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Distribution and Seasonal Occurrence of major insect pests of cotton in Uganda

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Abstract— *Both surveys and field expriments were conducted to study the distribution and seasonal fluctuation of major cotton pests in Uganda. The surveys were carried out in 13 cotton growing districts including; Wakiso, Mpigi, Mukono (Central region), Kamuli, Jinja (Eastern region), Amuria, Amolator, Pallisa, Serere (North-eastern region), Kasese, Nakasongola, Masindi and Kiryandongo (Western region), with laboratory rearing and the field experiment conducted at the national semi arid resources research institute (NaSARRI).Twenty cotton fields were selected from each district in four sub counties, 5 from each sub county giving a total of 260 fields for the study in 2013 and 2014 respectively. Each selected field was visited 3 times in each cropping season i.e. once at vegetative stage, once at Squaring stage and once at boll growth.*

For 2014 season. Cotton variety BPA2002, was sown on 16th, June, 2014 in plots, measuring 40 x 60 m^2 at 4 seeds/hole and soil depth of 2.5 cm. Plant to plant and row to row distances were kept at 30 cm and 75 cm, respectively. Recommended agronomic practices with no pesticide application were applied throughout the cotton season. Densities of insect pests were recorded on ten days interval on randomly selected leaves from top, middle and bottom of the 30 plants selected. The insects were recorded from 2nd week of July till 4th week of November.

On each sampling date, bollworm larval densities, Aphid counts, mite counts were evaluated on 20 randomly selected cotton plants per field in both 2013 and 2014 seasons respectively. Boll worm larvae collected were placed in plastic containers, reared in the laboratory until adult emergence, counted and added to the sweep net catches. For aphids and mite records were taken from upper, middle and lower leaves of randomly selected twenty plants (Shah et al., 2015). Adult boll worm moths, stainers and white flies were also collected using a sweepnet, where each field was divided diagonally and in the early morning and late evening insects were collected by sweeping through the field, the catches collected, separated by species, starved to death and then placed in alcohol for further morphological identification.

Data was analyzed by ANOVA using general linear model procedures at 5% level of significance. Meteorological parameters like temperature and relative humidity during the study period were recorded. Correlation analysis was made to study the relationship between weather parameters and incidence of major insect pests of cotton by following standard statistical methods

For the survey, high aphid occurrences were observed in Kasese, Serere, Wakiso and Mpigi districts respectively, Stainers (Mukono ,Serere, Pallisa and Kasese districts),Mites showed higher occurrences in all the districts surveyed with highest counts of bollworms observed in Kasese and Pallisa districts and for the seasonal fluctuation study, mites (Tetranychus urticae), peaked (38.4 individuals per plant), in the first week of September, Aphids (38 individuals per plant) in the last week of August, White flies (35 individuals per plant) in the last week of August, Jassids (17.5 individuals per plant) in the second week of October, and stainers peaked (10.5 individuals per plant) in the last week of September.

In conclusion the districts surveyed appeared to be hot spots for a particular pest and farmers should now employ integrated pest management in order to reduce the pest pressure in their regions. This should be employed with proper timing of when a particular pest becomes a threat to the cotton crop based on the seasonal fluctuation data obtained.

Keywords— insect pests, cotton, uganda

I. INTRODUCTION

Cotton plays a vital role in Uganda's economy and ranks the third in terms of traditional export crops (UBOS 2015).

