This study evaluated the comparative effects of organically and inorganically maize production systems on maize nutrient composition, yield and level of fall armyworm infestation on the maize plant during the 2023 cropping season at the National Forestry Research Institute located at Ahiaeke Ndume, in Umuahia North, South Eastern Nigeria. Five treatments were evaluated which included: Control (Sole Maize), maize with Poultry manure + chemical pesticide, maize with Chemical fertilizer + chemical pesticide, maize with Chemical fertilizer only and maize with Poultry manure + Neem extract. These were arranged in a Randomized Complete Block Design with 3 replications. Data was collected on growth performance, yield parameters, percentage infestation, and proximate and mineral composition of the maize grain after harvest. Data collected were analyzed using Analysis of Variance (ANOVA), and treatment means were separated using the Least Significant Difference (LSD) test at 5% probability level. Results from the study showed significant differences ($p \leq 0.05$) among treatments for the parameters assessed. Sole maize (control) recorded the highest infestation level (36.66), higher leaf damage (2.08), and higher insect count (7.80), which reduced yield and grain quality while organic treatments that combined botanical extracts with poultry manure, had significantly lower infestation (12.08), lower leaf damage (0.44), and lower insect count (2.20) which increased the grain yield and quality. Although other integrated treatments perfomed better than the control, the organic treatment outperformed them all. Also the nutrient composition of the maize grain performed better in the plots with organic treatments compared with every other treatment while the control which has no treatment gave the least nutrient compostion. It was observed that generally the control plot which had no treatment had poor performance compared with other treated plots and this was followed by plots treated with only chemical fertilizer. Plots with chemical inputs showed moderate performance in yield and lower nutrient component compared with the plots with organic treatments. This study demonstrates that organic management practices, particularly the integration of poultry manure and plant extracts can enhance maize productivity, improve grain nutritional quality and effectively reduce fall armyworm infestation and therefore should be adopted in the management of the maize fall armyworm.

KEYWORD: *Maize, Inorganic treatments, Organic treatments, Armyworm, Nutrient composition, Botanical extracts.*

INTRODUCTION

Maize (*Zea mays*), also known as corn, is a cereal grain first domesticated by indigenous peoples in southern Mexico about 10,000 years ago (Benz, 2001). Maize was introduced to West Africa by the Portuguese in the 10th century, and is among the ten most important world crops consumed (Macauley, 2015). In Nigeria, Maize is ranked as the second most important cereal. Despite the importance of maize, its average yield in Africa is one of the lowest in the world (Ragasa et al., 2014). Maize is one of the most important staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice (Serna-Saldivar, 2016). In addition to being consumed directly by humans, maize is also used for animal feed and other maize products, such as corn starch and corn syrup (Foley, 2019). Maize is also used in making ethanol and other biofuels according to the report of the International Grains Council, (2013). In sub-Saharan Africa especially in Nigeria, it plays a critical role in food security, rural livelihoods, and economic development. A greater weight of maize is produced each year than any other grain (Erenstein *et al.,* 2022). It accounts for 30-50% of low-income household expenditures in Africa. Over 300% of the caloric intake of people in Sub-Saharan Africa comes from maize (Iseki and Matsumoto, 2021). Despite the global significance of maize, its production is often threatened by pests and diseases, leading to significant yield losses. To mitigate these challenges, farmers employ various pest management strategies, including the use of organic and inorganic manure, chemical pesticides and plant extracts (Foley, 2019). While chemical pesticides have been widely used for their effectiveness, concerns have been raised about their potential environmental and health impacts, soil degradation, and food safety. On the other hand, plant extracts have gained attention as a more sustainable and eco-friendlier alternative for pest management. Nevertheless, the effects of these treatments on the nutritional composition of maize remain poorly understood. Nutrient compotion is a key determinant of maize quality, influencing its dietry value and suitability for human and animal consumption. Nutritional profile of maize including its protein, carbohydrate, mineral and vitamin content can be significantly affected by production system. Organic production systems are often associated with improved micro nutrient density and improved soil fertility. Despite the growing interest in sustainable agriculture, there is still limited comparative data on how different production systems such as organic and inorganic systems influence maize quality and yield. The understanding of these systems is a critical component for the development of balanced agricultural strategies that optimize yield, nutritional quality and environmental sustainability. Therefore the aim of this study is to comparatively analyse the nutrient composition and armyworm infestation in organic and inorganic maize production sysytems with a view to providing evidence based recommendation for a sustainable maize production.

