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# Distribution, abundance and severity of citrus pests in northern Uganda

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**Abstract**
A survey was conducted in September 2014 to determine the status of citrus pests in Northern Uganda. Eighty farmer fields were sampled in districts of Nwoya, Gulu, Amuru, Agago, Kitgum, Lira, Dokolo, Oyam, and Apac. The results showed leaf miner as the most prevalent pest (97.3%) and scales (38.73%) as the least among citrus orchards in the region. Agago and Dokolo had the highest orange dog (100%) and leaf miner (100%) incidences where as Oyam (87%) and Kitgum (93%) districts registered the least incidences of the similar pests. The highest (63.2%) and lowest (12%) scales incidences were recorded in Agago and Nwoya districts respectively. There was a significant relationship observed between the districts and scales incidence (p= 0.000175). Age had no significant relationship with the scales, leaf miner and orange dog pest incidences. The fact that leaf miner had the highest incidence necessitates the need for its control since it bears a strong relationship with the devastating citrus canker and alternaria brown spot disease. The study also points out to the need for control of the leaf miner for a sustainable citrus pest management plan in northern Uganda.

**Keywords:** Fruit, leaf miner, orange dog, scales

## 1. Introduction
Citrus is amongst the highest value fruit crop found in both tropical and sub-tropical countries of the world [18]. Trade in citrus fetches a lot of currency with orange juice being the fruit juice product consumed in the world [18]. It fetches a lot of money it in terms of international trade as it has two main markets; the fresh fruit market and processed fruits market. Citrus plays a key role in human diets as a high source of vitamin C and other important nutrients including folate and potassium, and in fresh form, is a good source dietary fibre [18]. Brazil, United States and China continue to be the three largest processed orange producing regions in the world taking up 85% of the market [18]. In East Africa citrus is an important crop, and production is estimated at 10 tonnes per hectare below the demand and the expected yield of 50 to 70 tonnes per hectare. However, the decline in production by these countries is attributed to pests and diseases, despite the immense potential to export to the European Union [16].
In Uganda, the sweet orange (*Citrus sinensis*) is the most widely grown [12] and produced for both domestic consumption and regional markets [19]. Majority of citrus trees are grown in either plantations or as a few stands around homesteads [12]. Production is characterized by low inputs in terms of pest and disease control, use of improved planting materials and soil fertility enrichment measures [10]. This low investment in citrus farming is exacerbated by the fact that citrus is attacked by a wide range of pests from aphids, scales, Leaf miners, orange dogs to fruit flies [14] and in combination with diseases can lead to 100% losses [7, 10]. In addition, presence of leaf miner damages in citrus is associated with citrus canker and alternaria brown spot, devastating diseases in citrus [4, 8]. This is attributed to creation of entry points for the disease inoculum [8-10].
With the Uganda government plan to increase production of citrus in the northern region mainly for the purpose of steady household income through the Operation Wealth Creation programme [1] and the opening of a fruit factory in Soroti [15], demand for quality citrus is bound to increase. However not much is known about the major pests affecting already existing orchards and citrus trees in the region. The present survey was conducted to study pests' distribution, incidence and severity, in the different citrus growing locations of Northern Uganda.

**2. Materials and Methods**

The present survey was carried out in the citrus-growing districts of Lango and Acholi sub regions of Uganda in September 2014. A total of 80 citrus fields were sampled at regular intervals of at least 10 km on average along the main roads and with occasional traversing through feeder roads during the survey. In each field sampled, 10 randomly selected plants were examined. Data was collected on three known common citrus pests (Scales, leaf miner, and orange dogs) based on field observations. Four districts (Lira, Apac, Dokolo and Oyam) representing half of Lango sub region and four districts (Gulu, Nwoya, Kitgum and Agago) representing three quarters of Acholi sub regions were sampled. From each district, 10 fields were randomly selected and assessed. GPS location of each field was recorded. Incidence was calculated using the formulae [6].

