THE WORLD BANK

APPEALS PROJECT

AGRO-PROCESSING, PRODUCTIVITY ENHANCEMENT AND LIVELIHOOD IMPROVEMENT SUPPORT PROJECT

KANO STATE

A STUDY ON FARMERS' PERCEPTION, EXPERIENCE AND CAPACITIES ON:

INTEGRATED PEST MANAGEMENT ON RICE, TOMATO AND WHEAT IN KANO STATE, NIGERIA

DRAFT REPORT
Submitted to;
The State Coordinating Office;

AGRO-PROCESSING, PRODUCTIVITY ENHANCEMENT AND LIVELIHOOD IMPROVEMENT SUPPORT PROJECT (APPEALS), KANO STATE
BY

GULF AND INLAND LIMITED
No.6, Hamisu Abba Complex, Tarauni Quarters, Kano

MARCH 2020

A STUDY ON FARMERS' PERCEPTION, EXPERIENCE AND CAPACITIES ON:

INTEGRATED PEST MANAGEMENT ON RICE, TOMATO AND WHEAT IN KANO STATE, NIGERIA

DRAFT REPORT

Submitted to;

The State Coordinating Office;

AGRO-PROCESSING, PRODUCTIVITY ENHANCEMENT AND LIVELIHOOD IMPROVEMENT SUPPORT PROJECT (APPEALS), KANO STATE

BY

GULF AND INLAND LIMITED
No.6, Hamisu Abba Complex, Tarauni Quarters, Kano

March, 2020

Draft Report on;

A STUDY ON FARMERS' PERCEPTION, EXPERIENCE AND CAPACITIES ON:

INTEGRATED PEST MANAGEMENT ON RICE, TOMATO AND WHEAT IN KANO STATE, NIGERIA

Submitted to;

AGRO-PROCESSING, PRODUCTIVITY ENHANCEMENT AND LIVELIHOOD IMPROVEMENT SUPPORT PROJECT (APPEALS), KANO STATE

March, 2020

Prepared by:

GULF AND INLAND LIMITED

Agricultural value chain experts, Monitoring, Evaluation, Learning and Sharing Specialists & General Contractors.

Office Address: Block, A. No 16, Hamisu Abba Investment Complex, Tarauni Quarters, Kano, Kano state, Nigeria. gulfandinland@yahoo.com, www.gulfandinlandlimited.com

Table of Contents

List of Tables

List of Figures

ACRONYMS

ADPs	Agricultural Development Programs
EA	Extension Agents
FBO	Farmer Based Organization
FGDs	Focus Group Discussions
FOs	Farmer's Organizations
FTC	Farmers Training Center
KIIs	Key Informant Interviews
PHAP	Postharvest and Agro-processing
TOR	Terms of Reference

Executive Summary

This report gives a glance on reality check in the field and identification of the key issues in line with the study objectives which is the includes the identification of major pests for Kano state priority value chain (Rice, Wheat & Tomato), identify the existing legislations and farmers' perception about the use of chemicals for pest management. Assessment of farmers' experience in pest management and capacity on integrated pest management approach. Description of the pesticides banned for use in Nigeria, particularly those related to Rice, Wheat & Tomato) as well as those approved for use and identification of potential risk to users of pesticides and related safety measures

The sampling procedure used for the survey was a multistage in which the first stage involved a purposive selection of the focused LGAs. Six local government areas (LGAs) of Kano State were selected along the Rice, Wheat and Tomato value chain. These are Bagwai, Bunkure, Danbatta, Kura, Garun Malam, and Warawa. In all the LGAs. The second stage was 14 locations/villages which include; Dakasoye, Danhassan (Kura), Dorawar Sallau, Kadawa, Garun Babba, Kwanar Gafan (G/Malam), Bunkure, Shimar (Bunkure), Tomas (Danbatta), Gishiri Wuya, Larabar Gadon Sarki, Katarkawa (Warawa) and Bagwai (Bagwai) considered as communities focused by APPEALS project interventions. The last multi-stage sampling was a purposive selection of other stakeholders (Farmers and Farmer groups, Youth Groups, Traditional rulers) that are directly or indirectly involved in the project. Questionnaires and interview where used to collect data from the beneficiaries and Key Informant Interviews was used to collect the qualitative data from other stakeholders and key partners of the program. The study discovered some important findings under specific areas as follows

I. The survey deduced that rice, tomato and wheat production are agricultural activities solely overtaken and conducted by male that are within the active age capable of undertaking all the mental and physical activities. This could be attributable to the cultural gender roles of the people in the State, which assigns domestic roles and less rigorous activities that keep the females indoors. Majority of them attained a substantial level of formal education, which would allow them to apprehend and utilize innovations that would improve on their productivity. The rice, tomato and wheat farmers in the State found to have relatively large household sizes above the national average.

II. The survey revealed that, majority (>90%) of the Rice, Tomato and Wheat farmers experienced pest on their farm which implies that pest infestation is a serious problem

bedeviling farm production of the said crop in the study area. The infestation was at varying level of loss 30% of rice farmers lost (6% to 30%), 96% of tomato farmers lost (1% to 30%) and 61% of wheat farmers lost (1% to 15%) of their produces on the farm accordingly.

III. The study found that, despite the knowledge of traditional means of getting rid of pest as per the responses (57% Rice, 56% Tomato and 67% Wheat) the use of chemical in pest control is inevitable as opined by the majority (>90%) of all the farmers for the three crops (Rice, Tomato and Wheat)

IV. The study revealed that, farmers' experience in pest management and capacity on integrated pest management found the be below average. on the basis of their ability to read the directives of use, abiding by the directives of use, number of training received on IPM and quality methods of IPM trained on and expressed satisfaction with respect to the quality of the training.

V. The survey revealed that, most of fields visited were recently (1-2 days ago) sprayed one kind of agrochemical or another, so the number and type of insect sampled were limited. And the problem of pesticide resistivity is quite increasing, as the farmers are handicapped with knowledge of integrated pest management (IPM) as an option (cultural control and local plants with insecticidal effects etc.).

VI. It was observed in wheat that, Spittle Bugs (*Locris rubens*) which is endemic pests of sorghum (*S. bicolor* (L.) in Nigeria according is now becoming major pest in those areas. And it was observed through interviews that, a lot of pesticide gravely cases occurred between the farmers in most of these areas visited.

VII. The survey revealed complex disease situation prevails in which more than one disease is found in a farm and based on the interview with farmers during the survey we discovered indiscriminate application of pesticides and this is detrimental to the farmers, soil organisms, environment and consumers living mostly in urban areas. Most of them don't use protective equipment while spraying and even not aware of banned pesticides.

VIII. The survey observed that *C. rotudus* and *A. viridis* have established in both fields of tomato and wheat with highest relative abundance in most of local government areas. In addition, *P. oleraceae*, and *D. horizontalis* are becoming dominant weeds species of tomato plants. Similar *E. obstusifora* is one of the dominant weed species in wheat, although the study was conducted when wheat was at younger stage.

Recommendations

- This amount of loss is high and efforts to provide facilities that would reduce the level of loss due to pest infestation is necessary to reduce the level of the loss
- Future research is urgently needed to ascertain wither or not Spittle Bugs (*Locris rubens*) is become major pest of wheat at different stage of development (emergence, tillering, stem elongation, boot, heading/flowering, and grain-fill/ripening.) in Kano state.
- Training of farmers on the IPM options for the control of these pests is urgently needed to save them from total yield lost.
- A separate study should be conducted to ascertain the incidence and severity of Spittle Bugs (*Locris rubens*) in those irrigation areas visited. And An urgent training and awareness campaign should be conducted on the following

a) Detrimental effects of pesticides to the farmers, environment and natural enemies
b) Safe precaution before, after and during application
c) Personnel protective equipment
d) Awareness on the existence of Biological control agents and Biological control of insect pest

- Therefore, effective control management should encompass integrated diseases management that combines the use of more than one technique. No single method can effectively manage plant disease as such IPD is the most reliable techniques, based on this the following practices should be used as disease management package.

i) Deep ploughing of fields controls nematodes population, to expose pupae and resting stage of insect pests, popagules of soil borne pathogens.
ii) Soil solarization
iii) Use of resistant/tolerant varieties
iv) Timely sowing should be done.
v) Field sanitation, roguing.
vi) Destroy the alternate host plants
vii) Growing marigold as a repellent crop for the management of root-knot nematode.
viii) Crop rotation with non-cereals.
ix) Nutrient management especially organic manures and biofertilizers
x) Amend soil with 4.0 tons/ acre of compost at 2-3 week before sowing or vermicompost at 2.0 ton/acre at one week before sowing.
xi) Soil health improvement (mulching and green manuring)

xii) Apply well decomposed FYM to discourage termite infestation.

xiii) Treat the seed with recommended pesticides especially biopesticides

xiv) Avoid late sowing of crops.

xv) Follow proper spacing

xvi) Proper irrigation

xvii) Apply Carbofuran for nematodes control

xviii) For in-depth disease and pest assessment single field visitation to identify pests and diseases attacking wheat, rice and tomato is not enough as they affect plants at various stages of plants growth and also at both dry and rainy seasons. Therefore, the following points are suggested

i) Three surveys to be conducted at seedling, developmental and tillering/fruiting stages in both dry and seasons

ii) Training should be organized for farmers on the use of locally available materials as sustainable and eco-friendly approach to pests and disease

iii) Training on selection, handling and safety precautionary measures in the use of pesticides

- Further studies need to be carried out on the determinants of weed communities and the implication in the management of theses weeds. Works of this nature cannot be complete in one farming season and as such, further studies need to be carried out in order to establish a comprehensive list of weed species in the field as a step towards the establishment of an effective weed control Programme.
- It is important that farmers in these local government areas are educated through trainings on the basic principles of herbicides use and training should cover safety (personnel protective equipment), sprayer calibration, and the appropriate use of herbicides and awareness on the existence of Biological control agents and Biological control of weeds

SECTION ONE:

INTRODUCTION, BACKGROUND AND CONTEXT

1.0 Background of the Study

The study is an attempt to identify the Pests and disease vectors which constitute serious hazards to public health, food security and general welfare of the citizenry in Nigeria, particularly, Tomato, Rice and Wheat value chains selected for the state. It is estimated that agricultural pests destroy about 50 percent of crops, fruits, ornamental plants, vegetables and livestock annually. Household pests also destroy property such as furniture items, clothing, books, etc. Estimated cost of damage caused by pests runs into millions of Naira annually.

Considering the land mass required for the large-scale cultivation of crops, breeding and processing activities, there is undoubtedly the likelihood of infestation by pests. These forced farmers to use pesticides in an attempt to protect their crop production, breeding and processing activities. The practices resulted into either over-use or incorrect use hence creating residue which produce a threatening health condition for the farmers and the environment.

Pesticide residue is a very small amount of the pesticide, or its metabolites' or 'degradation products', which remain in the crop until after it is harvested. This can arise from; the use on a crop of legally allowed pesticides according to good agricultural practice – (leave smallest and acceptable amount of residue). Overuse of a pesticide, or use too close to harvest, of a legally permitted pesticide illegal use of a pesticide that is not approved for that crop and Incorrect use of pesticides after harvest, to reduce pest infestation in storage or in transit. Some of the excess pesticides contaminate soil, water and atmosphere. Human can be affected through; Dermal contact, Oral ingestion and Inhalation

The study will highlight workable combination and the best strategies of all control methods that apply to a problem created by the activities of pests in the production of priority value chains in the state. The survey will also identify potential risk to users of pesticides and related safety measures (water, soil, crop laboratory tests, and examination of farmer's health.

In line with World Bank Environmental and Social Safeguard Policies, an agricultural development project such as this will trigger World Bank's Operational Policy OP 4.09 (Pest Management), hence the need for an Integrated Pest Management Plan (IPMP) which is the suitable safeguard instrument for tackling pest management issues. Therefore, this study will serve as a bedrock IPMP of the priority value chains of Kano State.

1.1 Objectives of the survey

The overall objective of the IPM study is to disclose the practical manipulation of pest populations using sound ecological principles to keep pest populations below a level causing economic injury, with view to mitigate the potential risks of pesticides users in the state. The specific objectives are to:

- Identify major pests for Kano state priority value chain (Rice, Wheat & Tomato)
- Identify existing legislations and farmers' perception about the use of chemicals for pest management.
- Assess farmers' experience in pest management and capacity on integrated pest management approach.
- Describe pesticides banned for use in Nigeria, particularly those related to Rice, Wheat & Tomato) as well as those approved for use.
- Identify potential risk to users of pesticides and related safety measures.

Identifies institutional responsibility with regards to mitigation measures and monitoring indicators to be observed in order to evaluate the performance and effectiveness of the survey.

1.2 The Scope of the assignment

The proposed IPM study is to cover areas where the priority value chains (Rice, Wheat & Tomato) are produce in Kano State. The study will also assess the legislations and farmers' perception about pesticides, farmers' experience and capacity on integrated pest management approach

1.3 Findings and Analysis

The results from the survey unveiled a number of findings which include the Demographic and Socio – Economic Information of the respondents during the survey, Farmers' perception about the use of chemicals for pest management, Pest Infestation Experience, Level of Loss due to Pest infestations, Use of Traditional Methods of pest control, Farmers' consideration of chemicals uses for Pest management, Awareness of Health risks of Pesticides among Farmers, Identified effect of chemical pesticides at the study area, Protection during pesticide application, Pesticides and pesticides usage in the study area, Availability of Pesticides, Affordability of pesticides, Quality of the pesticides, Awareness about pesticides regulations and Farmers' Experience in Pest Management and Capacity on IPM among other things.

SECTION TWO:

SOCIO-ECONOMIC CHARACTERISTICS

2.0 Background of farmer's Socio-economics Characteristics

This section describes the socio-economic characteristics of rice, tomato and wheat farmers in kano state. Socio-economic variables are important human attributes that enhance the efficiency of crop production. They also assist in getting the clear understanding of the behaviors of the individuals as well as providing a hint towards explaining their disposition that could improve their productivity. The socio-economic variables identified include gender, age, marital status, level of education and household. These variables are presented in Tables below:

Table 1: Socio-economic characteristics of rice, tomato and wheat farmers in kano state.

Variables	**Rice**		**Tomato**		**Wheat**		**Pooled**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Gender								
Male	138	98.57	139	100	45	100	322	99.1
Female	2	1.43					2	0.6
Marital Status								
Single	20	14.6	16	11.68	2	4.44	38	11.7
Married	115	83.94	121	88.32	43	95.56	279	85.8
Widow	1	0.73					1	0.3
Divorced	1	0.73					1	0.3
Age								
18-30	36	25.53	15	10.78	6	13.33	57	17.5
31-40	46	32.62	50	35.97	11	24.44	107	32.9
41-50	29	20.57	48	34.53	12	26.67	89	27.4
51-60	25	17.73	14	10.07	9	20	48	14.8
Above 60	5	3.55	12	8.63	7	15.56	24	7.4
Level of Education								
No formal	19	13.48	23	16.55	3	6.67	45	13.8

Primary	24	17.02	30	21.58	9	20	63	19.4
Secondary	29	20.57	31	22.3	9	20	69	21.2
Tertiary	6	4.26	9	6.47	4	8.89	19	5.8
Qur`anic	63	44.68	46	33.09	20	44.44	129	39.7
Household size								
1 to 5	24	17.02	15	10.79	5	11.11	44	13.5
6 to 10	41	26.08	39	28.06	9	20	89	27.4
11 to 15	38	26.95	39	28.06	9	20	86	26.5
16 to 20	21	14.89	30	21.58	14	31.11	65	20.0
above 20	17	12.06	16	11.51	8	17.78	41	12.6

2.2 Gender of the Rice, Tomato and Wheat Farmers

Gender refers to the segregation of human beings according to their social roles as either male or female. The results are presented in Table 1 for rice, tomato and wheat farmers. Results revealed that about 99% of rice farmers in the State are male, implying that there is a relative paucity of female engagement in rice production. All tomato and Wheat farmers revealed to be male, implying that tomato production in the State is almost solely male dominated and there is no female engaged in wheat production in the State. With this it could be deduced that rice, tomato and wheat production are agricultural activities solely overtaken and conducted by male. This could be attributable to the cultural gender roles of the people in the State, which assigns domestic roles and less rigorous activities that keep the females indoors. However, females undertake outdoor activities in the farms such as planting, harvesting, threshing and assembling, which improve their livelihoods.

2.3 Age of the Rice, Tomato and Wheat Farmers

The age of rice, tomato and wheat farmers is the factor that may enhance the adoption of innovation. Younger and middle-aged individuals are known to be active and innovative. The results of the age of rice, tomato and wheat farmers are presented in Table 1 above. Results indicated that about 96% of the rice farmers are within the active age of labour supply, ranging from 18-60 years. However, majority of rice farmers (59%) fall within the agility period of 18-40 years. there is a trace of old farmers beyond 60 years (4%). Similarly results in Table 1 indicated that about 91% of the tomato farmers are within the active age of labour supply, ranging from 18-60 years. However, about (46%) of tomato farmers fall within the agility period of 18-40 years. there is a trace of old farmers beyond 60 years (8%). More so, 84% of the wheat farmers are within the active age of labour supply, ranging from 18-60 years. However, about 38% of wheat farmers fall within the agility period of 18-40 years. There is an appreciable number of old farmers beyond 60 years (16%).

The results indicated that there is a presence of young people in the production of rice, tomato and wheat in the State. Impliedly, they fall within the active age capable of undertaking all the mental and physical activities needed for producing rice, tomato and wheat in the State. Furthermore, they fall within the age that would enhance accurate, prompt and effective decision making. They are also expected to be in the position to effectively utilize available resources to them and may be keen in undertaking Integrated Pest Management.