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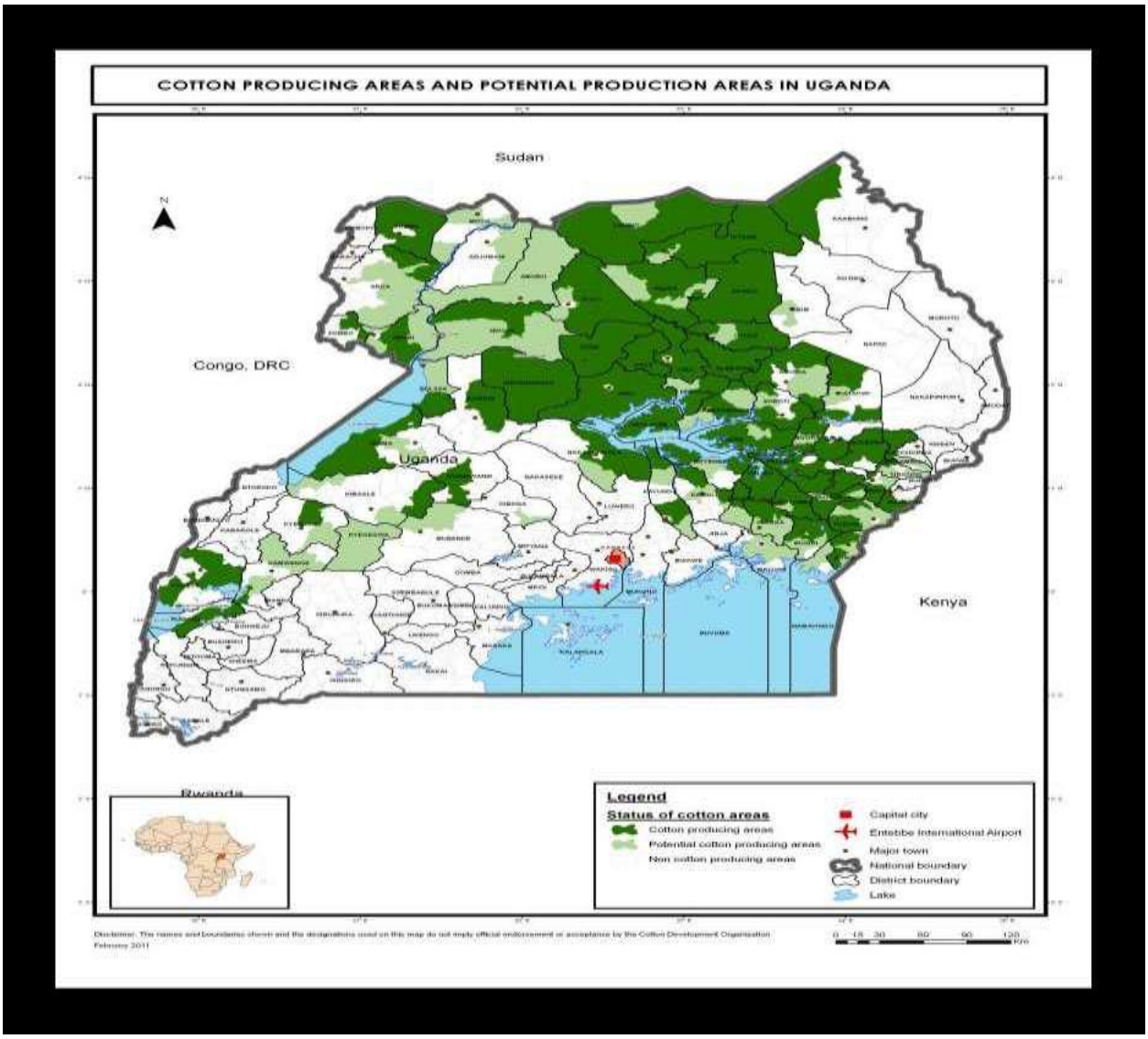
It is grown in all regions of the country with most production concentrated in the Northern, Eastern and South western regions whose sandy and loamy soils are suitable for cotton production (CDO annual report 2013).



Source: Cotton Development Organisation (CDO) final Uganda Brochure October 2011

It is a perennial semi-shrub grown as an annual crop in Uganda with production periods as shown in table 1.

Table.1: Periods of cotton planting and Harvesting In Uganda

Regions	Planting period	Harvesting Period
Northern	May-June	December-February
Eastern	May-June	December-February
Western	July-August	January-March
Mid-Western	July-August	January-March
Central	July-August	January-March
West Nile	June-July	January-March

Source; Cotton Development Organization (CDO) annual report 2011

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Gossypium hirsutum (L) is attacked by a range of both early and late season insect pests during its growth cycle including; the bollworm complex; American bollworm, *Helicoverpa armigera*, spotted bollworm, *Earias insulana*; pink bollworm, *Pectinophora gossypiella*, Stainers *Dysdercus cingulatus* Fabricius, Mites, *Tetranychus urticae* Koch (The yellow tea mite and red spider mite); Aphids, *Aphis gossypii*, Whitefly, *Bemisia tabaci* and Jassid, *Amrasca biguttula*; (Byabagambi *et al*, 2013).

These pests cause considerable yield losses estimated at 80% (Shahid *et al* 2015) worldwide with up to 100% loss registered elsewhere in Africa (Abate *et al* 2000). At present information on extent of spread by these insect pests of cotton in Uganda is scanty.

More still, Mujurizi J *et al*, 2007, reported that cotton farmers in Uganda spray cotton fields with high dosages of pesticides at a time when most pollinators are visiting the cotton flowers leading to high mortality of forager honey bees.