$$\text{Leaf miner incidence} = \frac{Number\ of\ plants\ with\ leaf\ miner\ damage}{Number\ of\ sampled\ plants} x100$$

$$\text{Orange dog damage Incidence} = \frac{Number\ of\ plants\ with\ O.D\ damage}{Number\ of\ sampled\ plants} x100$$

$$\text{Scales incidence} = \frac{Number\ of\ plants\ with\ scales}{Number\ of\ sampled\ plants} x100$$

Leaf miner, scales and orange dog severities were assessed (based on visual estimates of plants exhibiting foliar damage or presence in young shoots) using the scale of 1 to 5 on individual plants: where 1 = 0 – 20% of foliage consumed, 2 = 21 – 40% of foliage damage, 3 = 41 – 60% of foliage damage, 4 = 61 – 80% of foliage damage and 5 = 81 – 100% of foliage damage [3].

**2.1 Statistical analysis**

The survey data was then subjected to analysis of variance, using R version 3.3.3 statistical software (2017 The R Foundation for Statistical Computing Platform). Means of pest incidence were further separated using Fishers LSD. Pearson's correlations between variables were explored.

**3. Results and discussion**

The survey showed that the majority of farms had average acreage of 0.8 ±0.74 with Lira district having the highest mean acreage of 1.38 and Apac with the least of 0.30 (See Table 1). The mean age in years of citrus fields in the region was 6.43±4.26 with Kitgum having the oldest fields (8.3) and Oyam the youngest (4.7) (Table 1). The differences in age are due to the differences in planting dates of the fields in different districts.

**Table 1:** Mean age and acreage of citrus fields in different districts

| Variable | Age(Years) | Acreage |
|---|---|---|
| Agago | 7.95±7.96 | 0.59±0.31 |
| Kitgum | 8.30±5.10 | 0.79±0.37 |
| Dokolo | 5.60±5.32 | 1.29±0.53 |
| Lira | 6.80±3.084 | 1.38±0.77 |
| Oyam | 4.70±1.359 | 0.80±1.19 |
| Gulu | 6.90±2.132 | 0.84±0.91 |
| Apac | 6.30±2.830 | 0.30±0.10 |
| Nwoya | 4.80±2.044 | 0.67±1.19 |
| *Mean* | 6.425±4.262 | 0.8324±0.7365 |

Each of the districts of Agago and Dokolo had the highest Orange dog (100%) and Leaf miner (100%) incidences. However, Oyam (87%) and Kitgum (93%) districts registered the least incidences of orange dog and Leafminer. The highest (63.2%) and lowest (12%) Scales incidences were recorded in Agago and Nwoya districts respectively (Table 2). Leafminer incidence was the highest in all study districts and the results agree with studies conducted in Eastern Uganda, India and southern Spain where leaf miner was identified as the most common pest [7, 13, 17]. The high incidences only confirm the fact that there is very little input into citrus fields in the region [10].

One-way analysis of variance was conducted to determine the significant difference in means of pest's incidence and damage in the different districts. Scales incidence showed a significant difference in means ($F(7,72) = 4.811$, $p<0.05$) in the different districts. the differences and variations in scales incidence is caused by a number of factors ranging from age of plant [11], weather conditions and management practices [10, 17]. There was however no statistically significant difference observed between orange dog incidence ($p=0.299$), leaf miner incidence ($p=0.751$) and the sampled districts. Means of scales incidence were further separated using Fisher LSD post-hoc test (Table 2).

**Table 2:** Mean scales, orange dog damage and leaf miner damage incidence in the different districts

| District | Scales incidence(SI) | Orange dog Incidence(ODI) | Leaf miner Incidence (LMI) |
|---|---|---|---|
| Agago | $63.2^{a}$ | $100^{a}$ | 100a |
| Kitgum | $61.0^{a}$ | $95^{ab}$ | 93a |
| Dokolo | $56.0^{a}$ | $100^{a}$ | 100a |
| Lira | $42.9^{ab}$ | $97^{ab}$ | 99a |
| Oyam | $27.0^{bc}$ | $87^{b}$ | 96a |
| Gulu | $21.0^{bc}$ | $99^{a}$ | 99a |
| Apac | $19.0^{bc}$ | $98^{a}$ | 98a |
| Nwoya | $12.0^{c}$ | $98^{a}$ | 95a |
| *C.V* | *78.49* | *12.59* | *10.72* |
| *LSD $_{p=0.05}$* | *26.42* | *10.85* | *9.30* |
| *F-statistic* | *4.811* | *0.603* | *0.751* |