2.4 Marital Status of Rice, Tomato and Wheat Farmers in the State

Marital status is another important socio-economic variable studied which may likely affect the level of labour availability. The greater number of wives one possesses, the more children he may likely bear, all things being equal, and the more family labour would available for him. The results of the marital status of the farmers are presented in tables 1. Results in Table 1 revealed that majority of rice farmers in the State (84%) were married. There is relative dominance of married individuals in rice farming in the State. Results also revealed that majority of tomato farmers in the State (88%) were married. There is relative dominance of married individuals in tomato farming in the State. More so, majority of wheat farmers in the State (96%) were married this shows There is relative dominance of married individuals in wheat farming in the State. The Results indicated that majority of rice, tomato and wheat farmers in the State were married and impliedly, majority of the farmers have family responsibilities bestowed on them in terms of financial and social commitments.

2.5 Educational Status of Rice, Tomato and Wheat Farmers

The educational status of the rice, tomato and wheat farmers allows them to easily understand and apply new practices, objects and techniques in the production processes, especially about Integrated Pest Management. The higher the level of one's education, the faster the rate of apprehension and application of an innovation. Results of the educational status of those farmers are presented in Table 1.

The result shows that about 42% of the rice farmers in the State have attained one form of formal education or the other at Primary, Secondary and Tertiary levels. Majority of rice farmers in the State (45%) have attained Quranic education, which is normal with any Islamic community. Only about 13% of the rice farmers who have not obtained any formal education.

Similarly, the results indicated that majority (50%) of tomato farmers in the State have attained one form of formal education or the other at Primary, Secondary and Tertiary levels. About (33%) of tomato farmers in the State have attained Qur'anic education, which is normal with any Islamic community. Only about 17% of tomato farmers have not obtained any formal education. The results indicated that majority (49%) of wheat farmers in the State have attained one form of formal education or the other at Primary, Secondary and Tertiary levels. About (44%) of wheat farmers in the State have attained Qur'anic education, which is normal with any Islamic community. Only about 7% of wheat farmers have not obtained any formal education.

Results in table have indicated that majority of rice, tomato and wheat farmers in the State have attained a substantial level of formal education, which would allow them to apprehend and utilize innovations that would improve on their productivity. These results indicate a clear improvement in the behavior of the farmers, who are dominantly living in rural areas but have embraced formal education. In a near future, all farmers in the State would attain at least, basic formal education. This would assist in obtaining required information about Integrated Pest Management in the area.

2.6 Household size of rice, tomato and wheat farmers

Household size refers to the total number of individuals who live within and feed from the same pot. According to the National Population Commission (NPC). These individuals think of themselves as a unit. The household size of rice, tomato and wheat farmers are presented in Tables 1 which revealed that rice farmers in the State have relatively large family sizes. This could be seen as 83% of rice farmers have household size beyond the national average of 5 as provided by the National Bureau of Statistics. Results in table 1 revealed that tomato farmers in the State have relatively large family sizes. This could be seen as 89% of tomato farmers have household size beyond the national average of 5 as provided by the National Bureau of Statistics.

Results in Table I revealed that wheat farmers in the State have relatively large family sizes. This could be seen as 89% of wheat farmers have household size beyond the national average of 5 as provided by the National Bureau of Statistics.

It could be deduced from the result that the rice, tomato and wheat farmers in the State have relatively large household sizes above the national average. But it is normal to have such large household sizes in the Northern part of Nigeria. The high number of household size could be due to the fact that farmers in the study area practice polygamy and having large household size is a source of pride and a compelling force to produce more output by the household head in the farms.

SECTION THREE:

FARMERS' PERCEPTION ABOUT THE USE OF CHEMICALS FOR PEST MANAGEMENT

3.1 Farmers Experience in Pest Infestations

Table 2: Background information on pest and pest infestation

Items	Rice		Tomato		Wheat		Pooled	
Pest Infestation Experience	F	%	F	%	F	%	F	%
Not Experience Pest infestation	6	4.26	14	10.07	4	8.89	24	7.38
Experience Pest infestation	135	95.74	125	89.93	41	91.11	301	92.62
Level of Loss								
0%-15%	92	66.19	79	58.09	27	61.36	198	60.92
16%-30%	47	33.81	52	38.24	13	29.55	112	34.46
31%-45%	-	-	1	0.74	2	4.55	3	0.92
46%-60%	-	-	4	2.94	1	2.27	5	1.54
Above 60	-	-	-	-	1	2.27	1	0.31
Use of Traditional Methods of Pest Control								
No	64	57.14	61	55.96	22	66.67	147	45.23
Yes	48	42.86	48	44.04	11	33.33	107	32.92
Use of Chemicals for Pest Management								
No	2	1.43	3	2.24	2	4.76	7	2.15
Yes	138	98.57	131	97.76	40	95.25	309	95.08

3.2 Pest Infestation Experience

Results in table 2 indicated that majority of the farmers' Rice (96%), Tomato (90%) and Wheat (91%) experienced pest infestations in the study area. This implies that pest infestation is a serious problem bedeviling farmers of the three value chains and they must be using traditional or chemical methods of pest control.

Common Pests report by the respondent indicates Rice farms suffers from diseases like Rice blast (tsatsa) (*Pyricularia oryzea*) and Rice rust (*Puccinia graminis)*, insects/ worms (grasshopper, *tsutsa*), weeds (*Digitaria spp*, *harkiya*: *Cynadon dactylon, Kir-kiri*. More so, Tomato farms suffers from Anthracnose *(Colletotrichum capsici)*, Insects such as Sharon *(Tuta absoluta)*.

3.3 Level of Loss due to Pest infestations

Farmers record a lot of loss in rice production. Results of the study in Table 2 reveals that majority of rice farmers in the study area (66%) record loss of 1% to 15%, while about 34% of the farmers record a loss of 16% to 30%. This result however, shows that 1% to 30% of rice produced is lost every year as a result of pest infestations. This amount of loss is high and efforts to provide safe pesticides that would reduce the level of loss should be intensified. Farmers record a lot of loss in tomato production. Results of the study in Table 2 reveals that majority of tomato farmers in the study area (58%) record loss of 1% to 15%, while about 38% of the farmers record a loss of 16% to 30% and about 3% record a loss of 46% to 60%. This result however, shows that 1% to 30% of tomato produced is lost every year. This amount of loss is high and efforts to provide safe pesticides that would reduce the level of loss should be intensified.

Farmers record a lot of loss in wheat production due to pest and diseases infestations. Results of the study in Table 2 reveals that majority of wheat farmers in the study area (61%) record loss of 1% to 15%, while about 30% of the farmers record a loss of 16% to 30% and about 5% record a loss of 31% to 45%. This result however, shows that 0% to 45% of wheat produced is lost every year. This amount of loss is high and efforts to provide facilities that would reduce the level of loss due to pest infestation is necessary to reduce the level of the loss.

3.4 Use of Traditional Methods of pest control

Results in Table 2 reveals that majority of rice farmers (57%) use traditional methods of pest control available in the study area. This implies that the farmers have a local knowledge of the control methods and they still utilize them. Results in the same table shows that, majority of tomato farmers (56%) use traditional methods of pest control available in the study area. This implies that the farmers have a local knowledge of the control methods and they still utilize them. Results similar table reveals that majority of wheat farmers (67%) use traditional methods of pest control available in the study area. This implies that the farmers have a local knowledge of the control methods and they still utilize them.

3.4 Farmers' consideration of chemicals uses for Pest management

Results in Table 2 reveal that almost all rice farmers in the study area (99%) believe that the use of chemical is necessary for pest management. So also, tomato farmers in the study area (98%) believe that the use of chemical is compulsory for pest management. Likewise, wheat farmers, in which results in Table 2 reveal that majority of them in the study area (95%) believe that the use of chemical is obligatory for pest management.

Table 3: Awareness of Health risks of Pesticides among Farmers

Items	Rice		Tomato		Wheat		Pooled	
Risk awareness	F	%	F	%	F	%	F	%
No	6	4.35	4	2.99	5	12.2	15	4.62
Yes	132	95.65	130	97.01	36	87.8	298	91.69
perception on quality of pesticides								
Yes	118	85.51	97	78.86	24	66.67	239	73.54
No	20	14.49	26	21.14	11	21.14	57	17.54
Availability of pesticides								
Adequate	121	93.08	114	96.61	32	94.12	267	82.15
Inadequate	9	6.92	4	3.39	2	5.88	15	4.62
Affordability of pesticides								
No	51	37.23	64	48.48	20	48.78	135	41.54
Yes	86	62.77	68	51.52	21	51.22	175	53.85
Rate Pesticide use								
High	88	63.31	69	51.88	19	46.34	176	54.15
Moderate	46	33.09	59	44.36	20	48.78	125	38.46
Low	5	3.6	5	3.76	2	4.88	12	3.69

Results in Table 3 reveal that almost all rice farmers in the study area (96%) are aware that the use of chemicals for pest management is associated with health risks. Therefore, rice farmers are aware that as they use the chemical pesticides, they could be inflicted with one health risk or the other. Similarly, results in Table 3 reveal that (97%) of tomato farmers in the study area are aware that the use of chemicals for pest management is associated with health risks. Therefore, tomato farmers are aware that as they use the chemical pesticides, they could be inflicted with one health risk or the other. And for the wheat farmers, results in Table 3 reveals that majority of wheat farmers in the study area (87%) are aware that the use of chemicals for pest management is associated with health risks. Therefore, wheat farmers are aware that as they use the chemical pesticides, they could be inflicted with one health risk or the other.

3.5 Identified effect of chemical pesticides at the study area

The observed effects of pesticide, particularly when applied without full protective clothing according to the farmers include itching (42%), abdominal pain (25%), vomiting (21%), diarrhea (7%) and nausea (5%). Impliedly, itching and abdominal pain are the most observed effects and health risks of pesticide application to the farmers without proper protective clothing.

This is indicating direct farmers exposure to pesticides on their skin and also direct inhalation into their stomach which required measures.

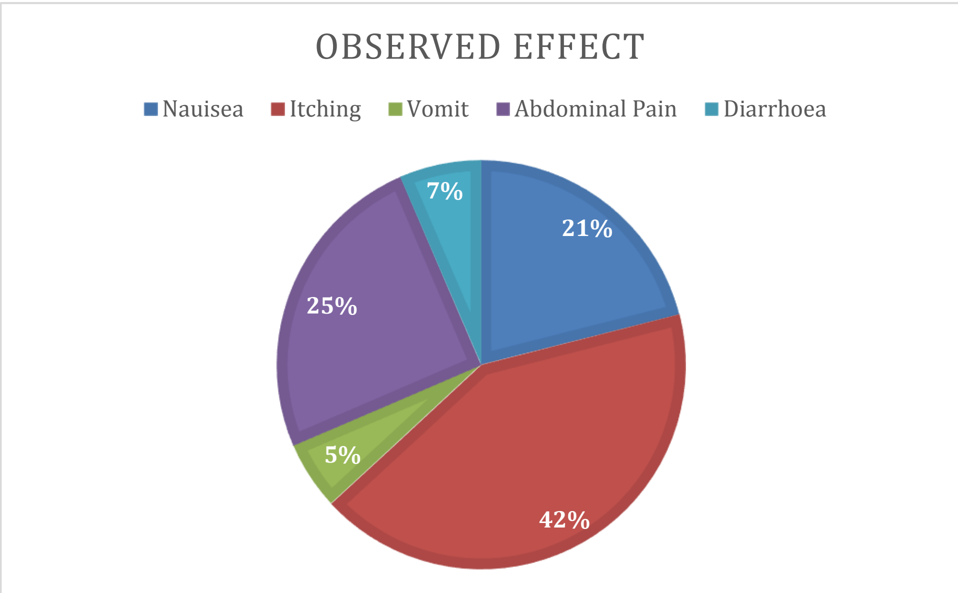


Figure 1: Observed effect of Pesticide on Human

3.6 Protection during pesticide application

Table 4: Use of protective clothing

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
			Rice		
Goggle	20	1.05	0.2236	1	2
Glove	26	1.5769	0.5038	1	2
Coats	8	2.75	0.7071	1	3
Boot	27	2.6666	1.5191	1	4
Hand veils	15	1.8	1.6561	1	5
			Tomato		
Glove	79	1.0379	0.1923	1	2
Coats	32	1.0625	0.3535	1	3
Boot	96	1.1562	0.6700	1	4
Head veils	63	1.1904	0.8586	1	5
			Wheat		
Goggle	20	1.05	0.2236	1	2
Glove	26	1.5769	0.5038	1	2
Coats	8	2.75	0.7071	1	3
Boot	27	2.6666	1.5191	1	4
Hand veils	15	1.8	1.6561	1	5

Results in Table 4 revealed that only few of the farmers of Rice in the study area use rain boot during pesticide application for protection. Other protective materials they use in order of usage include hand gloves, head veils, eye goggles and coats. Results in Table 4 revealed only small number of tomato farmers in the study area use rain boot during pesticide application for protection. Other protective materials they use in order of usage include hand gloves, eye goggles, head veils and coats. Results in Table 4 reveal that majority of wheat farmers in the study area use rain boot during pesticide application for protection. Other protective materials they use in order of usage include hand gloves, eye goggles, head veils and coats.

3.7 Pesticides and pesticides usage in the study area

3.7.1 Rating the use of chemical pesticides in farms

The results in Table 5 revealed that majority of rice farmers in the study area (63%) rated the use of chemical pesticides in the farms as high, while 33% of the farmers rated the use of the chemical pesticides as moderate. The results in Table 5 revealed that majority of tomato farmers in the study area (52%) rated the use of chemical pesticides in the farms as high, while 44% of the farmers rated the use of the chemical pesticides as moderate, while 4% of the farmers rated the use of chemical pesticides as low. The results in Table 5 revealed that majority of tomato farmers in the study area (49%) rated the use of chemical pesticides in the farms as moderate, while 46% of the farmers rated the use of the chemical pesticides as high, while 5% of the farmers rated the use of chemical pesticides as low.

Table 5: Pesticides and pesticides usage in the study area

	Rice		Tomato		Wheat		Pooled	
Risk awareness	F	%	F	%	F	%	F	%
No	6	4.35	4	2.99	5	12.2	15	4.62
Yes	132	95.65	130	97.01	36	87.8	298	91.69
perception on quality of pesticides								
Yes	118	85.51	97	78.86	24	66.67	239	73.54
No	20	14.49	26	21.14	11	21.14	57	17.54
Availability of pesticides								
Adequate	121	93.08	114	96.61	32	94.12	267	82.15
Inadequate	9	6.92	4	3.39	2	5.88	15	4.62
Affordability of pesticides								
No	51	37.23	64	48.48	20	48.78	135	41.54
Yes	86	62.77	68	51.52	21	51.22	175	53.85
Rate Pesticide use								
High	88	63.31	69	51.88	19	46.34	176	54.15
Moderate	46	33.09	59	44.36	20	48.78	125	38.46
Low	5	3.6	5	3.76	2	4.88	12	3.69

3.7.2 Availability of Pesticides

Majority of the rice farmers in the study area (93%) have indicated that the availability of pesticide in the area is adequate. Only about 7% of the farmers indicated that the pesticide is inadequately available. Majority of the tomato farmers in the study area (97%) have indicated that the availability of pesticide in the area is adequate. Only about 3% of the farmers indicated that the pesticide is inadequately available. Majority of the wheat farmers in the study area (94%) have indicated that the availability of pesticide in the area is adequate. Only about 6% of the farmers indicated that the pesticide is inadequately available.

3.7.3 Affordability

Majority of the rice farmers in the study area (63%) have indicated that the pesticide in the area is cheap and affordable. Only about 37% of the farmers indicated that the pesticide is not cheap and affordable. Majority of the tomato farmers in the study area (52%) have indicated that the pesticide in the area is cheap and affordable. Only about 48% of the farmers indicated that the pesticide is not cheap and affordable. Majority of the wheat farmers in the study area (51%) have indicated that the pesticide in the area is cheap and affordable. But about 49% of the farmers indicated that the pesticide is not cheap and affordable.

3.7.4 Quality of the pesticides

Majority of the rice farmers in the study area (86%) have rated the quality of the pesticides they use as high, implying that the pesticides available to them are of good quality in averting the menace of pest infestations. Only about 14% of the farmers rated the quality of the pesticides as low. Majority of the tomato farmers in the study area (79%) have rated the quality of the pesticides they use as high, implying that the pesticides available to them are of good quality in averting the menace of pest infestations. Only about 21% of the farmers rated the quality of the pesticides as low. Majority of the what farmers in the study area (67%) have rated the quality of the pesticides they use as high, implying that the pesticides available to them are of good quality in averting the menace of pest infestations. Only about 21% of the farmers rated the quality of the pesticides as low and about 3% rated it as poor.

3.7.5 Using chemical pesticides would improve yield

The result from figure 2 indicated that (99%) of rice farmers and (100%) of wheat and tomato opined that using chemical pesticides would improve the quantity of rice produced in the study area without which serious damage and loss would be recorded. Although, all the rice, Tomato and Wheat farmers in the study area (100%) are aware about the existence of pest regulations.