However information on seasonal fluctuation of these pests due to variations in climatic conditions in Uganda is also lacking. Hence, an attempt has been made to establish the distribution of major cotton pests and an insight on their spread in Uganda which will give an idea about peak periods of their activity and may be helpful in developing real time pest management strategies in cotton production systems.

II. MATERIALS AND METHODS

Study sites

Survey studies were carried out in 2013 and 2014 cotton growing seasons respectively in 13 cotton growing districts of Uganda including; Wakiso, Mpigi, Mukono (Central region), Kamuli, Jinja (Eastern region), Amuria, Amolator, Pallisa, Serere (North-eastern region), Kasese, Nakasongola, Masindi and Kiryandongo (Western region). These districts are well known for commercial cotton production.

Generally these districts are characterized by bimodal distribution of rain fall, with peaks in April and September and an annual average precipitation of about 1500mm. The short and long rainy seasons last from mid-March to end of June and from early August to end of November, respectively. A short dry spell of about four weeks occurs in July. The major dry spell begins in the last week of November and lasts until mid-March with an annual average temperature of 25˚C.

Since the predominance of cotton pests varies with the crop growth cycle (Shahid *et al., 2012*), surveys were conducted for one season each year in all the 13 districts while supporting laboratory and field studies were carried out at the National Semi-Arid Resources Research Institute (NaSARRI).These districts were selected basing on information provided by cotton development organisation (CDO) which indicated that these districts are among the main cotton growing districts in Uganda with organized farmer groups.

Experimental design

The study sites were selected basing on field sizes, average between 0.5-5 ha. Twenty cotton fields were selected from each district in four sub counties, 5 from each sub county giving a total of 260 fields for the study in 2013 and 2014 respectively. Each selected field was visited 3 times in each cropping season i.e. once at vegetative stage, once at Squaring stage and once at boll growth.

For the field experiment, the population fluctuation of insect pests of cotton were evaluated at the national semi-arid resources research institute (NaSARRI) for 2014 season. Cotton variety BPA2002, was sown on 16th, June, 2014 in plots, measuring 40 x 60 m^2. Cotton was sown at 4 seeds/hole at soil depth of 2.5 cm. Plant to plant and row to row distances were kept at 30 cm and 75 cm, respectively. Recommended agronomic practices were applied throughout the growing period of the crop. No pesticides were applied to the crop. Densities of insect pests were recorded on ten days interval on randomly selected leaves from top, middle and bottom of the 30 plants selected. For counting the insect pests, the leaf was gently held at the petiole by thumb and fore finger and turned until the entire underside of Leaf was clearly visible. Data were recorded at morning hours (8-10 am) because at that time winged pests were Sluggish and could easily be counted. The insects were recorded from 2nd week of July till 4th week of November. The data recorded was subjected to mean values of individual plants for ten days interval

Data collection

Assessment of pests occurrence on cotton

On each sampling date, bollworm larval densities, Aphid counts, mite counts were evaluated on 20 randomly selected cotton plants per field in both 2013 and 2014 seasons respectively. Boll worm larvae collected were placed in plastic containers, reared in the laboratory until adult emergence, counted and added to the sweep net catches. For aphids and mite records were taken from upper, middle and lower leaves of randomly selected twenty plants (Shah *et al.,* 2015). Adult boll worm moths, stainers and white flies were also collected using a sweepnet, where each field was

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divided diagonally and in the early morning and late evening insects were collected by sweeping through the field, the catches collected, separated by species, starved to death and then placed in alcohol for further morphological identification.

Data analysis

Data was analyzed by ANOVA using general linear model procedures at 5% level of significance. Meteorological parameters like temperature and relative humidity during the study period were recorded. Correlation analysis was made to study the relationship between weather parameters and incidence of major insect pests of cotton by following standard statistical methods.

III. RESULTS AND DISCUSSION

A) Survey on occurrence of cotton pests in major cotton growing districts

Generally 2014 season had significantly higher pest infestation and occurrence than 2013 (Figure2-5) season.

Aphid Occurrence

Comparison of aphid infestation and occurrence in the 13 districts surveyed showed significantly higher counts in Kasese and Serere and Wakiso districts in both 2013 and 2014 seasons at ($P<0.05$). Mpigi district had the highest aphid infestation in 2014 than any other district with lower infestation in 2013 season. The district of Pallisa, Masindi, Mukono, Kamuli, Jinja, Nakasongola, Kiryandongo, Amuria and Amolator showed relatively higher aphid counts albeit at varying levels (Figure 2).