Means with same letter are not significantly different from each other at p=0.05

A Pearson product-moment correlation coefficient was computed to assess the relationship between age, leaf miner, orange dog and scales incidences. Results showed a positive significant relationship between leaf miner incidence and orange dog incidence $r=0.4467$, $n=80$ $p=0.0003$ (Table 3). This relationship can be explained by the fact that both pests have a preference for new flush and have similar feeding points [13]. However, the results showed that age has no influence on pest incidence. These results are in contrary to a study conducted in southern Spain that showed trees less than 10 years are likely to have higher infections [11]. In addition, field observations have shown scales damage to be more severe on younger trees than old. The absence of the relationships of age of tree with both leaf miner and orange dog incidence may be explained by the fact that trees at all ages flush trough out the fruit tree life cycle and thus the flushing pattern affects the incidence not age [13]. The absence of a relationship between scales and age can be explained scales doesn't attack only the new tree branches but fruits and leaves therefore its presence throughout the year [5].

**Table 3:** Correlation between Age, LMI, ODI and SI

| Variables | Age | LMI | ODI | SI |
|---|---|---|---|---|
| Age | 1.0000 | | | |
| | | | | |
| LMI | 0.0449 | 1.0000 | | |
| | 0.6924 | | | |
| ODI | -0.0095 | 0.4467 | 1.0000 | |
| | 0.9331 | 0.0000 | | |
| SI | 0.0467 | -0.0341 | 0.0666 | 1.0000 |
| | 0.6808 | 0.7637 | 0.5573 | |
| Cell contents: | Pearson correlation | | | |
| | P-value | | | |