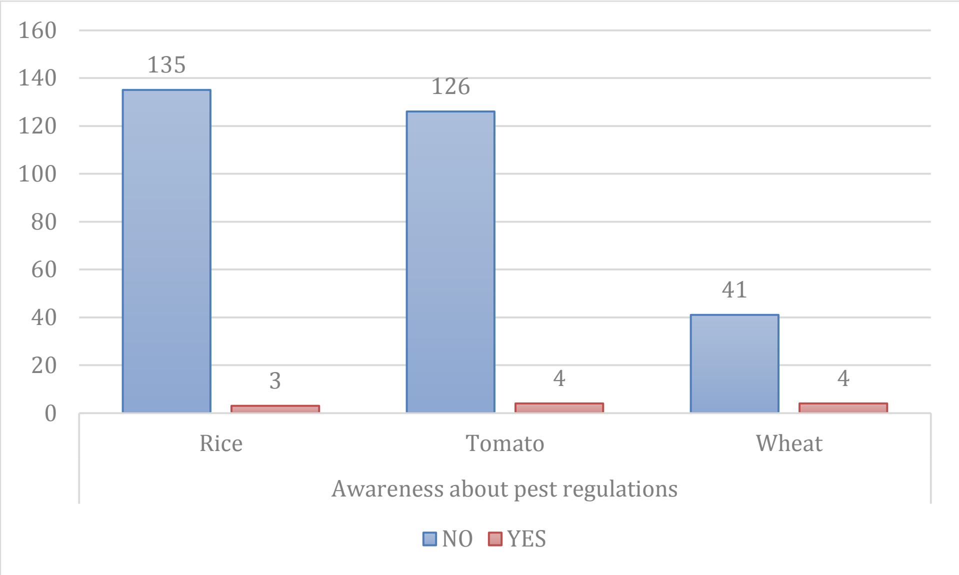


Figure 2: Awareness about pesticides regulations

SECTION FOUR:

FARMERS' EXPERIENCE IN PEST MANAGEMENT AND CAPACITY ON IPM

4.0 Background

The farmers' experience in pest management and capacity on integrated pest management were assessed on the basis of their ability to read the directives of use, abiding by the directives of use, number of training received on IPM and quality methods of IPM the farmers were trained on and satisfaction of expressed by the farmers with respect to the quality of the training.

4.1 Reading the directions for use on the container

Results in Table 6 revealed that majority of rice farmers (60%) could not read the directions for use provided on the pesticide containers. Only about 40% of the rice farmers could read the directions for use. Results in Table 6 revealed that majority of tomato farmers (67%) could not read the directions for use provided on the pesticide containers. Only about 33% of the tomato farmers could read the directions for use. Results in Table 6 revealed that majority of wheat farmers (52%) could read the directions for use provided on the pesticides containers. Only about 47% of the wheat farmers could not read the directions for use.

Table 6: Reading the directives for use

Reading the directives for use			
Reading directives for use	**Rice**	**Tomato**	**Wheat**
No	**59.69**	**66.92**	**47.37**
Yes	**40.31**	**33.08**	**52.63**

4.2 Farmers abiding by the directives for use

Figure 3 revealed that, majority of farmers producing rice (95%) abide by the directives of use provided on the containers of the chemical pesticides. Only 5% of them do not abide by the directives according to their responses. Majority of farmers producing tomato (72%)

abide by the directives of use provided on the containers of the chemical pesticides. About 28% of them do not abide by the directives.

Majority of farmers producing wheat (74%) abide by the directives of use provided on the containers of the chemical pesticides. About 26% of them do not abide by the directives.

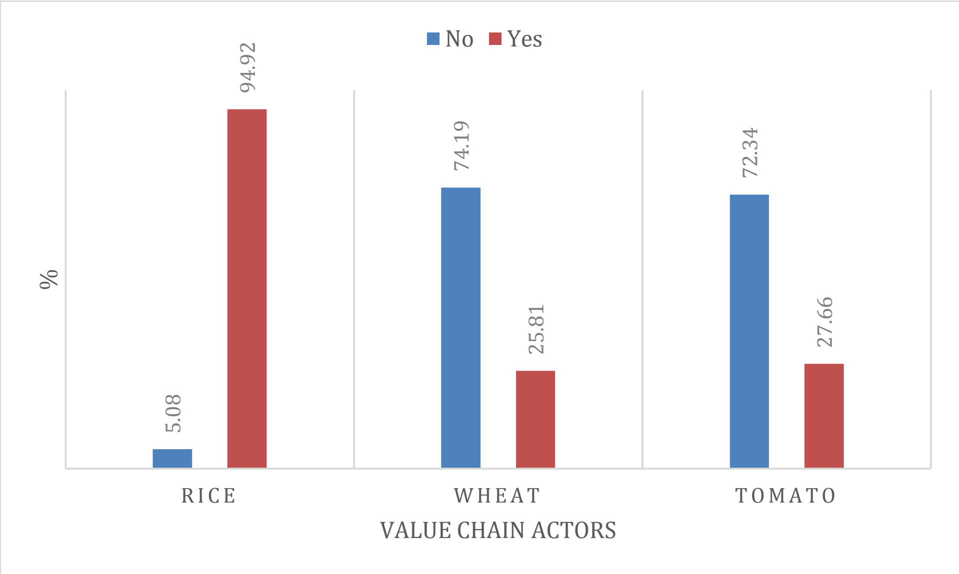


Figure 3: Value Chain Actors

4.3 Organizations providing training on IPM

Majority of the farmers producing rice, tomato and wheat in the study area (94%) received training on IPM from Sasakawa, 89% were trained on IPM by FADAMA III project, while about 70% of the farmers were trained on IPM by KNARDA as given in figure 4.

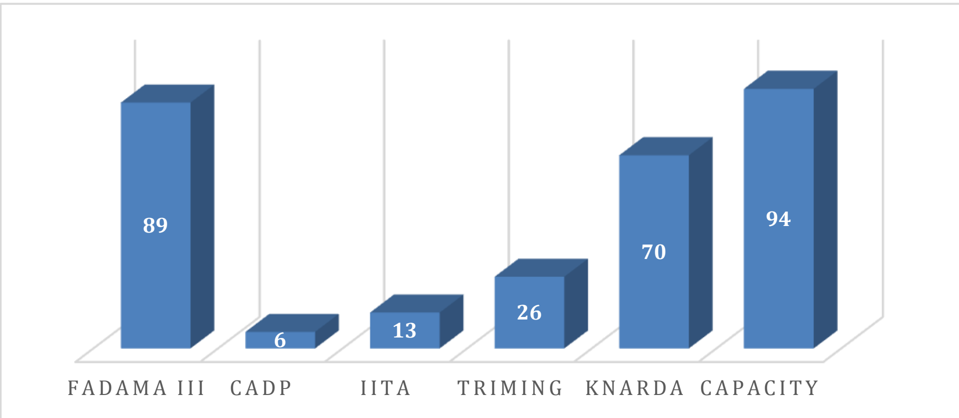


Figure 4: Training Providers

4.4 Capacity at the training

Majority of the rice farmers (58%) received IPM training as trainers. Impliedly, they were trained to train other farmers on IPM. About 42% of the rice farmers received training as trainees. Majority of the tomato farmers (57%) received IPM training as trainees. Impliedly, they were trained to apply what they learnt on IPM. About 43% of the tomato farmers received training as trainers to train other farmers.

Table 7: Capacity Development

	Rice	Tomato	Wheat
Trainer	**57.69**	**42.86**	**-**
Trainee	**42.14**	**57.14**	**-**

The farmers received training on seed dressing, rogueing, farm hygiene, crop rotation and burning in order of intensity. The farmers practiced the IPM they were trained on in the following hierarchy: seed dressing, crop rotation, farm hygiene and burning.

Table 8: Methods of IPM the farmers were trained and practice level

Training Received	Training Received	PRACTICE
Seed Dress	140	139
Crop Rotation	77	96
Rogueing	96	-
Burning	68	82
Farm Hygiene	86	92
Other Method	83	99

4.5 Adequacy of training

Results in Table 9 revealed that 91% of rice farmers rated the training they received on IPM as adequate. Only about 6% rated the training as inadequate. Results in Table 9 revealed that 91% of tomato farmers rated the training they received on IPM as adequate. Only about 4% rated the trainings as inadequate. Results in Table 9 revealed that 80% of wheat farmers rated the training they received on IPM as adequate. Only about 20% were undecided.

Table 9: Farmers Level of Satisfaction with the training

	Rice	Tomato	Wheat
Adequate	**91.04**	**91.18**	**80.00**
Inadequate	**5.97**	**4.41**	**-**
Undecided	**2.99**	**4.41**	**20.00**

SECTION FIVE:

INSECT PESTS OF WHEAT, RICE AND TOMATO IN SOME SELECTED IRRIGATION AREAS OF KANO, NIGERIA

5.0 Background on Insect Pest

The aims and objective of this survey is to identify major insect pest of rice, wheat and tomato value chain in some selected irrigation areas of Kano state, under the project titled "integrated pest management study for rice, wheat and tomato production in Kano state". This is sponsored by Agro-processing, Productivity Enhancement and Livelihood Support (APPEALS) Project which is a World Bank funded project prepared by Federal Ministry of Agriculture and Rural Development. Six local government areas (LGAs) of Kano State were selected in along the Rice, Wheat and Tomato value chain. In all the LGAs, 14 locations were visited and 1-3 farms each for Rice, Tomato and wheat was randomly selected for insect collection/sampling. In each farm, 3 replications in form of quadrant of $1m^2$ were randomly selected for sampling. Three methods of trapping the insects were employed, namely hand capture for wingless insects, sweep nets for flying insects and aspirators. The results show that, in tomato fields, some of the major insect pest identified includes Spittle Bugs (*L. rubens*), Rusted red Flour beetle (*A. diaperinus*), Tomato fruit borer (*H. armigera*), Two-spotted red spider mite (*T. urticae*), White Flies (*B. Tabaci*), Tomato Leaf miner (*T. absoluta*) and Greenhouse White flies (*T. vaporanum*). Whereas in wheat, seven insect species were identified, these include Carolina Grasshopper (*Dissostera corolina*), Long headed grasshopper (*L. migrotoria*), Spittle bugs (*L. Rubens*), Pointed lady moth (*V. cardui*), White flies (*B. tabaci*), Mole cricket (*N. abbreviatus*) and Rusted red Flour Beetle (*A. diaperinus*). It was observed in wheat that, Spittle Bugs (*L. rubens*) which is endemic pests of sorghum (*S. bicolor*) in Nigeria according is now becoming major pest in those areas. According to previous studies, the major pests of rice in Kano are African rice gall midge (AfRGM) *O. oryzivora*, stem borer species, Pink stem borers *Sesamia* spp., African yellow stem borers *Scirpophaga* spp, Stalk-eyed shoot flies *Diopsis* spp., Rice Army worm *Mythimna separata.* The farmers complained bitterly on the increase in pesticides resistance, as resulted in drastic decrease in their yield. We recommend repeating these studies at 2 weeks after transplanting, during flowing and fruiting and also before harvesting. Training should also be organized for the farmers on safety precautions of pesticides and integrated pest management practices.

5.1 Methodology

5.1.1 Study area and sampling sites

The study was conducted in some irrigation areas of Kano state. Six local government areas (LGAs) of Kano State were selected along the Rice, Wheat and Tomato value chain. These are Bagwai, Bunkure, Danbatta, Kura, Garun Malam, and Warawa. In all the LGAs, 14 locations/villages were visited which include; Dakasoye, Danhassan (Kura), Dorawar Sallau, Kadawa, Garun Babba, Kwanar Gafan (G/Malam), Bunkure, Shimar (Bunkure), Tomas (Danbatta), Gishiri Wuya, Larabar Gadon Sarki, Katarkawa (Warawa) and Bagwai (Bagwai). The sizes of the farms studied are irregular; however it ranged between 0.5 and 1.5 ha. In each location/village, 1-3 farms each for Tomato and wheat were randomly selected for insect collection/sampling. Each farm, 3 replications in form of quadrant of 2m x 2m were randomly selected and used for sampling/collection.

5.1.2 Sample collection

Insect samples were collected from the quadrant after quick visual count of the insects on the plants (where possible), and taken to the laboratory for identification. Three methods of trapping the insects were employed, namely hand capture; for wingless insects, larvae and slow-moving insects. Sweep nets for flying insects and aspirators for collecting tiny insects. Polythene bags, specimen tubes and rearing jars were used to transfer the insects to the laboratory and Ethyl acetate was used to preserve them for identification at Entomology Laboratory, Department of Crop Protection, Bayero University Kano (Imam *et al*., 2010).

5.2 Insect pest identification and quantitative assessment

Morphological identification of insect species was done using hand lens, and utilizing identification keys (Zim and Cottam, 2000; Imam *et al*., 2010; Mailafiya *et al*., 2014; Macharia *et al*., 2016). They were then placed into their respective groups. The infestation level was determined based on the degree of damage caused to plant as described in the scale of infestation by RuchikaKataria and Dolly Kumar, (2012).

5.2.1 Data Analysis

Data obtained from the study areas were subjected to descriptive statistics of mean and percentages (%) as described by RuchikaKataria and Dolly Kumar, (2012). Relative abundance was calculated using the following formula;

Relative abundance = Total Number of Individual species / divided by Total Number of Species Population X 100.

5.3 Results and Discussion

The results of insect pest survey for the purpose of identification of the insect's pest of Tomato and Wheat value chain along irrigation areas of Kano State were presented in **Table 1-3** and **Figure 1-2**. In **Table 1** the insect pests associated with tomato in six local government areas of Kano state were identified morphologically with reference to Zim and Cottam, (2000), Imam *et al*., (2010) Mailafiya *et al*., (2014), Macharia *et al*., (2016) works and identified insect collections deposited at Entomology lab., Department of Crop Protection, Bayero University, Kano. The infestation based on presence or absence of insect pests and the severity using one to four scale of infestation. In this table, we were able to identified 16 insects species, among which some are major pest, minor pest, pollinators, vectors and natural enemies (**Table 1**). The major insect pests in our study include; Spittle Bugs (*Locris rubens*), Rusted red Flour beetle (*Alphitobius diaperinus*), Tomato fruit borer (*Helicoverpa armigera*), Two-spotted red spider mite (*Tetranychus urticae*), White Flies (*Bemisia Tabaci*), Tomato Leaf miner (*Tuta absoluta*) and Greenhouse White flies (*Trialeurodes vaporanum*). In Figure 1, the percentage composition of insect's orders within tomato agro ecosystem in Kano state were maximum from order Lepidoptera 28 %, followed by order Homoptera 19 % and Orthoptera 13 %. The least was recorded on both Hymenoptera and Hemiptera. As shown in Table 3, Tomato fruit borer *H. armigera* (18.75 %) and White flies *B. tabaci* (16.63 %) appeared to be more abundant than other. However, the relative abundance of Dragon flies *M. ishaidai*, Tomato leaf miner *T. absoluta*, Two-spotted red spider mite *T. urticae*, Mole Cricket *N. abbreviates* and Rusted red Flour beetle *A. diaperinus* are 9.38, 9.38, 9.38, 6.25 and 6.25 % respectively.

In **Table 2**, seven insect species were identified in Wheat value chain along irrigation areas of Kano State, these include Carolina Grasshopper (*Dissostera corolina*), Long headed grasshopper (*Lucusta migrotoria*), Spittle bugs (*L. Rubens*), Pointed lady moth (*Venessa cardui*), White flies (*B. tabaci*), Mole cricket (*N. abbreviatus*) and Rusted red Flour Beetle (*A. diaperinus*). Out of these insects, some are major pests, while others are vectors and pollinators as shown in both Table 2 and Table 3. The percentage composition of insect's orders within Wheat agro ecosystem in Kano state as presented in **Figure 2** which includes order Homoptera 50 %, Orthoptera 38 %, Lepidoptera 6 % and Coleoptera 6 %. The relative abundance of individual's species of Wheat is reported in Table 3 and these includes; Spittle bugs (*L. rubens*) 27.78 %, long headed grasshopper (*L. migrotoria*) 16.67 %, Corolina grasshopper (*D. corolina*) 11.13% etc. It should be noted that, the survey was conducted when wheat was at younger stage, few days after transplanting. The number of insect pests collected during this study can't stand as the only insect pest scenario on wheat from transplanting of harvesting. Future study should be design at 3 stages of wheat growing period.

For rice plant that was not present at the time of the study, we consulted literatures on the previous studies conducted on the major insect pests of rice in Kano and Nigeria at large. According to Ogah and Nwilene (2016), the rice plant is an ideal host for a large number of insect pests-root feeders, stems borers, leaf feeders and grain feeders. These includes African rice gall midge, *Orseolia oryzivora* Harris and Gagne, African striped rice borer, *Chilo zacconius* Bleszynski, African white borer, *Maliarpha separatella* Ragonot, African pink borers, *Sesamia calamistis* Hampson, Rice caseworm, *Nymphula depunctalis* Guenée, Rice leaf folders, *Marasmia trapezalis* Guenée, African rice hispids, *Trichispa sericea* Guerin-Meneville, Rice whorl maggot and *Hydrellia prosternalis* Deeming. However, according to another report, the major pests of rice in Kano are African rice gall midge (AfRGM) *O. oryzivora*, stem borer species, Pink stem borers *Sesamia* spp., African yellow stem borers *Scirpophaga* spp, Stalk-eyed shoot flies *Diopsis* spp., Rice Army worm *Mythimna separata* (Alam, 2008). It is recommended that periodic surveys continue, in order to monitor the dynamic changes occurring in rice pests in the varied locations of Kano irrigation area.

Discussion

This study presented basic information on insect infestation of tomato and wheat value chain along irrigation areas in six local government areas of Kano state. In these areas, tomato and wheat are produced in commercial quantities and supplied to Kano city, as well other part of the country. However, during our survey, we collected and identified quite number of insect pests, some of which are known as the major insect pests of these crops, especially tomato. In tomato fields, some of the major insect pest identified includes Spittle Bugs (*L. rubens*), Rusted red Flour beetle (*A. diaperinus*), Tomato fruit borer (*H. armigera*), Two-spotted red spider mite (*T. urticae*), White Flies (*B. Tabaci*), Tomato Leaf miner (*T. absoluta*) and Greenhouse White flies (*T. vaporanum*). The farmers complained bitterly on the increase in pesticides resistance, as resulted in drastic decrease in their yield. Also, most of the tomato fields visited is at fruiting stage, some have even stated harvesting. Contrarily, in some areas like Gurdo, Bagwai LGA, the fruits are damaged by *H. armigera*, leaving behind little or nothing to harvest. In the same area, there is severe infestation of Tomato leaf miner, and nothing was done by the farmers to stop the damage, because tiny larvae are mining in between the leaf sheath, which protect it from toxic effect of insecticide. At Kadawa irrigation area, the story is quite different, as white flies ravaged the entire leaf area of most of the tomato fields visited. According to the farmers, the infestation is fast spreading and we speculate spread of virus diseases in those areas. In almost all the area visited, we collected samples of Corolina Grasshopper and Stink bug which are minor and major pest respectively. However, not all the insect collected are pest of tomato, some such as Monarch Butterflies and Purple –Short Copper serves as pollinator. Other such as Dragon flies are known to be natural enemies of insect pests.