The highest aphid occurrence observed could be due to the fact that cotton farmers in Serere, Kasese, Mpigi, Wakiso and Pallisa mainly grow cotton in a monocroping system which eased host searching ability and distribution of the aphids than the rest of the districts surveyed which had cotton intercropped with mainly legumes and vegetable crops or a vegetable crop within the vicinity of the cotton field. The results of this study support findings by Chabi *et al* (2005) and Kalidas *et al* (2012) who found intercropping to reduce the host searching ability of pests than in the monocrops for field cropping systems

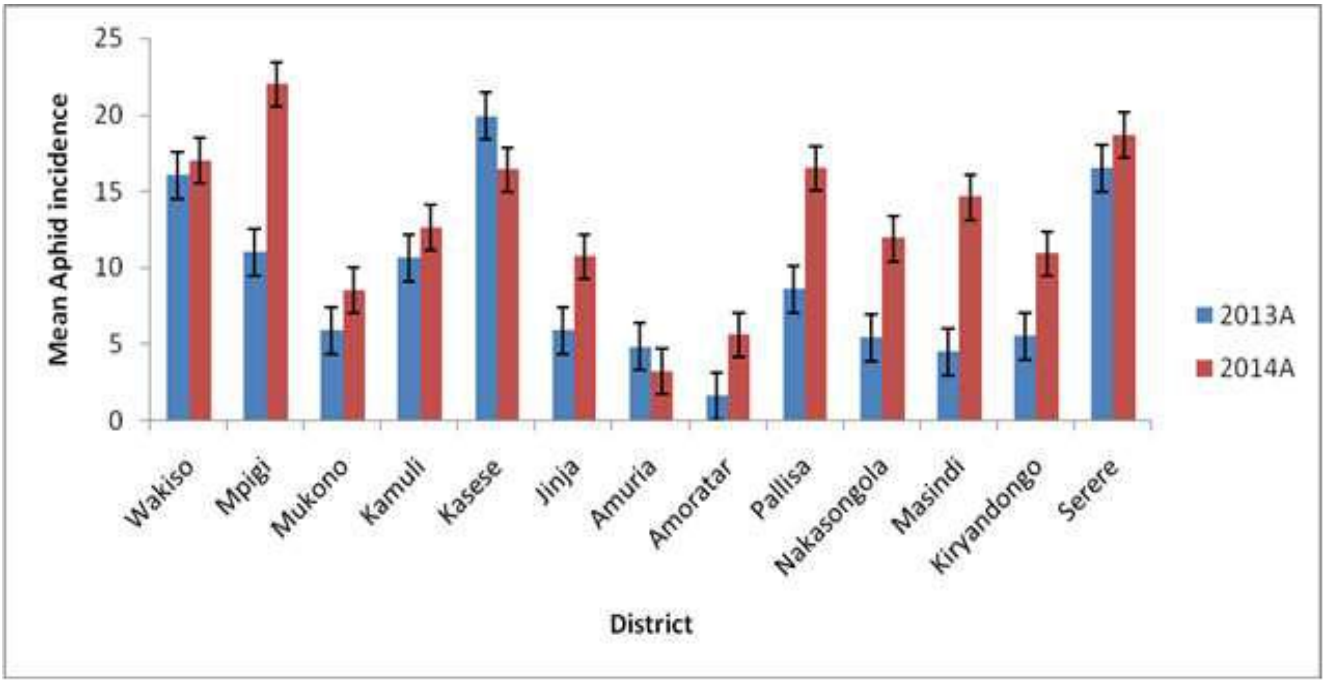

Fig.2: Mean Aphid occurrence in cotton agro ecologies in 2013 and 2014

Cotton stainer occurrence

Like aphids, 2014 season showed higher stainer infestation compared to 2013 season (Figure 3). Highly significant differences were observed ($P<0.05$) with highest stainer counts in Mukono, Serere, Pallisa and Kasese districts respectively. Higher occurrences were observed in Kamuli, Jinja, Amuria, Amolator, Masindi and Kiryandongo with no significant differences between the two cropping seasons. Nakasongola, Mpigi and Wakiso districts showed lower stainer counts in both 2013 and 2014 respectively. Cotton stainers in Uganda were known to feed on cotton, hibiscus and Okra (B. sekamatte *et al* 2003). This spread and level of occurrence in the surveyed districts could be an indicator that the pest now has a wider host range hence the higher

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counts observed in all the 13 districts surveyed since in the study cotton was planted both in monocropped and intercropped systems respectively.