MATERIALS AND METHODS

Experimental Site Description

The study was conducted at the National Forestry Research Institute Ahieke Ndume, in Umuahia North, Abia State, in the year 2023. It is located between latitude 5.54° N and longitude 7.52° E. The climatic conditions in Ndume include average annual temperatures ranging from 22.5°C to 36.2°C, a seasonal rainfall pattern with an average annual precipitation of 2153 mm, high humidity levels, and a specific photoperiod influenced by its geographical location. The rainy season is characterized by a bimodal rainfall pattern with peaks occurring in July and September, and a short dry spell of about three weeks between the peaks, known as the August break. Relative humidity varies between 75 and 90 %.

Agronomic Activities

The experimental field was measured using a meter tape. The area was manually cleared, and the plot marked out with each plot size measuring 3m x 3m. Then it was manually harrowed and ploughed using a hoe, and poultry manure was incorporated into the soil during ploughing. On the raised beds, planting was done using a local maize variety, Bende white, at 75 cm x 30 cm with direct seeding. Three seeds were directly sown into the soil at a depth of 3 cm, and thinning was done after seed germination. This gave a total of 40 stands per plot, and 10 plants per treatment were selected and tagged for data collection. Weeds were manually maintained until harvesting.

Experimental Design

A Randomized Complete Block Design was used in the study, with five (5) treatments which included: maize with Chemical fertilizer + chemical pesticide, maize with Chemical fertilizer, maize with Poultry manure + Neem extract, sole maize (control and maize with poultry manure and chemical pesticideall replicated three (3) times, and these gave 15 experimental plots. **2.4**

Sources of Treatments

Poultry manure was collected from the Livestock unit of Michael Okpara University of Agriculture Umudike. Chemical fertilizer (NPK 20:10:10) was collected from farm center of CCSS, Michael Okpara University of Agriculture Umudike. Neem leaves were collected from the Neem tree within the school environment while Maize seeds (Oba super 6) was bought from an agrochemical shop within the environment

Extract Preparation

The extracts were prepared according to (Nzanza and Mashela 2012). Matured and healthy neem leaves were obtained from Micheal Okpara University of Agriculture Umudike Environment. The leaves were air dried, ground using a blender, sieved, and stored in an airtight container, and kept ready for use for the experiment. Three weeks after maize germination, 100g of the plant powder material was measured using the Camry™ weighing scale in the laboratory unto which 1 litres of cold distilled water was added and then stirred and this was kept for 24 hours before application and thereafter, filtered through a 1.0 mm sieve into a plastic rubber and approximately 8g detergent was added as a sticking agent and was later transferred into a knapsack sprayer for immediate spraying in the maize field. Spraying was done early in the morning hours at a 2-week interval directly into the maize funnel and base.

Treatment application:
Poultry manure: was applied at the rate of 6 tons per hectare with equivalent weight of 2.7kg per 4.5 cm^2 plot.

Chemical Fertilizer (NPK 20:10:10) was applied at the rate of 220kg per hectare with equivalent weight of 99 g per 4.5 cm^2 plot using ring method of application

Inorganic pesticide Lambda-Cyhalothrin was mixed with a measurement of 2ml / Litre of water and applied with a hand held sprayer.
100g of neem powder was weighed and grinded after which it was sieved with 1 litre of water over night before application.

DATA COLLECTION

The following parameters were recorded:
The following data were collected: Insect count, Leaf damage, Cob number, Cob damage, and crop Yield at harvest. Data on proximate and mineral analysis were also carried out at The Laboratory of National Root Crop Research Institute Umudike and the following nutritional components were collected carbohydrate, protein, iron, sodium, magnessium etc.

Statistical Analysis

All the data collected were subjected to analysis of variance (ANOVA) using GenStat. Treatment means were compared using Least Significant Difference (LSD) at a 5% level of probability to determine statistically significant differences among treatments.