In Wheat producing areas, the most abundant insect species collected is Spittle Bugs (*Locris rubens*) which is endemic pests of sorghum (*Sorghum bicolor* (L.) in Nigeria according to Ajayi O. and Oboite F. A., (2000). Though, the wheat plants visited in most farms are at tillering and stem elongation stages (younger stage). The second most abundant insect pests of wheat are long headed grasshopper (*Lucusta migrotoria*) and Corolina grasshopper (*Dissostera corolina*). The type and extent of grasshopper injury to above- and below ground plant parts for wheat (*Triticum aestivum* L.) were observed in some locations. White flies' infestation (*Bemisia tabaci*) was also observed to some extend in Kadawa irrigation area.

Table 10: Summary of the Insect Collected on Tomato Field

LGAs	Study Area	Insect Order	Common Name	Specific Name	Pest Status	Infestation Level
Kura	Danhassan	Homoptera	Spittle Bugs	*Locris rubens*	Major pest	3
		Coleoptera	Rusted red Flour beetle	*Alphitobius diaperinus*	pest/ Vector	3
		Orthoptera	Corolina Grasshopper	*Dissostera corolina*	Minor Pest	1

		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
G/Malam	Kadawa	Homoptera	White Flies	*Bemisia Tabaci*	Vector, Pest	3
		Lepidoptera	Monarch Butterflies	*Danaus Plexeppus*	Pollinator	1
	Dorawar Sallau	Orthoptera	Mole Cricket	*Neoscaptericus abbreviates*	Pest	1
	Gafan	Odonata	Dragon Flies	*Macromidia Ishaidai*	Natural Enemy	2
	Garin Babba	Coleoptera	Rusted red flour beetle	*Alphitonius diaperinus*	Vector/pest	3
		Orthoptera	Mole Cricket	*Neoscaptericus abbreviates*	Pest	1
		Homoptera	White Flies	*Bemisia Tabaci*	Vector/Pest	3
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
Danbatta	Thomas	Lepidoptera	Purple – Short Copper	*Lyacaena alciphron*	Pollinator	1
		Odonata	Panted lady moth	*Venessa cardin*	Minor pest	2
		Coleoptera	Dragon Flies	*Bactra lancaelana*	Natural enemy	1
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Homoptera	White flies	*Bemisia tabaci*	Major Pest	3
		Lepidoptera	Tomato Leaf miner	Tuta absoluta	Major Pest	3
Bagwai	Gurdo	Orthoptera	Carolina Grasshopper	*Dissostera carolina*	Minor pest Pollinator/	1

		Hymenoptera	Saw flies	*Tenihendi mesonde*	minor pest	1
		Odonata	Dragon flies	*Epiophlebia superstes*	Natural Enemy	2
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Homoptera	White flies	*Bemisia tabaci*	Major Pest	3
		Lepidoptera	Tomato Leaf miner	*Tuta absoluta*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
Bunkure	Bunkure	Hemiptera	Greenhouse white flies	*Trialeurodes vaporanum*	Major pest	3
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
Warawa	Larabar Gadon sarki	Lepidoptera	Panted lady moth	*Venessa cardui*	Pollinator	1
		Hymenoptera	German wasp	*vespule Gemanica*	Pollinator	1
		Hemiptera	Stink bug	*Hlyomorpha halys*	Major pest	3
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
	Gishiri wuya	Homoptera	White flies	*Bemisia tabaci*	Vector/pest	3

Infestation scale/grade: 0 = no insect indecently seen, 1 = Scattered appearance of few insect on the plant, 2 = severe incidence of insect pest on only one branch, 3 = severe incidence of insect pest on more than 1 branch, 4 = severe incidence of insect on whole plant was recorded

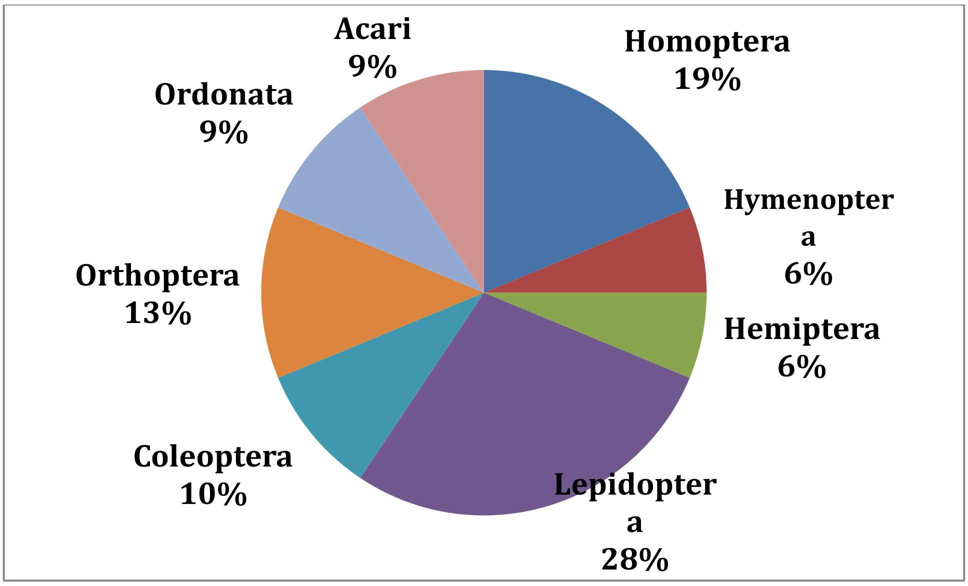


Figure 5: Percentage Composition of Insect Pest Order within Tomato Agro ecosystem in Kano State

Table 11: Summary of Insect Collected on Wheat Farms

LGAs	Study Area	Order	Common Name	Specific Name	Pest Status	Infestation Level
Kura	Dan Hassan	Homoptera	Spittle Bugs	*Locris Rubens*	Major pest	3
		Coleoptera	Rusted red F. Beetle	*Alphitobius diaperinus*	Vector/pest	3
		Orthoptera	Carolina Grasshopper	*Dissostera Corolina*	Minor/pest	1
Garun Malam	Kadawa	Homoptera	White flies	*Bemisia tabaci*	Vector/Pest	3
	Gafan	Orthoptera	Mole Cricket	*Neoscaptericus abbreviatus*	Pest	1
Danbatta	No Wheats Available	Nil	Nil	Nil	Nil	Nil

Bagwai	No Wheats Available	Nil	Nil	Nil	Nil	Nil
Bunkure	Bunkure	Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
	Alkamawa	Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Orthoptera	Long headed Grasshopper	*Achurum carinatum*	Minor pest	1
Warawa	Lababar Gadon Sarki	Homoptera	Spittle bugs	*Locris rubens*	Major pest	1
		Orthoptera	Long headed Grasshopper	*Lucusta migrotoria*	Pest	1
		Lepidoptera	Pointed lady moth	*Venessa cardui*	Pest	1
	Gishirin Wuya	Orthoptera	Carolina Grasshopper	*Diassostera Carolina*	Minor pest	1
		Orthoptera	Long headed Grasshopper	*Achurum carinatum*	Minor Pest	1
		Homoptera	Spittle bugs	*Locris ruben*	Major Pest	3

Infestation scale/grade: 0 = no insect indecently seen, 1 = Scattered appearance of few insect on the plant, 2 = severe incidence of insect pest on only one branch, 3 = severe incidence of insect pest on more than 1 branch, 4 = severe incidence of insect on whole plant was recorded

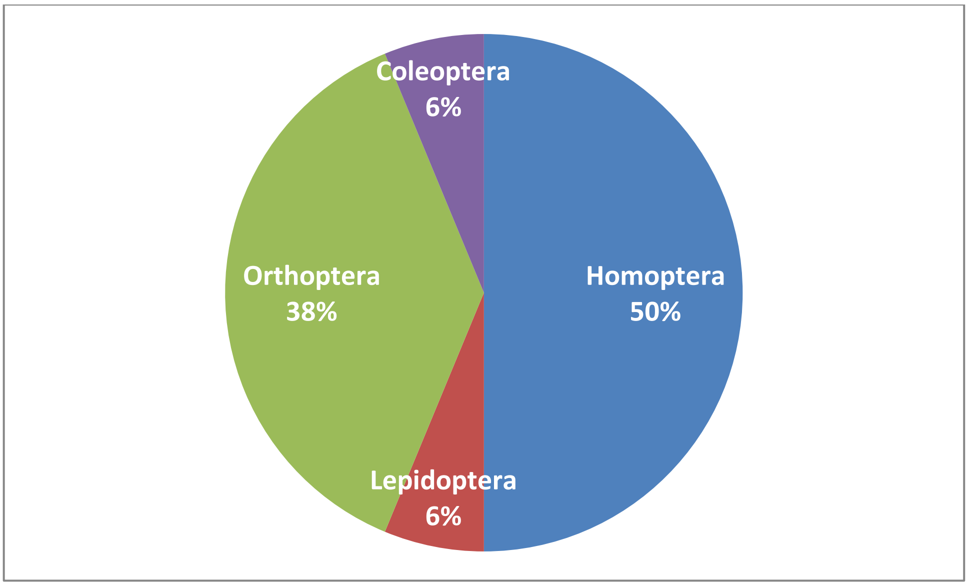


Figure 6: Percentage Composition of Insect Pest Order within Wheat Agro ecosystem in Kano State

Table 12: Percentage (%) relative abundance of individual's species of Tomato and Wheat

S/N	Common name	Scientific name	Relative abundance (%)	
			Tomato	Wheat
1	Spittle Bugs	*Locris rubens*	3.13	27.78
2	Rusted red Flour beetle	*Alphitobius diaperinus*	6.25	5.56
3	Corolina Grasshopper	*Dissostera corolina*	6.25	11.13
4	White Flies	*Bemisia tabaci*	16.63	5.56
5	Monarch Butterflies	*Danaus plexeppus*	3.13	-
6	Dragon Flies	*Macromidia ishaidai*	9.38	-
7	Mole Cricket	*Neoscapteriscus abbreviatus*	6.25	5.56
8	Purple Short Copper	*Lyacaena alciphron*	3.13	-
9	Painted lady moth	*Venessa cardin*	6.25	5.56
10	Saw flies	*Tenihendi mesonde*	3.13	-
11	Greenhouse W/flies	*Trialeurodes vaporanum*	3.13	-
12	German wasp	*Vespule gemanica*	3.13	
13	Stink bug	*Hlyomorpha halys*	3.13	-
14	Long headed Grasshopper	*Lucusta migrotoria*	-	16.67

15	Tomato fruit borer	*Helicoverpa armigera*	18.75	-
16	Two-spotted red spider mite	*Tetranychus urticae*	9.38	-
17	Tomato Leaf miner	*Tuta absoluta*	9.38	

SECTION SIX:

DISEASES OF WHEAT AND TOMATO IN FIVE LOCAL GOVERNMENT AREAS OF KANO STATE

6.0 Background

Nigeria produces 601000 tonnes of wheat in 2019 which shows a drastic increased in wheat production from 61000 tonnes in 1970. The capacity of the milling industry in the country is atleast 4.5 million tonnes of wheat and farmers in Nigeria are only producing about 30-0000 tonnes, despite availability of 650, 000 hectares of agricultural land for wheat production. This shows the dire need of more wheat farmers. Many Northern states in the country support wheat production. These states include Sokoto, Zamfara, Kano, KEBBI, Katsina, Bauchi, Adamawa, Borno, Gombe, Kaduna and Jigawa. Despite the economic and nutritional benefits of wheat it is affected by many diseases.

Rice is one of the major staple foods in Nigeria consumed in almost all ecological zones and socio-economic classes of Nigeria. Fifty seven percent of the 6.7 million metric tonnes of rice are locally produced leading to 3 million metric tonnes deficit. Nigeria is currently the second largest producer of fresh tomato in Africa, producing 10.8% of fresh tomatoes in the region. Tomato production has grown by 25% from 1.8 million tonnes to an estimated 2.3 million tonnes. Tomato is generally prone to over 100 diseases that are caused by bacteria, fungi and viruses.

6.1 Methodology

The survey was conducted in five local government areas (LGAs) of Kano to assess incidences of diseases of wheat and tomato. The survey was conducted in Kura, Garun Malam, Dambatta, Bagwai and Bunkure LGAs to assess disease incidences. Survey was done in the dry season during the month of January, 2020. Two or more villages in each local government were purposively selected. Three farms were considered from each village for the survey. Fields were tomatoes or wheat are grown were chosen. Verbal interviews with farmers was done when wheat or tomato were not grown during the period of the visit. A quadrant measuring 2m x 2m was used to assess the total number of plants and number of infected plants in a quadrant in each farm to calculate disease incidence. Five quadrants in each field were used for the disease assessment. Diseases were identified based on symptoms observed and interviews with farmers. Samples were also collected for further analysis in the laboratory for identification.

With respect to rice crop four local government areas were visited to identify major diseases of rice in the localities. The survey was conducted in Kura, Garun Malam, Danbatta and Bagwai LGAs to assess disease incidences and damage index. Survey was done in the month of June, 2020 when most of the rice crops are at harvesting stage. Three farms were selected from each local government where rice is grown. Farmers were interviewed and disease assessment was done using a quadrant measuring 2m x 2m. Five quadrants in each field were used to determine disease incidence and severity. Diseases were identified based on symptoms manifested by the infected rice. Samples collected were taken to laboratory for further identification.

6.2 Diagnostic Study of Wheat, Rice and Tomato

Diagnostic study was based on field assessment of incidences of tomato and wheat diseases in five local government areas of Kano. These Five surveyed local governments comprised Bagwai, Bunkure, Dambatta, Garum Malam and Kura. Among these local governments, Bagwai had the highest disease incidence which measured up to 63.7%. This was followed by Dambatta with disease incidence of 51%, Kura, Garun Malam and Bunkure recorded 33%, 185 and 11.4%, respectively (Figure 7).

For the rice crops data collected on disease incidences and severities were used to calculate damage index and were then subjected to analysis of variance. Means were separated using LSD at $p=0.05$. Disease incidence and damage index were significantly ($p<0.001$) lower in Garum Malam (23.8%; 7.5% damage index) than Kura, Danbatta and Bagwai. Danbatta had the highest diseases incidences and damage index but did not differ significantly with values obtained at Kura and Bagwai, as presented in Figure 8).

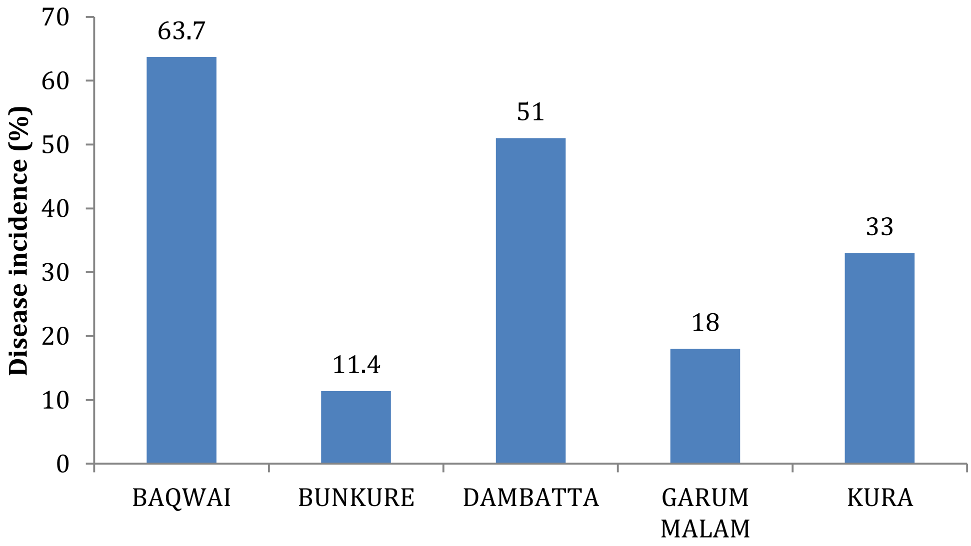


Figure 7: Incidence of wheat diseases in five local government areas of Kano State

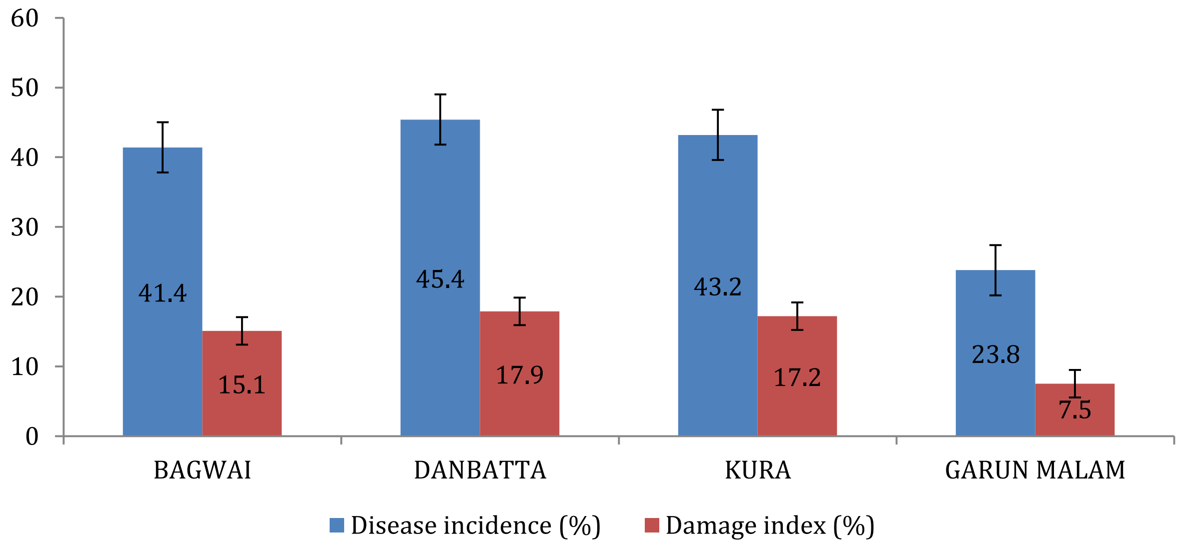


Figure 8: Incidence of Rice diseases in five local government areas of Kano State

Table 13a: List of Wheat & Tomato diseases identified by diagnostic survey in four local government areas of Kano

S/N	LGA	Town	Crop(S)	Diseases
1.	Kura	Dan Hassan	Wheat	Wheat streak mosaic, Wheat soil borne mosaic virus, Loose smut, Stripe or yellow rust and Tan spot.
			Tomato	Early blight, Cucumber mosaic virus, bacterial speck and septoria leaf spot.
2.	Garun	Samawa	Wheat	Powdery mildew, leaf spot and wheat

	Malam			streak mosaic virus and loose smut
		Yadakwari	Tomato	Tomato mosaic virus, Bacterial canker, bacterial speck, Cercospora leaf spot, Early blight, Fusarium wilt and root knot nematode disease.
3.	Bagwai	Gurdo	Tomato	Early blight, Cercospora leaf spot and Cucumber mosaic virus.
			Wheat	Wheat streak mosaic, Stripe or yellow rust and Tan spot.
4.	Dambatta	Thomas	Tomato	Tomato mosaic virus, Early blight, Cercospora leaf spot, root knot nematode disease, bacterial speck, Fusarium wilt and late blight.
			Tomato	Bacterial wilt, early and late blight, cucumber mosaic virus, Cercospora leaf spot, Altenaria stem canker, bacterial speck and Septoria leaf spot.