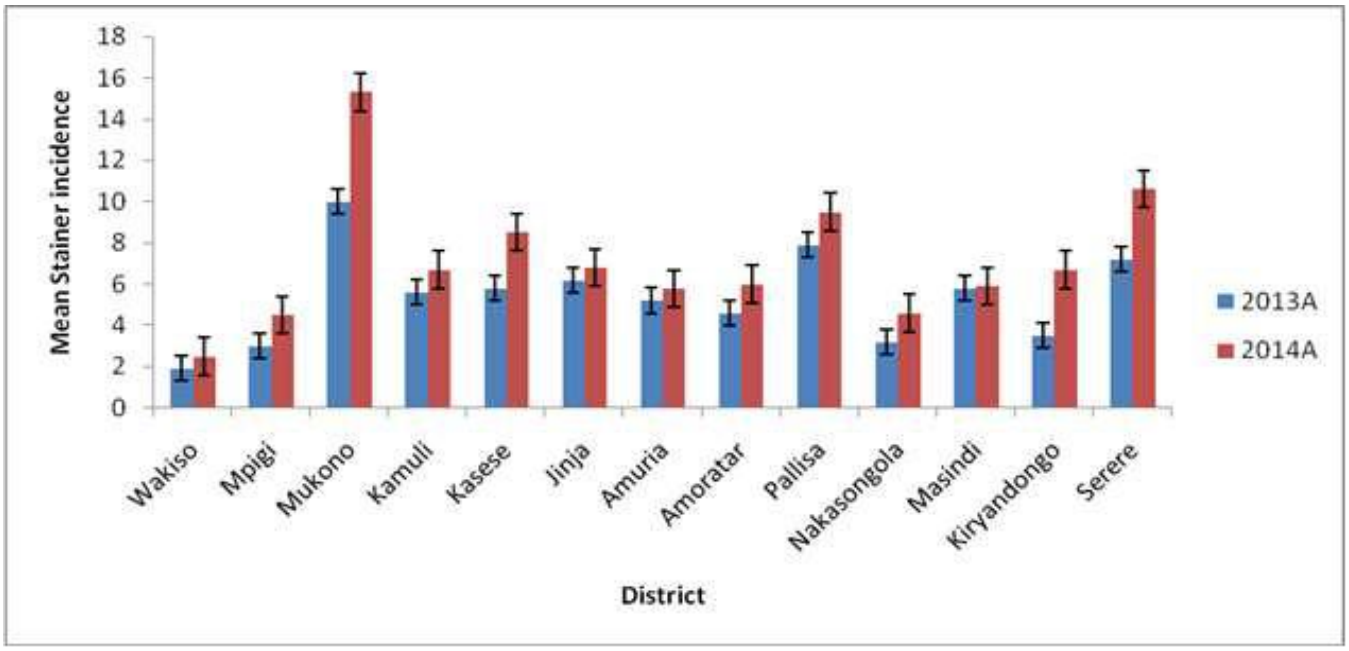

Fig.3: Mean cotton stainer occurrence in cotton agro ecologies in 2013 and 2014.

Mites Occurrence

For mites, the highest occurrence was recorded in Wakiso, Kasese, Amolator, Mukono, Pallisa, Masindi, Serere and Mpigi districts respectively (Figure 4). Unlike the other pests surveyed in the study, both 2013 and 2014 seasons showed higher mite occurrence which differed for each district with no significant differences between the cropping seasons ($P<0.05$). The survey results showed that mites were distributed throughout the 13 cotton growing districts with very high occurrences. The highest occurrence for the mite pest observed in the 13 districts surveyed supports findings by Hui Lu *et al* (2012) who found that although this pest has a low dispersive capacity, its spread increased with the rapid exchange and development of planting materials. This situation was also true for the districts surveyed where there was free exchange of planting materials for all crops between farmers hence the higher occurrences observed during the survey.