RESULTS

Effect of treatment on Infestation (%) of fall armyworm across weeks after planting

Table 1 presents the effect of treatment on Infestation (%) of fall armyworm across weeks after planting. Infestation percentage differs significantly at ($p \leq 0.05$) among treatments. The control (T1) consistently recorded the highest infestation level across the weeks, reaching a mean infestation of (37.66%) and this was followed by the plot with only chemical fertilizer (36.2). Application of poultry manure combined with neem extract resulted in the mean lowest infestation level throughout the growth stages (12.08). Infestation decreased from 20.00% at 4WAP to as low as 6.70% at 12WAP However other treated plots also recorded a significan lower infestation than the untreated plots but the plot with organic treatment performed better than all.

Table 1: Effect of Treatments on Percentage leaf Infestation

	Percentage	Infestation	at			
TREATMENT	**4WAP**	**6WAP**	**8WAP**	**10WAP**	**12WAP**	**Mean**
Control	40.00	43.30	48.30	51.70	53.30	37.66
Poultry manure + chem pesticide	21.70	18.30	15.00	10.00	10.00	15
Chemical fertilizer + chemical pesticide	25.00	20.00	18.30	11.70	11.70	17.34
Chemical fertilizer	30.00	25.00	34.00	45.00	47.00	36.2
Poultry manure + Neem extract	20.00	15.00	10.70	8.00	6.70	12.08
MEAN	**27.30**	**24.30**	**25.30**	**25.30**	**25.70**	
LSD $_{(0.05)}$	**7.64**	**7.36**	**4.01**	**5.89**	**5.56**	

Effect of treatment on leaf damage across weeks after planting.

Table 2 presents the effect of different treatments on leaf damage in maize over a 12-week period. The extent of leaf damage was monitored at 4, 6, 8, 10, and 12 weeks after planting (WAP), and the mean values for each treatment were compared. Leaf damage followed similar trend as was observed in leaf infestation. The control plot without treatment consistently recorded the highest leaf damage rating across the weeks and gave mean leaf damage rating of (2.08). This was followed by maize treated with chemical fertilizer (1.38). The other treated plots gave lower leaf damage rating but plots treated with poultry and neem extract recorded the least damage rating (0.44) among all. The LSD (0.05) values further confirm that the differences among treatments were statistically significant at different growth stages.

Table 2: Effect of treatment on leaf damage across weeks after planting

		Percentage	leaf	damage	at	
TREATMENT	4WAP	6WAP	8WAP	10WAP	12WAP	Mean
Control	1.50	1.80	2.10	2.50	2.50	2.08
Poultry man. + chem pesticide	0.70	0.60	0.50	0.40	0.30	0.5
	0.90	0.70	0.60	0.50	0.40	0.62
Chemical fert + chem pesticide	1.00	1.10	1.30	1.60	1.90	1.38
Chemical fertilizer	0.60	0.50	0.40	0.40	0.30	0.44
Poultry man + Neem extract	0.90	0.90	1.00	1.10	1.10	
MEAN	0.41	0.63	0.17	0.53	0.42	
LSD $_{(0.05)}$						

Effect of treatment on insect count (fall armyworm) across weeks after planting

Table 3 presents the effect of the treatments on insect count per plot across five observation periods (4–12 weeks after planting, WAP). The results revealed clear differences in insect population among the treatments. The control plots consistently recorded the highest insect counts, ranging from 6.00 insects per plot at 4 WAP to 9.00 insects per plot at 10–12 WAP. This resulted in the highest mean insect population (7.80), confirming the susceptibility of untreated maize to insect infestation under field conditions.

Table 3: Effect of Treatments on Insect count at 2, 4, 6,8, 10 and 12 Weeks After Planting

TREATMENT	Insect count Per plot at					
	4WAP	6WAP	8WAP	10WAP	12WAP	Mean
Control	6.00	7.00	8.00	9.00	9.00	7.80
Poultry manure + chem pesticide	4.00	4.00	3.00	2.00	2.00	3.00
Chemical fert + chem pesticide	5.00	4.00	3.00	2.00	2.00	3.20
Chemical fertilizer	5.00	5.00	6.00	5.00	7.00	5.67
Poultry man + Neem extract	4.00	3.00	2.00	1.00	1.00	2.20
MEAN	**4.80**	**4.60**	**4.40**	**3.90**	**4.30**	
LSD $_{(0.05)}$	**1.58**	**2.63**	**2.73**	**2.12**	**0.84**	