Table 14b: List of Rice diseases identified by diagnostic survey in four local government areas of Kano

S/N	**LGA**	**CROP**	**DISEASES**
1.	Kura	RICE	Rice blast, leaf spot and rice mottle virus.
2.	Garun Malam	RICE	Same with Kura
3.	Bagwai	RICE	Same with Kura
4.	Dambatta	RICE	Same with Kura

6.3 Symptoms of Identified disease, their causative agents and suggested preventive and control measures

Table 15: WHEAT

Disease	Causative Agent	Symptoms	Preventive and control strategies
Wheat streak mosaic	Caused by Virus	Bright yellow streaking of the leaves especially near leaf tip.	- Maintain farm sanitation - Delayed planting date - Use of resistant varieties - Avoid planting near maturing sorghum.
Loose smut	Caused by fungus Ustilago tritici	White kernel without grain, then red and black kernel.	-Seed treatment with fungicide -Use of resistant varieties -Early planting at the recommended time.
Stripe or yellow rust	Caused by fungus *Puccinia striformis* f. sp. *tritici*	Yellow streaks or long narrow stripes on leaves, stunted growth in severely infected plants	- Use of resistant varieties - use of fungicide eg. Carbendazim
Tan spot	*yrenophora tritici-repentis*	Brown lesions on the leaves surrounded by a distinctive yellow halo with a small dark spot in the center. Tan spot lesions develop on spikes and some bleaching of the spikes becomes visible and the kernels turn dark red. Tan spot is more severe on lower leaves and then progresses upward.	-Select tolerant varieties. -Remove or reduce residues infested with tan spot through tillage -Practice crop rotation to reduce the inoculum level within the field.
Barley yellow dwarf virus		Yellow, purplish-red discoloration of leaves, usually the flag leaf. Upright and stiff leaves, serrated leaf borders, reduced tillering and flowering.	-practice crop rotation -Use clean-disease free seed. -Apply a foliar fungicide when disease pressure is high. -Control insect vectors Uprooting infected plants
Wheat	Barley yellow dwarf	Pale -yellow discoloration shortly after breaking	- Use resistant varieties -Seed treatments may be a good strategy. -Use resistant varieties

soilborne mosaic	virus Wheat soilborne mosaic virus	Dormancy. Leaves of infected plants often have a mosaic pattern of dark green blotches on a pale-yellow background.	-Burning of crop residues -Soil solarization

Table 16: TOMATO

Disease	Causative Agent	Symptoms	Preventive and control strategies
Bacterial speck **Altenaria stem canker** **Early blight**	*Pseudomonas syringae* pv. *tomato* *Alternaria alternata* f. sp. *lycopersici* *Altenaria solani* *Septoria lycopersici*	-Dark brown or black spot on the leaves, stems, petioles, flowers and fruit. -Affected parts are often surrounded by a yellow halo. -Circular to angular lesion with greasy appearance. - Speck-like lesions on fruits -Dark-brown cankers on stems. -Dry, brown stem rots with brown streaks -Curling of leaf margins and leaf senescence. -Small gray flecks on fruits Irregular, dark-brown, necrotic lesions on the leaves, stems and fruits. Yellowing of leaves and senescence Defoliation of plants and appearance of dark-brown, elongated, sunken areas on	-Plant resistant varieties -Maintain farm sanitation - Copper sprays can reduce disease incidence and severity in transplant operations and in the field. -Avoid sprinkler irrigation; furrow or drip irrigation should be used when possible. -Control weeds and volunteer tomatoes in and around fields. -Proper management of plant debris after harvest - Use of resistant varieties -Maintaining farm hygiene as fungicides not effective in managing the disease. -Fungicide spray program -Use field sanitation techniques -Crop rotation

		stems and petioles. Fruit lesions as dark, leathery and sunken.	-Weed control, -Remove debris from previous crops to reduce disease severity.
Septoria leaf spot	*Fusarium oxysporum* f. sp. *lycopersici*	Small, dark, water-soaked spots on older leaves. Circular lesions on the leaves, stems and petioles.	-Use of resistant varieties
Fusarium wilt	*Fusarium oxysporum* f.sp.*lycopersici*	Defoliation of leaves Yellowing of leaves on only one side of a leaf or branch.	Crop rotation Spray with fungicides Management of crop residues
Root Knot Nematodes	*Meloidogyne incognita*	Wilting and death of leaves but remain attached to the stem. Red-brown discoloration of vascular tissue if the main stem is cut longitudinally or when a branch is snapped off the main stem.	The use of resistant varieties is the most effective way to control Fusarium wilt. Disinfect equipment before moving from infested to clean fields. Biosolarisation
Bacterial wilt	*Ralstonia solanacearum*	Stunted growth and wilting of leaves. Knots on roots when plants are pulled-up or irregular swellings of the roots. .	Use of botanical pesticides and bio-control agents Use of composts or vermicomposts Use of botanical extracts e.g. neem formulations -The use of resistant varieties Additional root-knot control -crop rotation with cover crops
Cocumber mosaic virus	Spread by insect vectors such as aphids	Dropping of lower leaves and wilting of entire plants. Symtoms is not associated with foliar yellowing. Yellow to light-brown vascular discoloration of the stem A white, milky stream of	-Biofumigation or solarisation -Biosolarisation Avoid infested soil Use disease free seeds or transplants Transplant onto raised beds,

		bacteria ooze from the stem. Stunted growth characterized with bushy appearance. Green mottling, chlorosis or severe necrosis. Small size fruits and often misshapen.	manage soil-moisture content by proper drainage Control weeds Soil solarisation or bio-fumigation Control of insect vectors Eliminate weeds Rogue infected tomato plants

Table 17: Rice

Disease	**Causative Agent**	**Symptoms**	**Preventive and control strategies**
Rice blast	Caused by a fungus *Magnaporthe oryzae*, previously known as *Magnaporthe grisea.* Syn. *Pyricularia oryzae.*	Oval or diamond-shaped spots with dark borders on leaf, leaf collar, culm nodes, panicle neck node and Panicle.	✓ Use of resistant varieties ✓ Use clean seed for planting ✓ Use recommended spacing (20 x 20cm) at planting to enhance aeration and light penetration ✓ Avoid excess nitrogenous fertilization. ✓ Maintain clean fields as some weeds are alternate hosts which can be sources of infection. ✓ Burn or bury infected crop debris. ✓ In endemic areas treat seeds with Tricyclazole 75 wp @ 1.5 g/kg seeds or with Carbendazim 50 wp @ 2g/kg seeds.

Brown spot of rice	Caused by fungus *Helminthospporium oryzae* Breda de Haan; Syn. *Bipolaris oryzae* (Breda de Haan) Shoemaker. The perfect stage of the fungus is *Cochliobolus miyabeanus.*	Dark brown spots on the upper surface of the leaf lamina. Necrotic lesions and seedlings blight.	✓ Planting of disease free seeds or treat seeds with botanicals or fungicides. ✓ Proper application of fertilizers, ✓ Good water management ✓ Application of soil amendments such as composts, vermicomposts etc.
Rice yellow mottle virus	Virus	Leaf yellowing, mottling, necrosis and stunted growth.	• Destruction of crop residues • the use of tolerant varieties, and • Management of vectors • Burning of rice straws after harvest • Other practices include reduction of fertilizer (e.g. urea) application on infected plots

Tobacco Mosaic and Tomato Mosaic Viruses are found in almost all surveyed villages. They are closely related viruses causing similar symptoms. Symptoms can be found during any growth stage and in all plant parts Plate 1. The virus is seed-borne. Infested tomato seeds can be the source of infection and the means by which the virus can be disseminated over large distances. The virus can be spread by man due to contaminated hands, clothing, and tools during routine

Plate 1: Tomato infected with tomato mosaic virus

operations such as transplanting, weeding, spraying, watering, and picking. The virus can also enter a tomato field through infected weed, pepper, or potato plants. The diseases could also be spread to a lesser extent by feeding grasshoppers, small mammals, and birds. The virus is quite stable under adverse environmental conditions and can persist in plant debris in dry soil for 2 years or in moist soil for 1 month or in root debris in fallow soil for 22 months. It can also persist in greenhouse structures for long periods of time. Healthy seedlings planted into contaminated soil can be infected through minor wounds caused by damage to roots. The virus may also be present in water used for irrigation. Dissemination of tiny particles of contaminated soil by wind is also possible.

6.4 Management strategies for the diseases

The following practices should be used as integrated pest management strategies for diseases:

Tomato (tomato mosaic virus)

1. Look for resistant varieties that are available
2. Use seed from healthy plants only.
3. Disease on the seed coat can be eliminated by soaking seed for 15 min in 100 g/l of tri-sodium phosphate solution (TSP), rinsing thoroughly, and spreading seeds out to dry. Do not re-contaminate seed by placing them in used containers.
4. Use a minimum 2-year rotation.

5. Avoid following tomato crops with susceptible crops such as tobacco, pepper, eggplant, or cucurbits.

6. Keep production areas and seedbeds free of weeds and other plants that can serve as hosts for the virus.

7. If growing transplants in a greenhouse, then use steam pasteurized soil.

8. Avoid touching or handling plants prior to setting them in the field.

9. Remove diseased seedlings that show leaf twisting, mosaic or unusual growth.

10. Do not touch other seedlings while discarding them.

11. Do not clip young seedlings since this increases the possibility of mechanical transmission of the virus from contaminated tools or hands.

12. Remove diseased plants from the field as soon as virus symptoms are noticed. This will reduce the spread of the virus by direct contact between plants.

13. Disinfect tools, stakes, and equipment before moving from diseased areas to healthy areas.

This can be done by: (1) heating or steaming at 150°C for 30 minutes; (2) soaking 10 minutes in

1% formaldehyde or a 1:10 dilution of a 5.25% sodium hypochlorite, do not rinse; or (3) by washing in detergent at the concentrations recommended for washing clothes or dishes.

14. Work in diseased areas last after working in unaffected parts of a field.

15. Wash clothing that comes into contact with ToMV-infected plants with hot water and a detergent.

Rice & Wheat

i) Deep ploughing of fields controls nematodes population, to expose pupae and resting stage of insect pests, popagules of soil borne pathogens.

ii) Soil solarization

iii) Use of resistant/tolerant varieties

iv) Timely sowing should be done.

v) Field sanitation, rouging.

vi) Destroy the alternate host plants

vii) Growing marigold as a repellent crop for the management of root-knot nematode.

viii) Crop rotation with non-cereals.

ix) Nutrient management especially organic manures and bio fertilizers

x) Amend soil with 4.0 tons/ acre of compost at 2-3 week before sowing or vermicomposting at 2.0 ton/acre at one week before sowing.

xi) Soil health improvement (mulching and green manuring)

xii) Apply well decomposed FYM to discourage termite infestation.

xiii) Treat the seed with recommended pesticides especially biopesticides

xiv) Avoid late sowing of crops.

xv) Follow proper spacing

xvi) Proper irrigation

xvii) Foliar and soil application of pesticides

SECTION SEVEN:

WEEDS FLORA SURVEY IN THE FIELDS OF WHEAT AND TOMATO IN SOME SELECTED IRRIGATION AREAS OF KANO, NIGERIA

7.0 Background on Weeds Flora

The aim and objective of this survey is to identify major insect pest of rice, wheat and tomato value chain in some selected irrigation areas of Kano state, under the project titled "integrated pest management study for rice, wheat and tomato production in Kano state". This is sponsored by Agro-processing, Productivity Enhancement and Livelihood Support (APPEALS) Project which is a World Bank funded project prepared by Federal Ministry of Agriculture and Rural Development. Six local government areas (LGAs) of Kano State were selected in along the Wheat and Tomato value chain. In all the LGAs, 14 locations were visited and 1-3 farms each for Rice, Tomato and wheat was randomly selected for weeds sampling. Our results revealed that, total of 23 weed species in 14 families were encountered in tomato and wheat fields in six local government areas of Kano state. In particular, sixteen weed species were identified in tomato fields visited and the frequency of occurrence for *Amarantus viridis*, *Portulaca oleraceae*, and *Digitaria horizontalis* was 30.76, 23.08, and 23.08 % respectively are the highest in the fields of tomato. Similarly, 13 weeds species were identified, out of which some are annual, perennial and annual/perennial species. The species of weeds with highest frequency of occurrences in wheat irrigated fields are *A. viridis* and *Echinocloa obstusifora* with 38.46 % and 30.76 % respectively. The study should be repeated at least two times to ascertain to identify possible problematic weed and weed population throughout the growing seasons (both rain fed and irrigation) of the crops. It is important that farmers in these local government areas are educated through trainings on the basic principles of herbicides use.

The survey results of the rice crop revealed that, total of 20 weed species in were encountered rice fields in four local government areas of Kano state. Some of the identified weed species includes; *Amarantus viridis*, *Panicum maxium*, *Cyperus rotundus*, *Ipomea aquatic*, *Acanthusperium hispidium*, *Cynodon dactylon*, *Panicum maxicum*, *Elusine indica*, *Boerhavia diffusa*, *Phyllanthus amarus*, *Commelina diffusa*, *Echinochloa* obtusiflora, *Kyllinga squamalata*, *Cynodon dactylon*, *Shenocleae zeylenica* etc. Among weeds species identified, some are annual, perennial and annual/perennial species. The most predominant species of weeds with highest frequency of occurrences in rice fields are - *P. maxium*, *C. rotundus*, *I. aquatica* and *C. dactylon*. The study should be repeated at least two times in raining season to ascertain to identify possible problematic weed and weed population throughout the growing seasons of the crops. It is important that farmers in these local government areas are educated through trainings on the basic principles of herbicides use.

7.1 Methodology

- **Study area**

The study was conducted in some irrigation areas of Kano state. Six local government areas (LGAs) of Kano State were selected along the Wheat and Tomato value chain. These are Bagwai, Bunkure, Danbatta, Kura, Garun Malam, and Warawa. In all the LGAs, 14 locations/villages were visited which include; Dakasoye, Danhassan (Kura), Dorawar Sallau, Kadawa, Garun Babba, Kwanar Gafan (G/Malam), Bunkure, Shimar (Bunkure), Tomas (Danbatta), Gishiri Wuya, Larabar Gadon Sarki, Katarkawa (Warawa) and Bagwai (Bagwai). The sizes of the farms studied are irregular; however, it ranged between 0.5 and 1.5 ha.
While for rice the study was conducted in some irrigation areas of Kano state. Four local government areas (LGAs) of Kano State were selected along the Wheat and Tomato value chain. These are Bagwai, Danbatta, Kura and Garun Malam. The sizes of the farms studied are irregular; however, it ranged between 0.5 and 1.5 ha

- **Weeds Sampling**

In each location/village, 1-3 farms each for Tomato and Wheat were randomly selected for weeds sampling. Weed samples were taken from a quadrant of 2m x $2m^2$ at three different points on each farm. The collected weed samples were counted and identified using standard text the hand book of West African Weeds (Akobundu and Agyakwa, 1998). Identification was later confirmed at the herbarium of Bayero University Kano.
Same as in Tomato and Wheat, for rice in each location/village, 1-3 farms each for Rice, Tomato and wheat were randomly selected for weeds sampling. Weed samples were taken from a quadrant of 2m x $2m^2$ at three different points on each farm. The collected weed samples were counted and identified and later confirmed at the same herbarium.