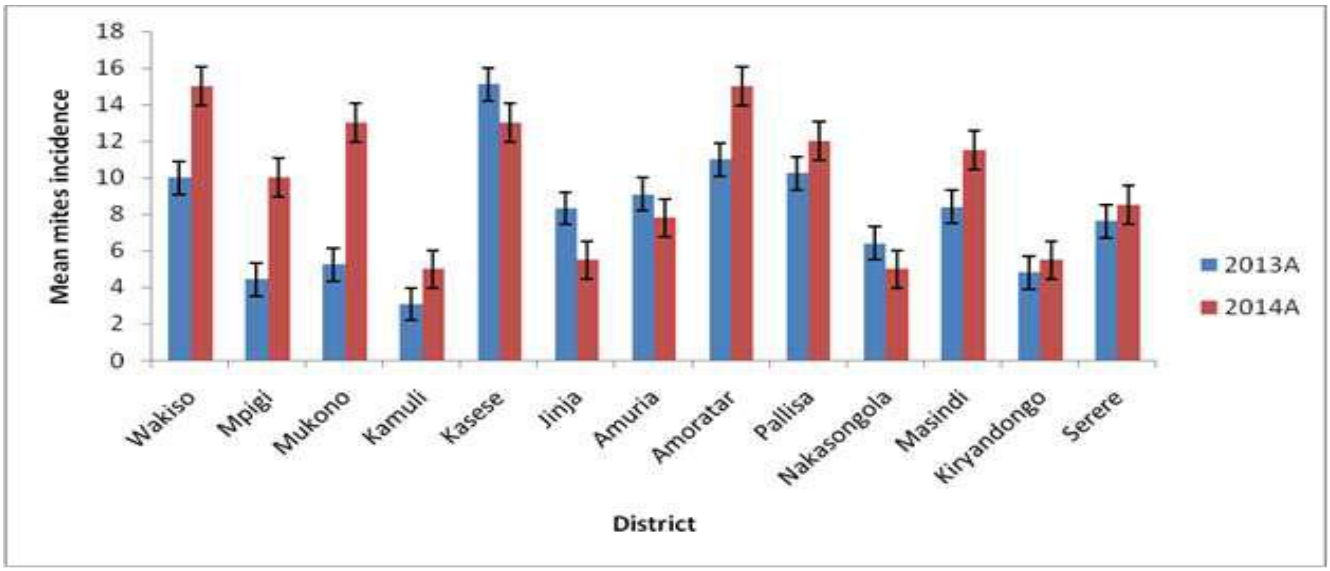

Fig.4: Mean mites occurrence in cotton agro ecologies in 2013 and 2014

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Cotton bollworm occurrence

Bollworm infestation and occurrence showed significant differences with highest counts recorded in Kasese and Pallisa districts (Figure 5). Serere, Nakasongola, Kiryandongo, Masindi, Amolator and Amuria districts showed higher bollworm occurrences with no significant difference between the two cropping seasons($P<0.05$). Tahvanainen and Root (1972) stipulated that intercropping lowers pest densities by reducing immigration into the crop or increases emigration from the field.

The observed difference in cotton bollworm populations in the surveyed field could be due to the fact that Kasese, Pallisa and Serere grow cotton as a sole crop. Another reason could be the continuous use of pesticide in Kasese and Pallisa and Serere which might have led to bollworms developing resistance to pesticide use hence the observed difference during the survey compared to other districts surveyed where pesticide use is minimal. The results of this study support findings by Kranthi *et al* (2005) who found bollworms to develop resistance to pesticides very fast and thus high population build up in cotton pesticide growing districts of India.