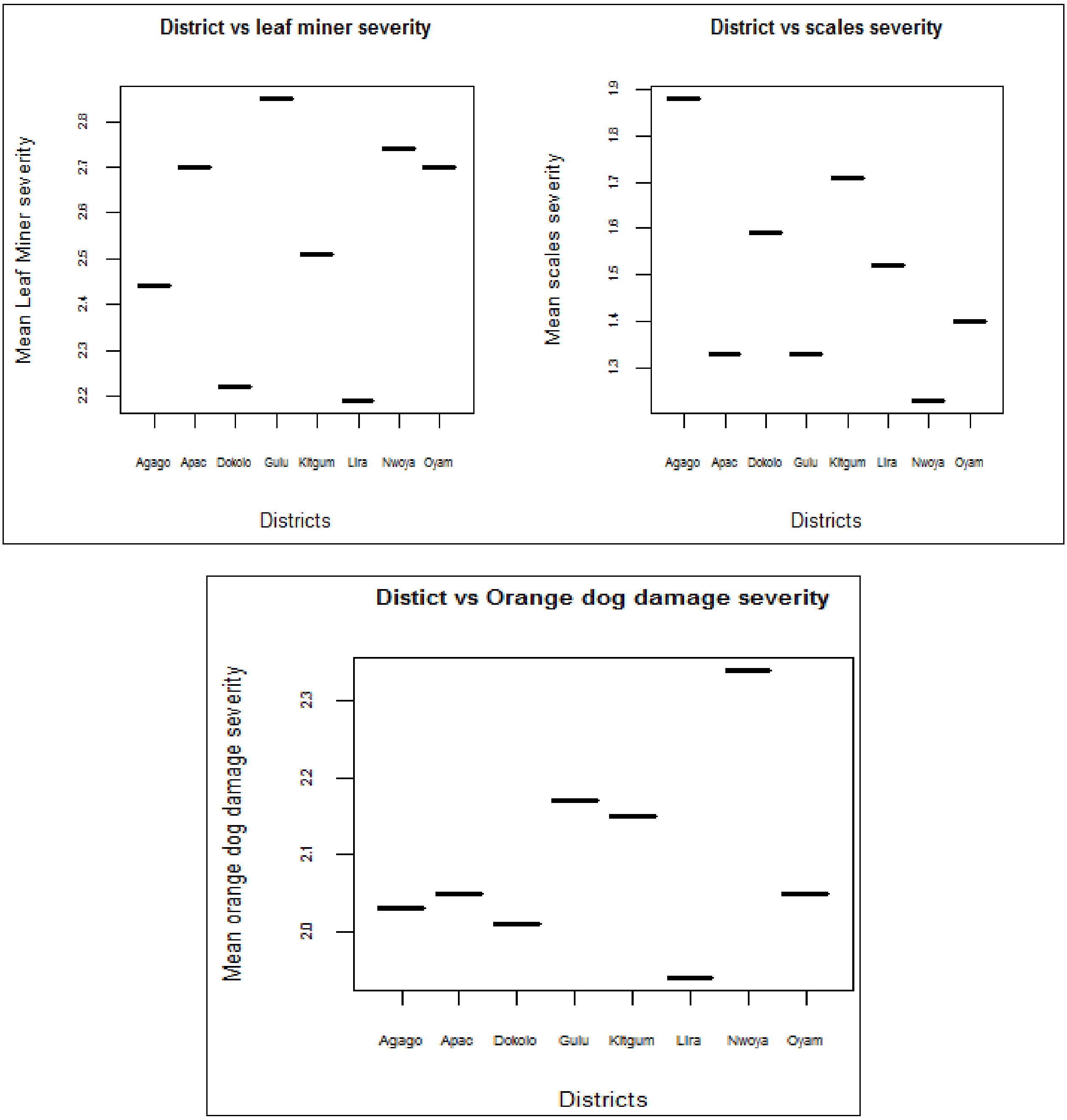


**Fig 1:** Leaf miner, Scales and Orange dog severity

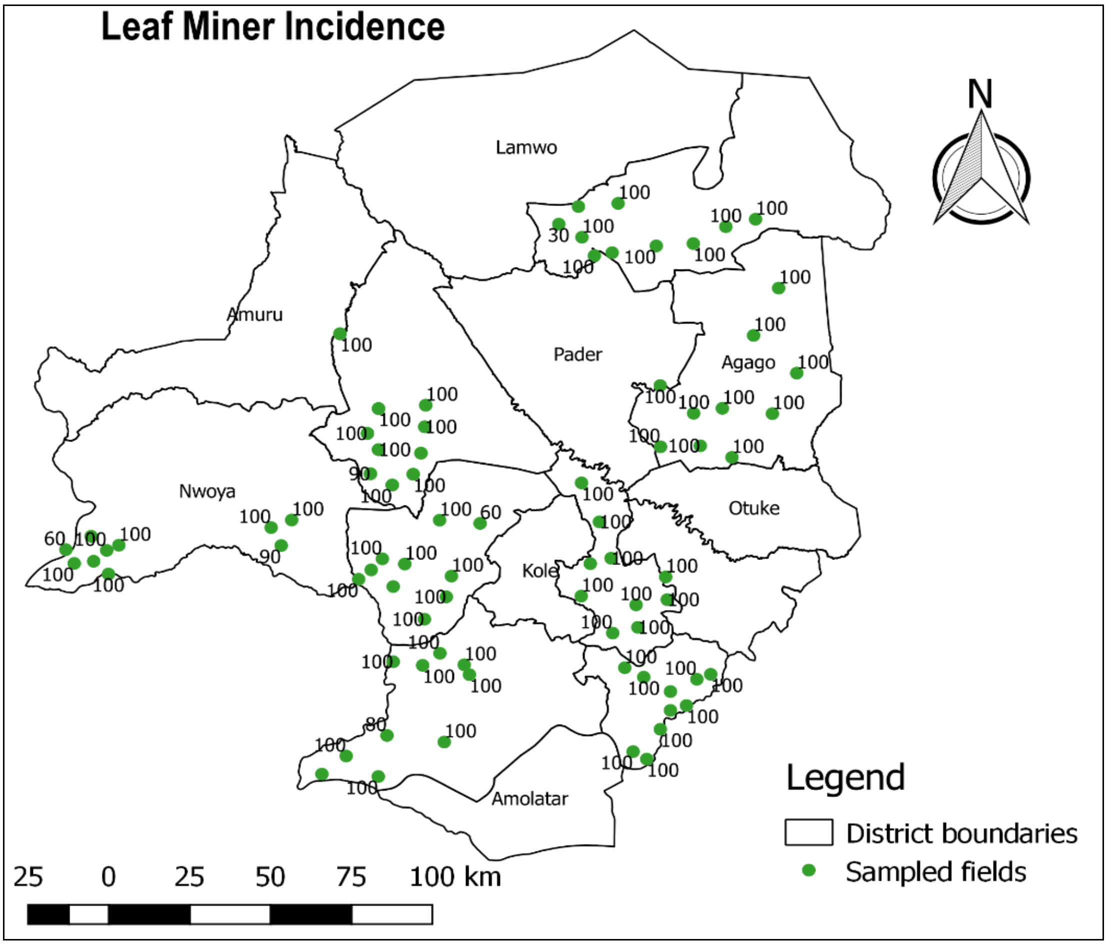


**Fig 2:** leaf miner incidence in sampled locations

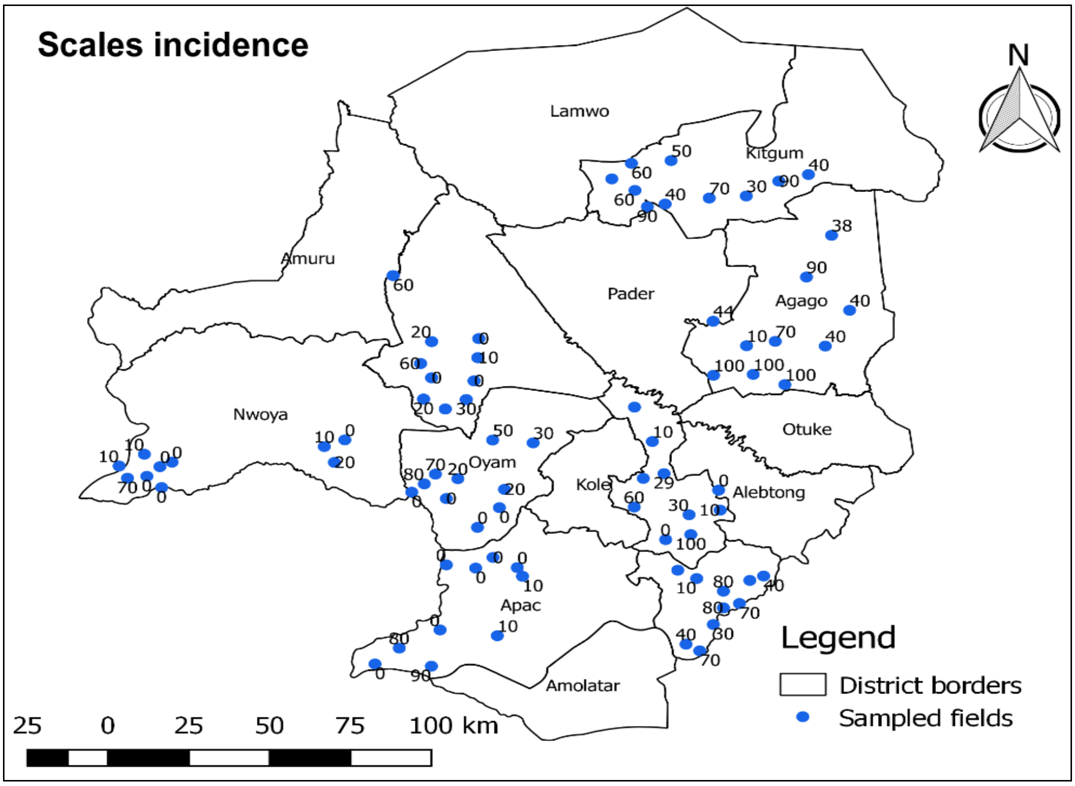


**Fig 3:** Scales Incidence in sampled location

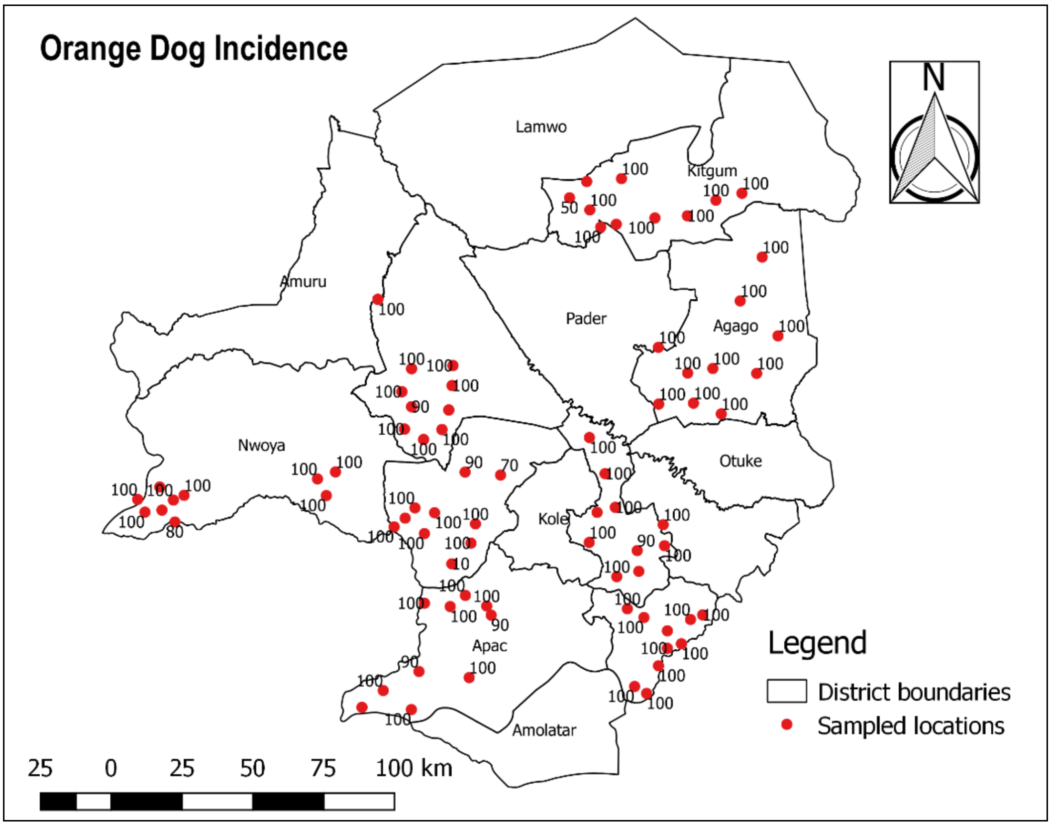


**Fig 4:** Orange dog incidence in sampled districts

Despite the fact that the orange dog and leaf miner pest incidences were very high (100%), their relative damage scores were ranging between low to moderate (1.230 to 2.850) (Fig 1.). There is need for more systematic studies to quantify damage and yield losses and relate these to infestation rates to better guide the need for, and timing of, control actions.

## 4. Conclusion

The study revealed that leaf miner is the most prevalent citrus pest in Northern Uganda. The presence of leaf miner on young shoots is suggestive that farmers are not effectively spraying their tree orchards. More to that, since very high incidence of leaf miner was registered, it is imperative that the chances citrus canker and alternaria brown spot infection are increased because of the relationships between the two. The findings point out to the need for an integrated pest management strategy to sustainably tackle the problem of pests and disease. The study also recommends a detailed study to determine the yield loss accruing from these pest damages. In addition, the factors contributing to the differential pests' incidence should be investigated. It's also important that efforts should be made to disseminate appropriate information and technologies for abating pest damage.

## 5. Acknowledgement

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