- **Data Analysis**

Data obtained from the study areas were subjected to descriptive statistics of mean and percentages (%) as described by RuchikaKataria and Dolly Kumar, (2012).

Frequency of occurrence was calculated as the percentage of farms in which a certain weed species was present. The relative abundance of each species in relation to crop was calculated as number of individuals in species divided by total number of all individuals

7.2 Results and Discussion

A total of 23 weed species in 14 families were encountered in tomato and wheat fields (Tables 1 and 2) in six local government areas of Kano state. In Table 1, the summary of weed species in each location was presented and sixteen weed species were identified in tomato fields visited. Frequency of occurrence for *Amarantus viridis*, *Portulaca oleraceae*, and *Digitaria horizontalis* was 30.76, 23.08, and 23.08 % respectively are the highest in the fields of tomato. Secondly, *Ageratum conyzoides*, *Solanum carolinse*, *Amarantus spinosus* and *Ludwigia hyssopifola* was calculated as, 15.38, 15.38, 15.38 and 15.38 % respectively in all the areas surveyed. Among the weeds sampled, the main dominant species are *A. viridis*, *P. oleraceae*, and *D. horizontalis* with 11 % relative abundance each in all the fields visited (Table 3). *A. viridis* occurred in Thomas (Danbatta), Tsamiyyar Makiyya (Bunkure) and Gishiri Wuya in Warawa local government area. Secondly, *P. oleraceae* was sampled in Gurdo (Bunkure), Danhassan (Kura) and Tsamiyyar Makiyya (Bunkure) irrigation areas. The life cycles of most of the weeds sampled are perennials, followed by annual species of weeds. The leaf morphology of most weeds are broad leaves types followed by grasses and sedges. The weeds species were identified, out of which some are annual, perennial and annual/perennial species. In terms of their leaves/morphological groups; some are grasses, sedges and broad leaf types. The species of weeds with highest frequency of occurrences in wheat irrigated fields are *A. viridis* and *Echinocloa obstusifora* with 38.46 % and 30.76 % respectively. The lists of weeds with lowest frequencies of occurrence are presented in table 3. *A. viridis* is reported to have highest relative abundance among all the species sampled in all the six local government areas of Kano state. It was observed that *Cyperus rotudus* and *A. viridis* occurred in both fields of tomato and wheat with highest relative abundance in most of local government areas. *A. conyzoides* with lowest relative abundance of all species also occurred in both tomato and wheat fields as shown in Table 18.

Table 18: Summary of Weed Collected on Tomato farms in Irrigated areas of Kano State

Local Gov. Areas	Study Area	Family	Genus	Specie	Life Cycle	Morphological Group	% Occurrence
Bagwai	Gurdo	Poaceace Solanaceae Hydrophyllaceae Gramine Asteraceae Solanaceae Poacaceae	*Digitaria* *Nictotiana* *Hydrolea* *Portulaca* *Ageratum* *Solanum* *Digitaria*	*horizontalis* *rustica* *palustris* *oleraceae* *conyzoides* *carolinse* *horizontalis*	A A A/P A/P A P A	G B - B B B G	23.08 7.69 7.69 23.08 15.38 15.38 23.08
Danbatta	Thomas	Cyperaceae Amaranthaceae Amaranthaceae Solanaceae Poaceae Amaranthaceae	*Cyperus* *Amarantus* *Amarantus* *Solanum* *Elusine* *Amarantus*	*rotundus* *viridis* *viridis* *elaeagnifolium* *indica* *spinosus*	P P P P A A/P	S B B G G B	7.69 30.76 30.76 15.38 7.69 15.38
Kura	Danhassan	Amaranthaceae Asteraceae Gramine	*Amarantus* *Laggera* *Portulaca*	*spinosus* *aurita* *oleraceae*	A/P P A	B B B	15.38 7.69 23.08
Garun Malam	Gafan D/ Sallau G/ Babba	Amaranceae Onagraceae Poaceae Onagraceae Asteraceae	*Alerva* *Ludwigia* *Echinocloa* *Ludgiwia* *Ageratum*	*javanica* *hyssopifola* *obstusiflora* *hyssopifolia* *conyzoides*	A/P P A/P A A	G G G B B	7.69 15.38 7.69 15.38 15.38
Bunkure	Tsamiyyar Makiyya	Gramine Amaranthaceae	*Portulaca* *Amarantus*	*oleraceae* *viridis*	A P	B B	23.08 30.76
Warawa	L/Gidan Sarki	Nitrariaceae Rubiaceae	*Pegoun* *Spermacoce*	*harmala* *ocymoides*	P A/P	G B	7.69 7.69
	Gishiri Wuya	Amaranthaceae Poaceae	*Amarantus* *Digitaria*	*viridis* *horizontalis*	P A/P	B G	30.76 23.08

Table 19: Summary of the Weed Collected on Wheat farms in Irrigated areas of Kano State

Local Government	Study Area	Family	Genus	Specie	Life Cycle	Morphological Group	% Occurrence
Garun Malam	Kadawa Garun Babba Dorawa r Sallau	Poaceace Gramine Amaranthac eae Poaceae Poaceae Astraceae Plantaginace ae Poaceae	*Echinocloa* *Portulaca* *Amarantus* *Echinocloa* *Echinocloa* *Cirsium* *Plantago* *Digitaria*	*obstusifo* *ra* *oleracea* *e* *viridis* *obstusifo* *ra* *obstusifo* *ra* *arvense* *major* *horzonta* *lis*	P A P P A A/P P A/P	G B B G G B B G	30.76 7.69 38.46 30.76 30.76 7.69 7.69 7.69
Bunkure	Tsamiyy ar Makaiyy a Alkama wa	Cyperaceae Amaranthac eae Poaceae Amaranthac eae Nitrariaceae Nitrariaceae Amaranthac eae Polygonacea e Uriticaceae Asteraceae Nyctaginace ae	*Cyperus* *Amarantus* *Echinocloa* *Gomphren* *a* *Peganum* *Peganum* *Amarantus* *Polygonum* *Parietaria* *Bidens* *Boerhavia*	*rotundus* *viridis* *obstusifo* *ra* *celosiode* *s* *harmala* *harmala* *viridis* *lanigeru* *m* *judaica* *pilosa* *cocccine* *a*	P P A A/P P P P A/P P A P	S B G B B B B G B B B	15.38 38.46 30.76 15.38 15.38 15.38 38.46 7.69 7.69 7.69 16.
Kura	Danhass an	Amaranthac eae Amaranthac eae	*Amarantus* *Gomphere* *na*	*viridis* *celosiode* *s*	P A/P	B B	38.46 15.38
Warawa	Laraban Gadon Sarki	Amaranthac eae Astraceae Cyperaceae	*Amarantus* *Agerantu* *m* *Cyperus*	*viridis* *conyzoid* *es* *rotondus*	P A P	B B S	38.46 7.69 7.69

Table 20: Summary of the Weed Collected on Rice farms in Irrigated areas of Kano State

Location	Family	Scientific name	Life cycle	Family Occurrences%		Species Occurrences %		Weed status
agwai	*Poaceae* *Cyperaceae* *Convolulaceae*	*Panicum maxium* *Cyperus rotundus* *Ipomea aquatica*	P P P	*Poaceae* *Cyperaceae* *convolulaceae*	25 11 5	*P. maxium* *C. rotundus* *I. aquatica*	8.5 5 5	Widespread Trouble widespread
Danbatta	*Ancanthceae* *Poaceae* *Poaceae* *Poaceae* *Nyctaginaceae* *Euphorbiaceae* *Commelinaceae* *Amaranthaceae* *Poaceae* *Cyperaceae* *Cyperacea* *Poaceae* *Sheleceaea*	*Acanthusperium hispidium* *Cynodon dactylon* *Panicum maxicum* *Elusine indica* *Boerhavia diffusa* *Phyllanthus amarus* *Commelina diffusa* *Amaranthus viridis* *Echinochloa obtusiflora* *Cyperus rotundus* *Kyllinga squamalata* *Cynodon dactylon* *Shenocleae zeylenica*	A P A A A A P A A P A P A	*Ancanthceae* *Nyctaginaceae* *Euphorbiaceae* *Commelinaceae* *Amaranthaceae* *leguminosae* *Potenderiaceae* *Lamaiaceae* *Ongraceae* *Sheleceaea*	2.8 2.8 8.5 8.5 8.5 5 2.8 2.8 2.8 2.8	*A hispidium* *C. dactylon* *E. indica* *B. diffusa* *P. amarus* *C. diffusa* *A. viridis* *E. obtusiflora* *K. squamalata* *A. phiccox* *C. macrocalyx* *M. oppositifolia* *L. martinicensis*	2.8 5 2.8 2.8 5 2.8 5 2 2.8 2.8 2.8 2.8 2.8	Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread Widespread
Garun malam	*Poaceae* *Euphorbiaceae*	*Echinochloa obtusiflora* *Phyllanthus amarus*	A A			*M. vignal* *S. obtusifolia*	2.8 2.	Widespread Widespre

	Commelinaceae *Commelinaceae* *Cyperaceae* *Amaranthaceae* *Convolulaceae* *leguminosae* *onagraceae*	*Commelina diffusa* *Commelina benghalensis* *Cyperus rotundus* *Alternanthara phicoxeroides* *Ipomea aquqtica* *Crotalaria macrocalyx* *Ludwiga hyssopifola*	P P A A P A A			*S. zeylenica* *E. stagnina* *C. Benghalensi* *O. longistaminata*	8 2 2.8 2.8 5	ad Widespread Widespread Widespread Widespread
Kura	*Portulacea* *Poaceae* *Amaranthaceae* *Euphorbiaceae* *Ongranceae* *Potenderiaceae* *Leguminosaea* *Lamaiaceae* *Poaceae*	*Portulaca olearacea* *Echinochloa staginine* *Amaranthus viridis* *Mallatus oppositifolia* *Ludwigia hyssopitofila* *Monochoria vignal* *Seena obtusifolia* *Leucas martinicensis* *Panicum maxicum* Wild rice - *Oryza longistaminata*	A P A P A A A/P A P P					

Table 21: Relative abundance of individual's species (by family) in Tomato and Wheat Fields in Irrigated areas of Kano State

S/N	Family	Scientific name	Relative abundance (%)	
			Tomato	Wheat
1	Poaceace	*Echinocloa obstusifora*	-	16.0
2	Amaranthaceae	*Amarantus viridis*	11.11	25.0
3	Astraceae	*Cirsium arvense*	-	4.1
4	Cyperaceae	*Cyperus rotudus*	3.7	8.3
5	Nitrariaceae	*Peganum Harmala*	3.70	8.3
6	Polygonaceae	*Polygonum Lanigerum*	3.70	4.1
7	Nyctaginaceae	*Boerhavia Cocccinea*	-	4.1
8	Asteraceae	*Bidens Pilosa*	-	4.1
9	Uriticaceae	*Perietaria Judiaca*	-	4.1
10	Amaranthaceae	*Gompherena celosiodes*	-	4.1
11	Plantaginaceae	*Plantago major*	-	4.1
12	Poaceace	*Digitaria horizontalis*	11.11	-
13	Gramine	*Portulaca oleraceae*	11.11	4.1
14	Solanceae	*Nictotiana rustica*	3.70	-
15	Hydrophyllceae	*Hydroleal palustris*	3.70	-
16	Rubiaceae	*Spermacoce ocymoides*	3.70	-
17	Solanaceae	*SolanumElaeagnifolium*	3.70	-
18	Ongaraceae	*Lidgiwia hyssopifola*	3.70	
19	Asteraceae	*Ageratum conyzoides*	7.40	4.1
20	Poaceace	*Elusine indica*	3.70	-
21	Amaranthaceae	*Amarantus Spinosus*	3.70	-
22	Asteraceae	*Leggera aurinta*	3.70	-
23	Solanaceae	*Solanum carolinse*	3.70	-

Recommendation

1. The study should be repeated at least two times during raining season to ascertain to identify possible problematic weed and weed population throughout the growing seasons of the crops.

2. Farmers should be well informed not to spray any chemical or manually removed the weeds until after the survey.

3. Works of this nature cannot be complete in one farming season and as such, further studies need to be carried out in order to establish a comprehensive list of weed species in the field as a step towards the establishment of an effective integrated weed management Programme.

4. It is important that farmers in these local government areas are educated through trainings on the basic principles of herbicides use and safety.

5. This training should cover safety (personnel protective equipment), sprayer calibration, and the appropriate use of herbicides and awareness on the existence of Biological control agents and Biological control of weeds

Conclusion

Certain weeds require more attention than others because they are very tough and difficult to
control, namely wild rice, sedges, and other weed. In this case, good agricultural practice can be very supportive plus good integrated weed management practices.

SECTION EIGHT:

INSECT PESTS OF WHEAT, RICE AND TOMATO IN SOME SELECTED IRRIGATION AREAS OF KANO, NIGERIA

Introduction

The aims and objective of this survey is to identify major insect pest of rice, wheat and tomato value chain in some selected irrigation areas of Kano state, under the project titled "integrated pest management study for rice, wheat and tomato production in Kano state". This is sponsored by Agro-processing, Productivity Enhancement and Livelihood Support (APPEALS) Project which is a World Bank funded project prepared by Federal Ministry of Agriculture and Rural Development. Six local government areas (LGAs) of Kano State were selected in along the Rice, Wheat and Tomato value chain. In all the LGAs, 14 locations were visited and 1-3 farms each for Rice, Tomato and wheat was randomly selected for insect collection/sampling. In each farm, 3 replications in form of quadrant of $1m^2$ were randomly selected for sampling. Three methods of trapping the insects were employed, namely hand capture for wingless insects, sweep nets for flying insects and aspirators. The results show that, in tomato fields, some of the major insect pest identified includes Spittle Bugs (*L. rubens*), Rusted red Flour beetle (*A. diaperinus*), Tomato fruit borer (*H. armigera*), Two-spotted red spider mite (*T. urticae*), White Flies (*B. Tabaci*), Tomato Leaf miner (*T. absoluta*) and Greenhouse White flies (*T. vaporanum*). Whereas in wheat, seven insect species were identified, these include Carolina Grasshopper (*Dissostera corolina*), Long headed grasshopper (*L. migrotoria*), Spittle bugs (*L. Rubens*), Pointed lady moth (*V. cardui*), White flies (*B. tabaci*), Mole cricket (*N. abbreviatus*) and Rusted red Flour Beetle (*A. diaperinus*). It was observed in wheat that, Spittle Bugs (*L. rubens*) which is endemic pests of sorghum (*S. bicolor*) in Nigeria according is now becoming major pest in those areas.

According to previous studies, the major pests of rice in Kano are African rice gall midge (AfRGM) *O. oryzivora*, stem borer species, Pink stem borers *Sesamia* spp., African yellow stem borers *Scirpophaga* spp, Stalk-eyed shoot flies *Diopsis* spp., Rice Army worm *Mythimna separata*. The farmers complained bitterly on the increase in pesticides resistance, as resulted in drastic decrease in their yield. We recommend repeating these studies at 2 weeks after transplanting, during flowing and fruiting and also before harvesting. Training should also be organized for the farmers on safety precautions of pesticides and integrated pest management practices.

Methodology

Study area and sampling sites

The study was conducted in some irrigation areas of Kano state. Six local government areas (LGAs) of Kano State were selected along the Wheat and Tomato value chain. These are Bagwai, Bunkure, Danbatta, Kura, Garun Malam, and Warawa. In all the LGAs, 14 locations/villages were visited which include; Dakasoye, Danhassan (Kura), Dorawar Sallau, Kadawa, Garun Babba, Kwanar Gafan (G/Malam), Bunkure, Shimar (Bunkure), Tomas (Danbatta), Gishiri Wuya, Larabar Gadon Sarki, Katarkawa (Warawa) and Bagwai (Bagwai). The sizes of the farms studied are irregular; however, it ranged between 0.5 and 1.5 ha. In each location/village, 1-3 farms each for Tomato and wheat were randomly selected for insect collection/sampling. Each farm, 3 replications in form of quadrant of 2m x 2m were randomly selected and used for sampling/collection.

While for rice crop Four local government areas (LGAs) of Kano State were selected and In all the LGAs, 1-3 farms each for Rice, was randomly selected for insect collection/sampling. In each farm, 3 replications in form of quadrant of $1m^2$ were randomly selected for sampling. Three methods of trapping the insects were employed, namely hand capture for wingless insects, sweep nets for flying insects and aspirators.

Sample collection

Insect samples were collected from the quadrant after quick visual count of the insects on the plants (where possible), and taken to the laboratory for identification. Three methods of trapping the insects were employed, namely hand capture; for wingless insects, larvae and slow-moving insects. Sweep nets for flying insects and aspirators for collecting tiny insects. Polythene bags, specimen tubes and rearing jars were used to transfer the insects to the laboratory and Ethyl acetate was used to preserve them for identification at Entomology Laboratory, Department of Crop Protection, Bayero University Kano (Imam *et al*., 2010).

For rice crop Insect samples were collected from the quadrant after quick visual count of the insects on the plants (where possible), and taken to the laboratory for identification. Three methods of trapping the insects were employed, namely hand capture; for wingless insects, larvae and slow-moving insects. Sweep nets for flying insects and aspirators for collecting tiny insects. Polythene bags, specimen tubes and rearing jars were used to transfer the insects to the laboratory and Ethyl acetate was used to preserve them for identification at Entomology Laboratory, Department of Crop Protection, Bayero University Kano (Imam *et al*., 2010).

Insect pest identification and quantitative assessment

Morphological identification of insect species was done using hand lens, and utilizing identification keys (Zim and Cottam, 2000; Imam *et al*., 2010; Mailafiya *et al*., 2014; Macharia *et al*., 2016). They were then placed into their respective groups. The infestation level was determined based on the degree of damage caused to plant as described in the scale of infestation by RuchikaKataria and Dolly Kumar, (2012).