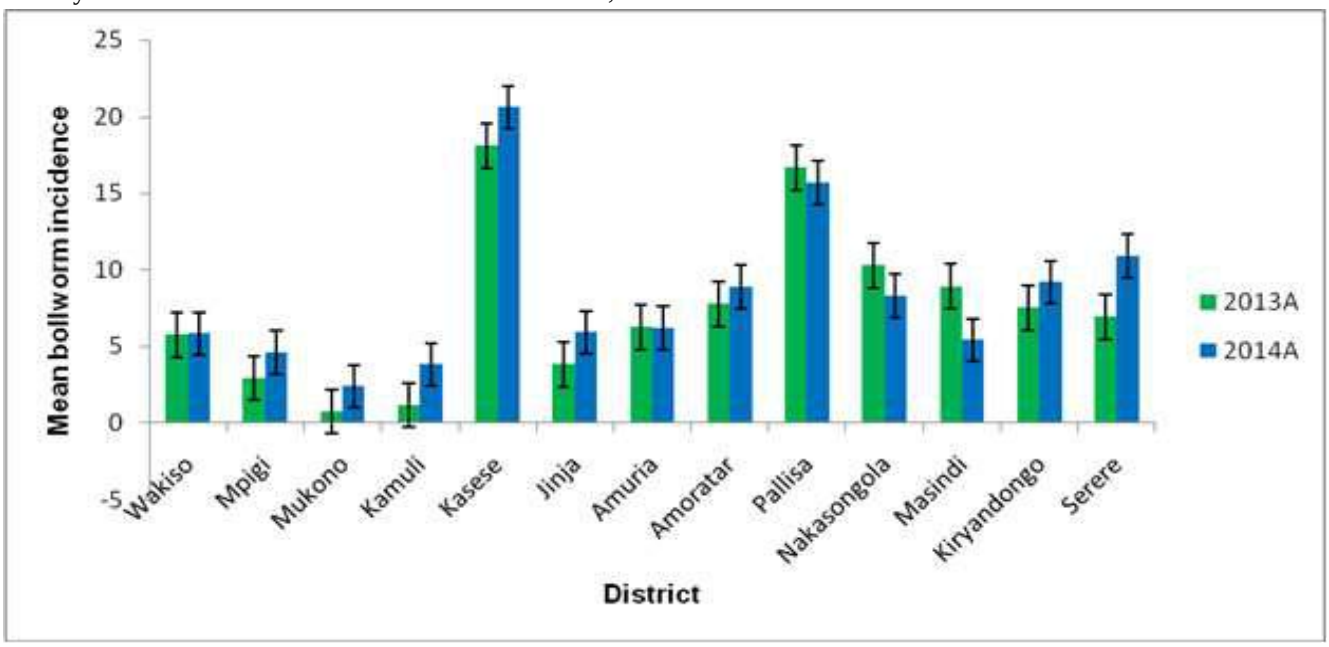

Fig.5: Mean bollworm occurrence in cotton agro ecologies in 2013 and 2014.

b) Pest population density counts during the cotton crop growth cycle in the field experiment

Results of observations on population fluctuations of sucking cotton pests made at various growth stages of the cotton crop at NaSARRI in 2014 are presented in Table 2 and 3.

Mites Infestation

Mite infestation begun as early as July in the season and increased rapidly till it peaked (38.4 individual mites per plant) on September 01st.2014 (Table 2). In general infestation was low and below ETL before end of August, then the population peaked in September with higher infestation up to late November and declined thereafter. The data on correlation between mite infestation and weather parameters showed that temperature had a positive relationship with mite population (0.59) and a negative relationship with relative humidity(-0.133) (Table 3).

Results of our study are supported by the findings of Shahid *et al* (2012) who reported that cotton mite populations were favoured by higher temperatures. The results described in Table 3 depicted that increasing temperature favoured the mite population growth with relative humidity exerting a negative correlation with the mite population. These research findings are in agreement with findings of Khan & Ullah (1994), who observed a negative relationship between population buildup of *Tetranychus urticae* and the mean relative humidity and crop growth reduction due to mite infestation was greater in early than in late infested crops.

Aphids Infestation

Aphid incidence was observed at varying intensities ranging from 0.52-39.2 individuals per plant with a mean of 17.95 aphids per plant. However, peak incidence was observed from 01st.08.2014 up to 01st.11.2014 and declined thereafter (Table 2). Aphids exhibited a positive correlation with

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temperature (0.256) and a negative response to relative humidity (-0.59) (Table 3). The present findings are in conformity with the findings of Ashfaq *et al* (2011) who reported population of *A.gossypii* throughout the cotton growth period.

White flies infestation

Like aphids, whiteflies population also varied significantly ranging from 0.4-35.0 individuals per plant with a mean of 15.-6 whiteflies per plant (Table 2). Unlike the aphids, the whiteflies infestation begun low early in the season (whole month of July), population peaked in the last week of August 2014 (35 whiteflies per plant) and remained consistently higher throughout the growing period. Whiteflies populations were positively correlated with temperature (0.312) and relative humidity (0.42) (Table 3). Findings of our study were in agreement with Shahid *et al* (2012) and Seif (1980) who also got similar results.

Jassids Population

The highest jassid population was observed in the second week of October with the peak population (17.5 Jassids per plant) recorded on 20th.10.2014. In general jassid population remained above ETL from 30th.08.2014 onwards (Table 2). Correlation studies (Table 3) showed that relative humidity exerted positive pressure (0.60) on jassid population with temperature exerting a negative relationship (-0.262). Our findings are in agreement with findings of Shahid *et al* (2012) and partially in agreement with findings of Khan & Ullah (1994). However the slight variations from Khan and Ullah (1994) could be due to difference in materials and methods used.