In contrast, plots treated with a combination of poultry manure and neem extract had the lowest insect counts throughout the experimental period. The insect population reduced progressively from 4.00 at 4 WAP to as low as 1.00 at 10–12 WAP, with an overall mean count of (2.20 counts). Similarly, the treatment involving poultry manure combined with chemical pesticide also maintained a lower insect populations (mean = 3.00). The insect count decreased steadily over time, from 4.00 at 4 WAP, reaching 2.00 at 10–12 WAP, demonstrating that integration of organic amendment with chemical control also enhanced fall armyworm suppression. Plots treated with chemical fertilizer plus chemical pesticide also performed well in reducing insect numbers from 5.00 at 4 WAP to 2.00 at 10 to 12 WAP with a mean count of (3.20). The sole application of chemical fertilizer was less effective in reducing insect infestation. The insect count fluctuated between 5.00 at 4 WAP and 7.00 at 12 WAP across the sampling periods, with a mean population of 5.67 although lower than the control, it still sustained higher pest pressure compared with the combined or integrated treatments with either neem extract or chemical pesticide.

Table 4: Effect of Treatments on Percentage Cob damage at harvest

Treatment	Percentage cob damage per plot
Control	41.00
Poultry manure + chemical pesticide	3.00
Chemical fertilizer + chemical pesticide	4.00
Chemical fertilizer	38.00
Poultry manure + Neem extract	2.00
MEAN	**5.60**
LSD $_{(0.05)}$	**2.92**

Figure 1 presents the effect of different treatments on maize plant height at 8 weeks after planting (WAP). The treatments demonstrated significant variation in plant height. The lowest plant height (89 cm) was observed in T1 (sole maize), which served as the control while the highest plant height (191 cm) was recorded under T2 (maize + chemical pesticide + poultry manure). And this was followed by the plot treated with neem extract and poultry manure though not significantly different at ($p \leq 0.05$). T3 (maize + chemical pesticide + chemical fertilizer) also produced comparatively tall plants (184 cm), showing that chemical fertilizer together with chemical pesticide can provide essential nutrients to sustain plant height however this does not guarantee healthy plant protection.

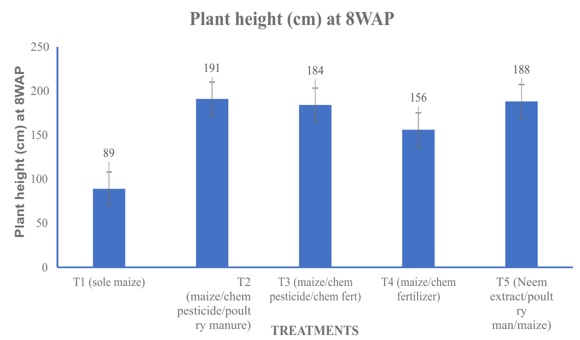

Fig 1 . Effect of treatment on plant height at 8 weeks after planting

T5 (Neem extract + poultry manure) supported robust plant growth (188 cm), performing better than plots treated with chemical fertilizer and chemical pesticide. This suggests that Neem extract in combination with poultry manure not only enhanced soil fertility but also reduced pest attack, thereby enhancing the plant growth. T4 (chemical fertilizer) recorded moderate plant height (156 cm), which, although greater than the control, was lesser compared to treatments that integrated organic manure

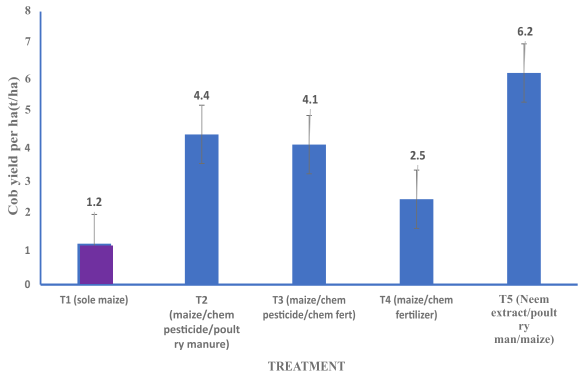

Figure 2: Effect of Treatments on Cob yield parameters

Figure 2 presents the effect of different treatments on cob yield per ton per hectare (t/ha). The results showed wide variation in cob yield across the treatments. Sole maize (T1) produced the lowest cob yield (1.2 t/ha**)**. Chemical pesticide plus poultry manure (T2) significantly improved cob yield (4.4 t/ha) and this was not significantly different from the yield of plots treated with chemical pesticide plus chemical fertilizer (4.1), however the highest yield was recorded with plots treated with poultry manure and neem extract (6.2 t/ha) while the lowest yield among the treatments was recorded with plots treated with only chemical fertilizer and this was not significantly different at ($p \leq 0.05$) from the untreated plots