Data Analysis

Data obtained from the study areas were subjected to descriptive statistics of mean and percentages (%) as described by Ruchika Kataria and Dolly Kumar, (2012). Relative abundance was calculated using the following formula;

Relative abundance = Total Number of Individual species / divided by Total Number of Species Population X 100.

Results

The results of insect pest survey for the purpose of identification of the insect's pest of Tomato and Wheat value chain along irrigation areas of Kano State were presented in **Table 20-22** and **Figure 9.** In **Table 20** the insect pests associated with tomato in six local government areas of Kano state were identified morphologically with reference to Zim and Cottam, (2000), Imam *et al*., (2010) Mailafiya *et al*., (2014), Macharia *et al*., (2016) works and identified insect collections deposited at Entomology lab., Department of Crop Protection, Bayero University, Kano. The infestation based on presence or absence of insect pests and the severity using one to four scale of infestation. In this table, we were able to identified 16 insect's species, among which some are major pest, minor pest, pollinators, vectors and natural enemies. The major insect pests in our study include; Spittle Bugs (*Locris rubens*), Rusted red Flour beetle (*Alphitobius diaperinus*), Tomato fruit borer (*Helicoverpa armigera*), Two-spotted red spider mite (*Tetranychus urticae*), White Flies (*Bemisia Tabaci*), Tomato Leaf miner (*Tuta absoluta*) and Greenhouse White flies (*Trialeurodes vaporanum*). In Figure 1, the percentage composition of insect's orders within tomato agro ecosystem in Kano state were maximum from order Lepidoptera 28 %, followed by order Homoptera 19 % and Orthoptera 13 %. The least was recorded on both Hymenoptera and Hemiptera. As shown in Table 3, Tomato fruit borer *H. armigera* (18.75 %) and White flies *B. tabaci* (16.63 %) appeared to be more abundant than other. However, the relative abundance of Dragon flies *M. ishaidai*, Tomato leaf miner *T. absoluta*, Two-spotted red spider mite *T. urticae*, Mole Cricket *N. abbreviates* and Rusted red Flour beetle *A. diaperinus* are 9.38, 9.38, 9.38, 6.25 and 6.25 % respectively.

In **Table 20**, seven insect species were identified in Wheat value chain along irrigation areas of Kano State, these include Carolina Grasshopper (*Dissostera corolina*), Long headed grasshopper (*Lucusta migrotoria*), Spittle bugs (*L. Rubens*), Pointed lady moth (*Venessa cardui*), White flies (*B. tabaci*), Mole cricket (*N. abbreviatus*) and Rusted red Flour Beetle (*A. diaperinus*). Out of these insects, some are major pests, while others are vectors and pollinators as shown in both Table 2 and Table 3. The percentage composition of insect's orders within Wheat agro ecosystem in Kano state as presented in **Figure 2** which includes order Homoptera 50 %, Orthoptera 38 %, Lepidoptera 6 % and Coleoptera 6 %. The relative abundance of individual's species of Wheat is reported in Table 3 and these includes; Spittle bugs (*L. rubens*) 27.78 %, long headed grasshopper (*L. migrotoria*) 16.67 %, Corolina grasshopper (*D. corolina*) 11.13% etc. It should be noted that, the survey was conducted when wheat was at younger stage, few days after transplanting. The number of insect pests collected during this study can't stand as the only insect pest scenario on wheat from transplanting of harvesting. Future study should be design at 3 stages of wheat growing period.

The results in rice fields show that, some of the major insect pest identified includes African rice gall midge- *Orseolia oryzae*, Stalk eyed flies- *Diopsis apicalis*, Stink bug- *Aspavia armigera* and Painted lady moth- *Venessa cardui*. It was observed that, Stink bug- *Aspavia armigera* is now becoming major pest of rice in those areas. According to previous studies, the major pests of rice in Kano are African rice gall midge (AfRGM) *O. oryzivora*, stem borer species, Pink stem borers *Sesamia* spp., African yellow stem borers *Scirpophaga* spp, Stalk-eyed shoot flies *Diopsis* spp., Rice Army worm *Mythimna separata*. The farmers complained bitterly on the increase in pesticides resistance, as resulted in drastic decrease in their yield. We recommend repeating these studies at 2 weeks after transplanting, during flowing and fruiting and also before harvesting during the raining season. Training should also be organized for the farmers on safety precautions of pesticides and integrated pest management practices.

Discussion

This study presented basic information on insect infestation of tomato and wheat value chain along irrigation areas in six local government areas of Kano state. In these areas, tomato and wheat are produced in commercial quantities and supplied to Kano city, as well other part of the country. However, during our survey, we collected and identified quite number of insect pests, some of which are known as the major insect pests of these crops, especially tomato. In tomato fields, some of the major insect pest identified includes Spittle Bugs (*L. rubens*), Rusted red Flour beetle (*A. diaperinus*), Tomato fruit borer (*H. armigera*), Two-spotted red spider mite (*T. urticae*), White Flies (*B. Tabaci*), Tomato Leaf miner (*T. absoluta*) and Greenhouse White flies (*T. vaporanum*). The farmers complained bitterly on the increase in pesticides resistance, as resulted in drastic decrease in their yield. Also, most of the tomato fields visited is at fruiting stage, some have even stated harvesting.

Contrarily, in some areas like Gurdo, Bagwai LGA, the fruits are damaged by *H. armigera*, leaving behind little or nothing to harvest. In the same area, there is severe infestation of Tomato leaf miner, and nothing was done by the farmers to stop the damage, because tiny larvae are mining in between the leaf sheath, which protect it from toxic effect of insecticide. At Kadawa irrigation area, the story is quite different, as white flies ravaged the entire leaf area of most of the tomato fields visited. According to the farmers, the infestation is fast spreading and we speculate spread of virus diseases in those areas. In almost all the area visited, we collected samples of Corolina Grasshopper and Stink bug which are minor and major pest respectively. However, not all the insect collected are pest of tomato, some such as Monarch Butterflies and Purple –Short Copper serves as pollinator. Other such as Dragon flies are known to be natural enemies of insect pests.

In Wheat producing areas, the most abundant insect species collected is Spittle Bugs (*Locris rubens*) which is endemic pests of sorghum (*Sorghum bicolor* (L.) in Nigeria according to Ajayi O. and Oboite F. A., (2000). Though, the wheat plants visited in most farms are at tillering and stem elongation stages (younger stage). The second most abundant insect pests of wheat are long headed grasshopper (*Lucusta migrotoria*) and Corolina grasshopper (*Dissostera corolina*). The type and extent of grasshopper injury to above- and below ground plant parts for wheat (*Triticum aestivum* L.) were observed in some locations. White flies' infestation (*Bemisia tabaci*) was also observed to some extend in Kadawa irrigation area.

Observations

i. We observed most of fields visited were recently (1-2 days ago) sprayed one kind of agrochemical or another, so the number and type of insect sampled were limited.
ii. The problem of pesticide resistivity is quite increasing, as the farmers are handicapped with knowledge of integrated pest management (IPM) as an option (cultural control and local plants with insecticidal effects etc.).
iii. It was observed in wheat that, Spittle Bugs (*Locris rubens*) which is endemic pests of sorghum (*S. bicolor* (L.) in Nigeria according is now becoming major pest in those areas.
iv. We observed through interviews that, a lot of pesticide gravely cases occurred between the farmers in most of these areas visited.

Recommendation

i. Future research is urgently needed to ascertain wither or not Spittle Bugs (*Locris rubens*) is become major pest of wheat at different stage of development (emergence, tillering, stem elongation, boot, heading/flowering, and grain-fill/ripening.) in Kano state.
ii. Future research is urgently needed to ascertain wither or not Stink bug- *Aspavia armigera* is become major pest of rice at different stage of development in Kano state.
iii. Farmers should be well informed not to spray any chemical insecticides until after the survey.
iv. Training of farmers on the IPM options for the control of these pests is urgently needed to save them from total yield lost.
v. A separate study should be conducted to ascertain the incidence and severity of Spittle Bugs (*Locris rubens*) in those irrigation areas visited.
vi. An urgent training and awareness campaign should be conducted on the following
    a) Detrimental effects of pesticides to the farmers, environment and natural enemies
    b) Safe precaution before, after and during application
    c) Personnel protective equipment

d) Awareness on the existence of Biological control agents and Biological control of insect pest

Table 20: Summary of the Insect Collected on Tomato Field

LGAs	Study Area	Insect Order	Common Name	Specific Name	Pest Status	Infestation Level
Kura	Danhassan	Homoptera	Spittle Bugs	*Locris rubens*	Major pest	3
		Coleoptera	Rusted red Flour beetle	*Alphitobius diaperinus*	pest/ Vector	3
		Orthoptera	Corolina Grasshopper	*Dissostera corolina*	Minor Pest	1
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
G/Malam	Kadawa	Homoptera	White Flies	*Bemisia Tabaci*	Vector, Pest	3
		Lepidoptera	Monarch Butterflies	*Danaus Plexeppus*	Pollinator	1
	Dorawar Sallau	Orthoptera	Mole Cricket	*Neoscaptericus abbreviates*	Pest	1
	Gafan	Odonata	Dragon Flies	*Macromidia Ishaidai*	Natural Enemy	2
	Garin Babba	Coleoptera	Rusted red flour beetle	*Alphitonius diaperinus*	Vector/pest	3
		Orthoptera	Mole Cricket	*Neoscaptericus abbreviates*	Pest	1
		Homoptera	White Flies	*Bemisia Tabaci*	Vector/Pest	3
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
Danbatta	Thomas	Lepidoptera	Purple –Short Copper	*Lyacaena alciphron*	Pollinator	1
		Odonata	Panted lady	*Venessa cardin*	Minor pest	2

			moth			
		Coleoptera	Dragon Flies	*Bactra lancaelana*	Natural enemy	1
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Homoptera	White flies	*Bemisia tabaci*	Major Pest	3
		Lepidoptera	Tomato Leaf miner	Tuta absoluta	Major Pest	3
Bagwai	Gurdo	Orthoptera	Carolina Grasshopper	*Dissostera carolina*	Minor pest Pollinator/	1
		Hymenoptera	Saw flies	*Tenihendi mesonde*	minor pest	1
		Odonata	Dragon flies	*Epiophlebia superstes*	Natural Enemy	2
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Homoptera	White flies	*Bemisia tabaci*	Major Pest	3
		Lepidoptera	Tomato Leaf miner	*Tuta absoluta*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
Bunkure	Bunkure	Hemiptera	Greenhouse white flies	*Trialeurodes vaporanum*	Major pest	3
		Lepidoptera	Tomato fruit borer	*Helicoverpa armigera*	Major Pest	3
		Acari	Two-spotted red spider mite	*Tetranychus urticae*	Major Pest	3
Warawa	Larabar Gadon sarki	Lepidoptera	Panted lady moth	*Venessa cardui*	Pollinator	1
		Hymenoptera	German wasp	*vespule Gemanica*	Pollinator	1

		Hemiptera Lepidoptera	Stink bug Tomato fruit borer	*Hlyomorpha halys* *Helicoverpa armigera*	Major pest Major Pest	3 3
	Gishiri wuya	Homoptera	White flies	*Bemisia tabaci*	Vector/pest	3

Infestation scale/grade: 0 = no insect indecently seen, 1 = Scattered appearance of few insect on the plant, 2 = severe incidence of insect pest on only one branch, 3 = severe incidence of insect pest on more than 1 branch, 4 = severe incidence of insect on whole plant was recorded

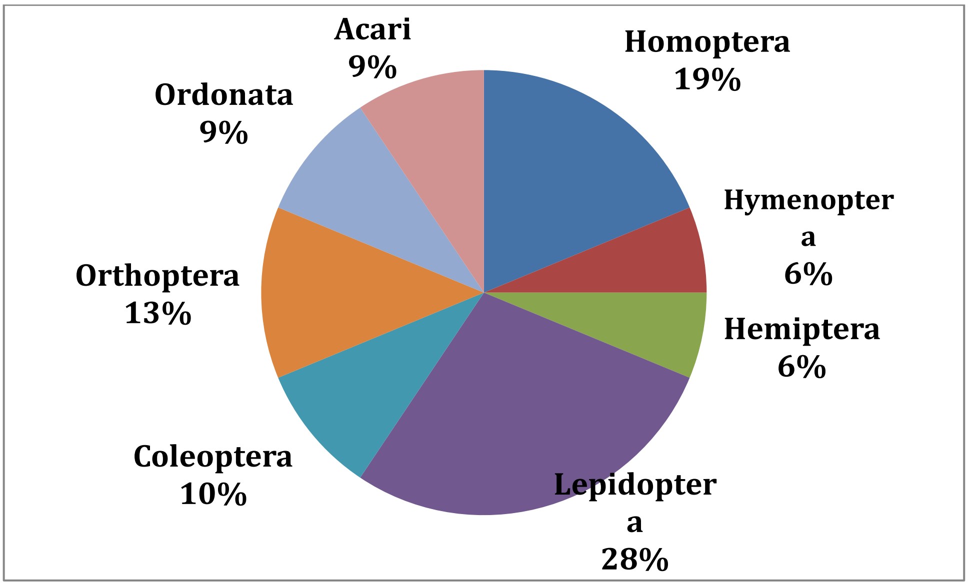


Figure 9: Percentage Composition of Insect Pest Order within Tomato Agro ecosystem in Kano State

Table 21: Summary of Insect Collected on Wheat Farms

LGAs	Study Area	Order	Common Name	Specific Name	Pest Status	Infestation Level
Kura	Dan Hassan	Homoptera Coleoptera Orthoptera	Spittle Bugs Rusted red F. Beetle Carolina	*Locris Rubens* *Alphitobius diaperinus* *Dissostera*	Major pest Vector/pest Minor/pest	3 3 1

			Grasshopper	*Corolina*		
Garun Malam	Kadawa	Homoptera	White flies	*Bemisia tabaci*	Vector/Pest	3
	Gafan	Orthoptera	Mole Cricket	*Neoscaptericus abbreviatus*	Pest	1
Danbatta	No Wheats Available	Nil	Nil	Nil	Nil	Nil
Bagwai	No Wheats Available	Nil	Nil	Nil	Nil	Nil
Bunkure	Bunkure	Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
	Alkamawa	Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Homoptera	Spittle bugs	*Locris rubens*	Major pest	3
		Orthoptera	Long headed Grasshopper	*Achurum carinatum*	Minor pest	1
Warawa	Lababar Gadon Sarki	Homoptera	Spittle bugs	*Locris rubens*	Major pest	1
		Orthoptera	Long headed Grasshopper	*Lucusta migrotoria*	Pest	1
		Lepidoptera	Pointed lady moth	*Venessa cardui*	Pest	1
	Gishirin Wuya	Orthoptera	Carolina Grasshopper	*Diassostera Carolina*	Minor pest	1
						1
		Orthoptera	Long headed Grasshopper	*Achurum carinatum*	Minor Pest	
		Homoptera	Spittle bugs	*Locris ruben*	Major Pest	3

Infestation scale/grade: 0 = no insect indecently seen, 1 = Scattered appearance of few insect on the plant, 2 = severe incidence of insect pest on only one branch, 3 = severe incidence of insect pest on more than 1 branch, 4 = severe incidence of insect on whole plant was recorded

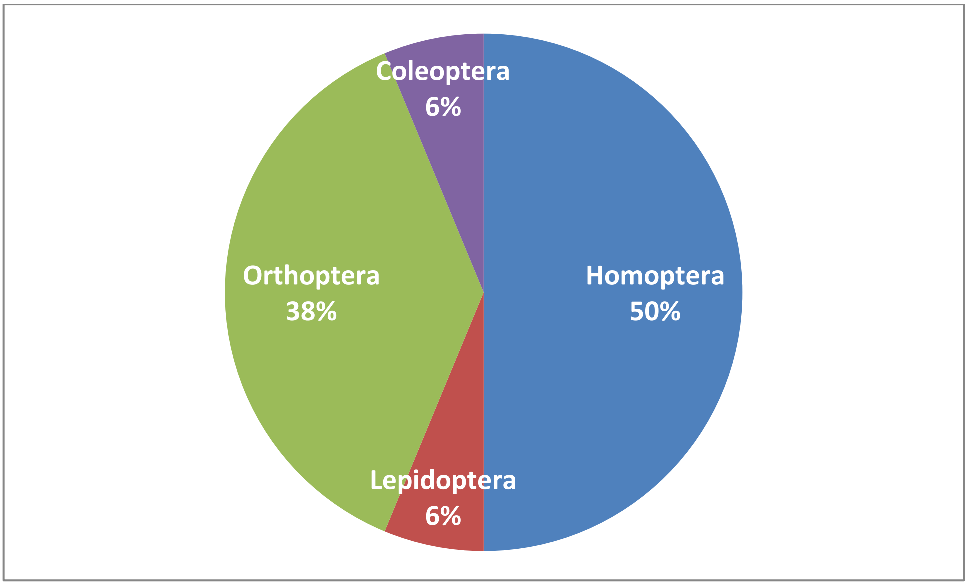


Figure 10: Percentage Composition of Insect Pest Order within Wheat Agro ecosystem in Kano State

Table 22: Percentage (%) relative abundance of individual's species of Tomato and Wheat