Cotton stainer Population

Cotton stainers infestation started in the 3rd week of august 20th.08.2014 and gradually increased up to peak value of 10.5 stainers per plant in the last week of September 30th.09.2014 (Table 2). On average mean cotton stainers per plant were 4.70 and the population steadily increased up to 30th.12.2014. Incidence of stainer population showed a negative relationship with temperature and relative humidity (-0.322,-0.193) respectively (Table 3).our study confirmed findings by David S *et al* 1965 who reported cotton stainers (*Dysdercus fasciatus* Sign.) being hygrosensitive to both dry and moist air, but not to intermediate relative humidities.

Table.2: Fluctuation of sucking insect pest population on cotton in 2014 season

Months	Mites	Aphids	Whiteflies	Jassids	Stainers
1-Jul	0.69	0.85	0.4	0	0
10-Jul	5.25	9.80	1.45	0	0
20-Jul	7.42	8.70	5.32	0	0
30-Jul	8.36	26.2	5	0	0
1-Aug	14.5	39.2	6.64	0.96	0
10-Aug	20.9	23.1	6.43	0.75	2.3
20-Aug	19	30.2	22.3	2.2	3.3
30-Aug	26.9	38	35	5.2	4.5
1-Sep	38.4	35.1	10.8	6.08	5.3
10-Sep	13.3	20.4	3.5	9.6	8.6
20-Sep	20.6	18.4	11.5	10.5	8.5
30-Sep	25.5	21.5	22.5	5.3	10.5
1-Oct	28.4	26.5	18.9	12.1	7.2
10-Oct	35.3	29.6	20.6	17.5	5.4
20-Oct	25.5	24.1	18.2	14.2	9.3
30-Oct	6.5	19.2	17.5	8.6	8.9
1-Nov	10.3	36.3	11.6	10.3	5.5
10-Nov	23.1	7.2	20.3	6.1	6.8
20-Nov	30.3	8.5	22.1	3.1	4.3
30-Nov	5.5	4.1	11.2	1.8	9.3
1-Dec	0.64	2.3	10.9	6.8	5.8

10-Dec	0.28	0.56	17.6	3.55	5.6
20-Dec	0	0.35	18.4	4.7	3.3
30-Dec	0	0.52	12.3	1.75	2.5
Mean	15.3	17.95	15.6	5.24	4.70
P(0.05)	0.56	0.002	0.002	0.004	0.006

Table.3: Correlation between Temperature, Relative humidity and insect pest population on cotton in 2014 season

Parameters	**Temp.°C**	**RH%**
Mites	0.59*	-0.133
Aphids	0.256**	-0.59*
Whiteflies	0.312**	0.42
Jassids	-0.262**	0.60*
Stainers	-0.322**	-0.193

* Correlation is significant at $P \leq 0.05$; ** Correlation is significant at $P \leq 0.01$

IV. CONCLUSION

In the present research work a general investigation of the distribution of major cotton pests has been conducted, especially on the occurrence and the potential geographical distribution areas of these pests in Uganda with districts showing higher occurrences as hotspots for a particular pest ie, in our study, high aphid occurrences were observed in Kasese, Serere, Wakiso and Mpigi districts respectively, Stainers(Mukono ,Serere, Pallisa and Kasese districts),Mites showed higher occurrences in all the districts surveyed with highest counts of bollworms observed in Kasese and Pallisa districts.

Similarly, for the seasonal fluctuation study, mites (*Tetranychus urticae*), peaked (38.4 individuals per plant), in the first week of September, Aphids (38 individuals per plant) in the last week of August, White flies (35 individuals per plant) in the last week of August, Jassids (17.5 individuals per plant) in the second week of October, and stainers peaked (10.5 individuals per plant) in the last week of September.

These findings are of great relevance by providing base line data on the status of major cotton pests in terms of species distribution and abundance in cotton agro ecological zones of Uganda and provides a better understanding of how insect pest population dynamics and seasonal weather variation mechanism can fine-tune pest management strategies and response to pest attacks for adopting their IPM strategies. This study also focused on ecological principles that are cheap and sustainable, relying on need/timing for control of insect pests of the cotton crop

V. RECOMMENDATIONS

The districts surveyed appeared to be hot spots for a particular pest and farmers should now employ integrated pest management in order to reduce the pest pressure in their regions. This should be employed with proper timing of when a particular pest becomes a threat to the cotton crop based on the seasonal fluctuation data obtained.

We also recommend that in order to control major *cotton pests*, effectively, we should investigate their biological characteristics and ecology. Further still use of molecular methods to determine levels of genetic diversity and population genetic structure, which will contribute to the elucidation of the population structure and history of these pest should be investigated.

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