Effect of treatments on proximate composition of harvested maize

Table.5 presents the effect of different treatments on the proximate composition of fresh corn, including moisture content (MC), dry matter (DM), ash, crude protein (CP), crude fiber (CF), fat, and carbohydrate (CHO). The results reveal significant variations across treatments, reflecting the influence of organic and inorganic pest management strategies on the maize crop. Among all the treatments (neem + moringa + poultry manure) produced grains with the highest nutrient values, including crude protein (14,47%) and this is higher than that of T2 and T3 which recoded (13.99 and 13.49) respectively while the lowest crude protein was recorded in the untreated plot (11.32) followed by plots treated with chemical fertilizer (12.55).

Table 5: Effect of treatments on proximate composition of harvested maize

Treatments	MC %	DM %	ASH %	CP %	CF %	FAT %	CHO %	Mean
Control	56.47	43.53	2.00	11.32	1.86	3.16	25.17	20.5
Poultry manure + chemical pesticide	44.61	55.39	3.42	13.99	3.05	5.29	29.63	22.2
Chemical fertilizer + chemical pesticide	47.66	52.34	2.55	13.49	2.54	4.44	29.31	21.8
Chemical fertilizer	49.94	50.06	2.34	12.55	2.24	3.61	29.32	21.4
Poultry manure + Neem extract	47.90	52.10	3.15	14.47	3.25	4.73	26.49	21.7
MEAN	**49.32**	**50.68**	**2.69**	**13.16**	**2.58**	**4.25**	**27.98**	
LSD (0.05)	**3.19**	**3.19**	**0.14**	**0.31**	**0.19**	**0.17**	**3.27**	

This indicates that treatments improved nutrient density by reducing water retention and enhancing solid biomass accumulation. Generally the analysis revealed that the untreated plots (control) recorded the lowest level of nutrient components and this was ststisticcaly different at ($p \leq 0.05$) from all the the treated plots except for the plots with only chemical fertilizer which gave a similar record to that of the control but with a slight different.

Table 6 presents the effect of different treatments on the mineral composition of fresh corn, focusing on six essential elements (Potassium (K), Phosphorus (P), Calcium (Ca), Magnessium (Mg), Sodium (Na), and Iron (Fe). The results further confirmed the benefits of organic treatmentst as presented in table 6. Grains from T5 (neem + poultry manure) recorded the highest concentrations of potassium (275.47 mg/100g), phosphorus (192.60 mg/100g), calcium (60.37 mg/100g), magnessium (168.73 mg/100g), sodium (66.9 mg/100g), and iron (5.56 mg/100g).

Tabie 6 Effect of Treatments on Mineral Composition of Fresh Corn

Treatment	K mg/100g	P mg/100g	Ca mg/100g	Mg mg/100g	Na mg/100g	Fe mg/100g	Mean
Control	165.93	134.30	41.50	109.77	45.77	3.83	83.52
Poultry manure + chemical pesticide	266.13	191.23	56.90	155.30	60.63	5.06	122.5
Chemical fertilizer + chemical pesticide	255.60	176.37	52.63	147.23	56.70	4.63	115.5
Chemical fertilizer	243.17	168.63	54.67	134.33	55.67	4.33	110.1
Poultry manure + Neem extract	275.47	192.60	60.37	168.73	66.27	5.56	128.2
Mean	**241.26**	**172.63**	11 **53.21**	**143.07**	**57.01**	**4.68**	
LSD (0.05)	**2.02**	**4.10**	**1.49**	**1.63**	**1.88**	**0.2 5**	

In contrast, the control (T1) consistently had the lowest mineral concentrations across all parameters - potassium (165.93 mg/100g), phosphorus (134.50 mg/100g), calcium (41.50

mg/100g), magnessium (109.77 mg/100g), sodium (45.77 mg/100g), and iron (3. 85 mg/100g) and these were all significantly different at ($p \leq 0.05$) from the treated plots with higher records. However there was also significant difference at ($p \leq 0.05$) recorded among the treated plots in their nutrient composition and this is an indication that the choice of soil amendment and pesticide strategy strongly influences the nutritional profile of fresh corn.

DISCUSSION

The result of this study revealed significant differences in both nutrient compostion and fall armyworm infestation across the different maize production systems highlighting the contrasting impacts of organic and inorganic management pracices. Maize grown under the integrated management practices particularly the combination of poultry manure and neem extracts, exihibited comparatively higher levels of essential nutrients such as crude protein and mineral contents than those grown under sole chemical fertilizer or untreated systems. This improvement can be attributed to the gradual release of nutrient and soil conditioning properties of poultry manure, which enhanced maicrobial activities and improved efficiently the uptake of nutrients. These finding are in line with the reports of Ayoola and Makinde (2007) who observed that organic ammendments significantly improved soil fertility and crop nutritional quality compared to inorganic fertilzers. Similarly, Ojeniyi (2000) also reported that poultry manure enhanced soil organic matter and increased nutrient availability in the soil resulting in improved crop quality and yield. It was observed that maize treated with chemical fertilizer and chemical pesticide alone showed lower nutrient density compared to that treated with the organic amendments (neem extracts and poultry manure). This observation is in line with findings of Tilman et al (2002) who noted that excessive reliance on inorganic imputs may reduce long term soil health and crop nutritional quality.

Records from fall armyworm infestation, revealed that untreated maize plots recorded the highest level of fall armyworm infestation, confirming the susceptibility of maize in the absence of pest management strategies. Among the treated plots, the combination of poultry manure and neem + moringa extract significantly reduced infestation levels, reuced cob damage, reduced the pest population and also increased the yield of maize compared to other treatments. Neem and moringa extracts demonstrated strong pest suppression effects possibly due to the presence of

azadiractin and other bioactive compounds that disrupts insect feeding and reproduction. These agrees with the findings of Schumutterer (1990) who documented the efficacy of neem extracts in controlling a wide range of insect pests. It also agrees with result of Butu et al (2020) who reported on the effectiveness of biopesticdes in reducing the incidence of insect pests and increasing yield. Plots treated with chemical fertilizer alone or in combibation with chemival pesticide showed reduced infestation levels, however their effectiveness was sometimes comparable but not superior to organic treatment. This suggests that while synthetic pesticides provide immediate control, organic pesticides offer a sustainable and environmentally friendly alternative This is in line with Prasanna et al (2018) who reported that integrated pest management strategies that can effectively reduce fall armyworm damage while minimizing environmental risks.. Plants treated with chemical fertilizer alone recorded higher infestation levels compared to organically treated plots. This may be due to the fact that excessive nitrogen availability promotes lush vegetative growth, making plant more attractive and susceptible to herbivorous pests. Sole maize (control) recorded the poorest performance in both nutrient compostion and pest reistance, emphasizing the need for soil fertility and pest management inputs. Chemical fertilizer + pesticide provided good pest control but did not significantly enhance nutrient quality compared to organic treatments. These findings is consistent with previous field demonstrations showing that neem extracts and integrated pest management approaches, such as push-pull and botanical strategies, can significantly lower pest-induced injury in West African maize systems (Yaméogo *et al.,* 2023)

CONCLUSION

The result from this study suggests that integrating organic imputs such as poultry manure and neem extracts offers aviable strategy for improving maize nutritional quality while effectively managing fall arnmyworm infestation. The organic and integrated treatments outoerform sole and onirganic systems in terms of both nutrient composition and pest management. The combination of poultry manure and neem extract stands out as the most effective and sustainable treatment optionand therefore iis recommended as an alternative to synthetic pesticide in the management of the maize armyworm

This approach supports sustainable agriculture by reducing

dependence on synthetic inputs , enhancing soil health and minimizing environmental hazardS and therefore should be employed in fall armyworm management

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The International Journal of Organic Agricultural Research and Development is a peer-reviewed, open access journal dedicated to publishing high-quality research that advances the science, practice, and policy of organic and sustainable agriculture. It aims to foster innovation, collaboration, and knowledge sharing for a more sustainable and food-secure future.

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