S/N	Common name	Scientific name	Relative abundance (%)	
			Tomato	Wheat
1	Spittle Bugs	*Locris rubens*	3.13	27.78
2	Rusted red Flour beetle	*Alphitobius diaperinus*	6.25	5.56
3	Corolina Grasshopper	*Dissostera corolina*	6.25	11.13
4	White Flies	*Bemisia tabaci*	16.63	5.56
5	Monarch Butterflies	*Danaus plexeppus*	3.13	-
6	Dragon Flies	*Macromidia ishaidai*	9.38	-
7	Mole Cricket	*Neoscapteriscus abbreviatus*	6.25	5.56
8	Purple Short Copper	*Lyacaena alciphron*	3.13	-
9	Painted lady moth	*Venessa cardin*	6.25	5.56
10	Saw flies	*Tenihendi mesonde*	3.13	-
11	Greenhouse W/flies	*Trialeurodes vaporanum*	3.13	-
12	German wasp	*Vespule gemanica*	3.13	
13	Stink bug	*Hlyomorpha halys*	3.13	-
14	Long headed Grasshopper	*Lucusta migrotoria*	-	16.67
15	Tomato fruit borer	*Helicoverpa armigera*	18.75	-
16	Two-spotted red spider mite	*Tetranychus urticae*	9.38	-
17	Tomato Leaf miner	*Tuta absoluta*	9.38	

Table 23: Summary of the Insect Collected on Rice Field

S/N	L.G.A	Study Area	Insect Ordeer	Common Name	Specific Name	Pest Status	Infestation Level	Role /Habits
1	Bagwai	Kanyu	Diptera	Band eyed horsefly	*Tabamus bromius*	Minor pest	1	Pollinating agent
			Diptera	Black garden ant	*Lasius niger*	Minor pest	1	Scavenger
			Hymenoptera	Honey bee	*Apis mellifera*	minor pest	1	Polliting agent
			Hemiptera	Stink bug	*Aspavia armigera*	Major pest	3	Seed and stem borers
			Diptera	Stalk eyed flies	*Diopsis apicalis*	Major pest	3	Stem and panicle borer
2	Danbatta	Thomas	Homoptera	Spittle bug	*Locris rubens*	Minor pest	1	Grain suckers
			Lepidoptera	Emperor butterfly	*Apatura lilia*	Minor pest	1	Natural Enemy

3	Garin mallam	Garin mallam	Lepidoptera	Paited lady moth	*Venessa cardui*	Minor pest	2	Nectar and leaf suckers
			Heteroptera	Cotton stainer	*Dysdacus supertitiusis*	Minor pest	1	Natural Enemy
			Odonata	Dragon fly	*Phyrrhosoma nymphula*	Minor pest	1	Natural Enemy
			Heteroptera	Stink bug	*Aspavia armigera*	Major Pest	3	Stem and stem borers
4	Garin Mallam	Garin Babba	Orthoptera	American grasshopper	*Schistocerca americana*	Major pest	3	Seed and stem borers
			Heteroptera	Stink bug	*Aspavia armigera*	Major pest	3	Leaf hopper
			Orthoptera	Common green grasshopp	*Omocestus viridulus*	Major pest	3	Leaf hopper

			Orthoptera	ers Giant green slant face grasshopper	*Acrida conica*	Major pest	3	Leaf hopper
5	Kura	Kura	Lepidoptera	Painted lady moth	*Venessa cardui*	Minor pest	2	Nectar and leaf suckers
			Lepidoptera	Emperor butterfly	*Apatura lilia*	Minor pest	2	Natural Enemy
			Heteroptera	Cotton stainer	*Dysdacus superstitiusis*	Minor pest	1	Plant tissue irritator
			Diptera	African rice gall midge	*Orseolia oryzea*	Major Pest	3	Seed borers
			Hymenoptera	German yellow jacket	*Vespula germanica*	Minor pest	1	Stem and seed borers
			Hemiptera	Leaf footed bug	*Leptoglossus occidentalis*	Major pest	3	

			Heteroptera	Stink bug	*Aspavia armigera*			

Table 24: Percentage (%) relative abundance of individual's species of Tomato and Wheat

S/N	Common name	Scientific name	Relative abundance (%)
			Rice
1	African rice gall midge	*Orseolia oryzea*	36.4
2	Stalk eyed flies	*Diopsis apicalis*	27.3
3	Painted lady moth	*Venessa cardui*	9.1
4	Stink bug	*Aspavia armigera*	18.2
5	Black garden ant	*Lasius niger*	4.5
6	Honey bee	*Apis mellifera*	4.5
8	Emperor butterfly	*Apatura lilia*	9.1
9	Spittle Bugs	*Locris rubens*	4.5
10	Cotton stainer	*Dysdacus supertitiusis*	9.1
11	American grasshopper	*Schistocerca americana*	4.5
12	Common green grasshoppers	*Omocestus viridulus*	4.5
13	Giant green slant face grasshopper	*Acrida conica*	4.5
14	Dragon Flies	*Macromidia ishaidai*	4.5
15	German yellow jacket	*Vespula germanica*	4.5
16	Leaf footed bug	*Leptoglossus occidentalis*	4.5
17	Band eyed horsefly	*Tabamus bromius*	4.5

Table 25: Rice stage wise integrated pest management plan for insect pest in Kano

S/N	Stage	Name of Pest	Extent of damage	Mitigation measures (control)	Responsible	Time Frame
I	Seedling/ Nursery	African rice gall midge - *Orseolia oryzivora*	Attacking the growing primordial, destroying the bud of young seedling and causing the production of tubular gall.	- use of varietal resistance/tolerance - Seed dressing - destroy alternative host plants such as rice ratoons, volunteers and the weed - Moderate levels of fertilizer should be used and applied in split doses - Movement of seedlings should be discouraged because such seedlings can be infested by AfRGM in the nursery	Agronomist, Entomologist and Pathologist	Early season
2	Vegetative	African rice gall midge - *Orseolia oryzivora*	Attacking the growing primordial, destroying the bud and causing the production of tubular gall. Yield loss beyond 80 % was reported	- early sowing - seedling treatment with insecticide - field application of insectide - search/enhancement of natural biological control	Biocontrol expert, Entomologist and Pathologist	

3	Reproductive	Stalk-eyed fly - *Diopsis longicornis*	- it appear on transplanted rice as early as about 10 Days After Transplanting (DAT) with its peak at 40 DA - Only one larva occupies a stem and feeding leads to **dead-heart** symptom.	- Early sowing, narrow spacing of plants and maintaining weed-free fields should be observed - Synchronized planting over a large area allows the most susceptible stage of rice to escape from *Diopsis* damage - maintaining weed-free fields should be observed - Management of stubble by burning, plowing and flooding after harvest destroys diapausing larvae - Search and establishment of natural control agents	Agronomist, Entomologist and Pathologist	
4	Ripening	Stink bug-*Aspavia armigera*	- grain-sucking bugs - *Aspavia spp.*	- Crop monitoring and survey - Resistant varieties - Cultural practices - IPM	Agronomist, Entomologist and Pathologist	

			feeding contributes to the incidence of the 'dirty panicle' syndrome. - Removal of the liquid milky white endosperm results in small and unfilled grains - When the bugs feed on soft or hard dough endosperm, they contaminate the grain with microorganisms that cause grain discoloration or "pecky" rice which are prone to break during milling.			

SECTION NINE:

QUALITATIVE DETERMINATIONS OF PESTICIDE RESIDUES IN SOIL AND WATER SAMPLES FROM SOME FARMING AREAS OF KANO STATE, NIGERIA.

Introduction

Pesticides are extensively used in agricultural production to check or control pests, diseases, weeds and other plant pathogens in an effort to reduce or eliminate yield losses and preserve high product quality (Eskenazi *et al.*, 2008). Pesticides are characterized by pronounced persistence against chemical/biological degradation, high environmental mobility, strong tendency for bioaccumulation in human and animal tissues, and significant impacts on human health and the environment, even at extremely low concentrations (Liu *et al.*, 2009).

Classification of pesticides

Pesticides are classified based on the pest they control as:

- Insecticides- Chemical substances used to kill insects, e.g. DDT, BHC
- Herbicides- Chemical substances used to kill weeds (i.e., unwanted plants) e.g. Borax, Nitrofen.
- Fungicides- Chemical substances used to kill fungus e.g. Captan, Mancozeb
- Rodenticides- Chemical substances used to kill Rodents e.g. Warfarin, Zinc phosphide.
- Nematicide-These are used to kill nematodes e.g. DBCP, Phorate
- Molluscicide-These are used to kill mollusks e.g Sodium pentachloridephenate.
- Algaecides-These are used to kill algae e.g. Copper sulphate, Endothal
- Bactericide-These are used to kill bacteria e.g. Dichlorophen,Oxolinic acid
- Piscicides-These are used to kill fishes (unwanted species) e.g. Trifloro methyl nitrophenol (TFM)

They are also classified based on the source or production methods as: -

- chemical pesticides,
- biopesticides
- and antimicrobials.

Chemical pesticides

- Organophosphate Pesticides - These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. However, they usually are not persistent in the environment. (e.g. parathion, malathion, and methyl parathion)
- Carbamate Pesticides affect the nervous system by disrupting an enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates. (e.g. Bendiocarb, Carbaryl, Methomyl, and Propoxur)
- Organochlorine Insecticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence (e.g. DDT and chlordane).
- Pyrethroid Pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system. (e.g. permethrin, resmethrin, and sumithrin)

Benefits of pesticides use

- They are used in public health programmes to control vector borne diseases
- They are used to protect the stored food grains.
- They protect the standing crop in the field. They do not increase the crop yield like fertilizer but by protecting the crop from pests.
- They can be used to control household pests.

Problems of pesticides

- The pesticides cause pollution of soil, water and air. The pesticide residue washed along with rain water, is added to the nearby water resources making it unfit for drinking.
- They enter the food chain and cause problem of bioaccumulation or biomagnification.
- They are not target specific hence also kills non-pest insects. It adversely affects the mechanism of entomophily.
- Continuous and indiscriminate use of pesticides may develop resistance in insect pest like superpest and superbugs.
- They are non-biodegradable and affect the balance of ecosystem.

- They are highly toxic in nature and if not handled carefully, they can cause serious health problems like cancer, deformities and disease.
- Accidents in pesticides manufacturing units cause great loss of human life e.g., Bolsover (England,1968), Seveso (Italy,1976), Bhopal Gas Tragedy (India,1984)

Pesticide residue

Pesticide residue refers to the pesticides or its 'metabolites' or 'degradation products' that may remain on or in food, soil or water after they are applied to food crops.

Residues can arise from:

- the use on a crop of legally allowed pesticides according to good agricultural practice (leave smallest and acceptable amount of residue)
- overuse of a pesticide, or use too close to harvest, of a legally permitted pesticide
- illegal use of a pesticide that is not approved for that crop
- incorrect use of pesticides after harvest, to reduce pest infestation in storage or in transit.

Pesticide in Nigeria

A survey on pesticides usage in Nigeria indicated that about 15,000 metric tons annually of pesticides comprising about 135 pesticide chemicals marketed locally under 200 different produce brands and formulation were imported during 1983-1990 thus making Nigeria one of the largest pesticides users in sub-Sahara Africa (Osibanjo, 2002).

Table 26: Common names of some pesticides and the names in which they are sold in Nigeria

Common name	Trade names of pesticide, as sold in Nigeria
Paraquat	Gramoxone, Bret-P, Paraforce, Weedoff, Weedcrusher, Dragon, Dizmaxone, Lasher, Miazone, Weedex, Ravage, etc.
Atrazine	Atrazine, Delzine, Atrataf, Atraforce, Xtrazine,
Butachlor	Butachlor, Butacrop, Butastar, Butacot, Butaclear, Risene, Teer, Butaforce, Cleweed
Propanil	Propanil, Propacare, Propan, Rhonil, Orizo, Propaforce, etc.
Pendimenthalin	Stomp, Pendilin
Oxidiaxone	Ronstar, Riceforce, Unicrown
Alachlor	Lasso, Alachlor, etc.

Glyphosate	Roundup, Glycel, Wipeout, Clearweed, Bushfire, Forceup, Sarosate, Rhonasate, Delsate, Glyphosate, Touchdown forte, etc.
2,4-D Amine	Aminoforce, Delmin-forte, 2,4-D-Amine, Select, etc.
Lamdacyhalothrin	Karate, Laraforce, Attack, Karto, Zap, etc.
Cypermethrin	Cypermethrin, Suraksha, Superthrin, Best, Cymbush, Cypercot, etc
Dichlovos	Nuvan, Pestoff, Rhonclov, Dash, Smash, Delvap, Wonder, Shooter, Nopest, Clepest, DDforce, VIP, etc.
Mancozeb	Z-force, Hi-shield, Mancozeb, Mycotrin, etc.

Source: IITA, 2008

Table 27: List of Banned Pesticide in Nigeria

	PESTICIDE	CATEGORY	STATUS
1	ALDRIN	INSECTICIDE	BANNED
2	BINAPACRYL	FUNGICIDE	BANNED
3	CAPTAFOL	FUNGICIDE	BANNED
4	CHLORDANE	INSECTICIDE	BANNED
5	CHLORDIMEFORM	INSECTICIDE	BANNED
6	DDT	INSECTICIDE	BANNED
7	DIELDRIN	INSECTICIDE	BANNED
8	DINOSEB & DINOSEB SALTS	HERBICIDE	BANNED
9	HEPTACHLOR	HERBICIDE	BANNED
10	LINDANE	INSECTICIDE	BANNED
11	ETHYLENE DICHLORIDE	FUMIGANTS	BANNED
12	PARATHION	INSECTICIDE	BANNED
13	METHYL PARATHION	INSECTICIDE	BANNED
14	PHOSPHAMIDON	INSECTICIDE	BANNED
15	MONOCROPTOPHOS	INSECTICIDE	BANNED
16	METHAMIDOPHOS	INSECTICIDE	BANNED
17	CHLOROBENZILATE	INSECTICIDE	BANNED
18	TOXAPHENE	INSECTICIDE	BANNED
19	PENTACHLOROPHENOL	HERBICIDE, INSECTICIDE	BANNED
20	ETHYLENE OXIDE	FUMIGANT, DISINFECTANT	BANNED
21	HCF (MIXED ISOMERS)/BHC	INSECTICIDE	BANNED
22	EDB (1,2-DIBROMOETHENE)	FUMIGANT	BANNED
23	2,4,5 TRICHLOROPHENOXY ACETIC ACID	HERBICIDE	BANNED
24	ENDRIN	INSECTICIDE	BANNED

24	MIREX	INSECTICIDE	BANNED
26	ETHYLENE DIBROMIDE	FUMIGANT	BANNED
27	HEXACHLOROBENZENE	FUNGICIDE	BANNED
28	ENDOSULPHAN ACARICIDE,	INSECTICIDE	BANNED
29	DELTA HCH	AGRICUTURALINSECTICIDE	BANNED
30	FLOURACETAMIDE	RODENTICIDE	BANNED

Source: NATIONAL AGENCY FOR FOOD AND DRUG ADMINISTRATION AND CONTROL (NAFDAC)

Environmental fate of pesticides

Once applied to the field, a lot of changes will happen to the applied pesticide. It may be taken up by plants or ingested by animals, insects, worms, or microorganisms in the soil. It may move downward in the soil strata and either adhere to soil particles or dissolve in water. The pesticide can enter into the atmosphere by vaporization or break down through microbial and chemical pathways into other less toxic compounds. It can also be leached out of the root zone through rain or irrigation water or wash off through surface runoff. All these changes that may happen on a pesticide applied to soil depend largely on two of its properties: persistence and solubility (Rao *et al,* 2012).

The intensive application of pesticides increases crop yields and food production; however, it results in some environmental problems such as contamination of soil. When applied, only 15% of the applied pesticide reaches the target, with the remaining 85% being distributed in soils and air (Leonila, 2002).

Pesticides residue in the soil can move from the surface when they dissolved in runoff water, or percolate down through the soil, and eventually reach the groundwater, and this may lead to the pollution of the water. Leachate from open dump and landfills are therefore recognized as sources of Oragnophosphorus pollution of surface water in Africa. This is of great concern to expert in the field of toxicity as most of the pesticide pollution goes unnoticed in Nigeria, as underground water supply has become the most important supply of water in urban areas. In their study on the degradation of Endosulfan in Ibadan soils and the effect of the application rate of this pesticide on some soil chemical properties, Aikpokpodion *et al.* (2010) found that there was a significant increase in the acidity, magnesium and iron content of the treated soil and decrease in the concentration of Ca, K and Na in the treated soil. An average of 3.91ng/g soil of Endosulfan was present as residue in the soil six months after application. There was also 85% population reduction of nematode as a result of the application of Endosulfan. They concluded that the application of

Endosulfan pesticide is moderately persistent in Ibadan soil and hinders availability of some soil nutrients.

Pesticides enter natural water from direct application for control of aquatic weeds, trash fish, aquatic insects, percolation and run off from agricultural lands, drift from industrial waste water and discharge from waste waters from clean up equipment's used for pesticide formulation and application. A high level of organochlorine and polychlorinated pesticides was revealed in some rivers in the northern part of Nigeria by Okaniyia *et al* (2009), this was attributed as a result of the extensive use of Lindane in fishing and Aldrin in cultivated farmland close to these water bodies. Although, these pesticides level were found to be less than obtainable results in United State America but, the bioaccumulation in fishes and other aquatic life is of great concern. Evidence of underground water pollution by some pesticides in Nigeria has also been established by Osibanjo and Aiyejuyo (1994), the study shows that total DDT and heptachlor found in Ibadan ground water exceeded the WHO limits for these chemicals in drinking water.

Etonihu *et al*. (2011) investigated the presence of pesticides in maize grains, white beans and sorghum which were purchased randomly from open markets in Nasarrawa and Plateau states. The results showed the presence of 28 pesticides represented in these food items. Osibanjo (2002) showed that 217 fruits and vegetables; four major cereal (rice, maize, sorghum and soybeans), as well as food stuffs of animal origin from different location within Nigeria were analyzed for the presence of organochlorine. Meat, pulses and cereals were discovered to contain DDT, Aldrin and Dieldrin above maximum residue limit (MRL) while, others contain the pesticides below MRL (Osibanjo and Adeyeye, 1995; Osibanjo and Adeyeye, 1997; Adeyeye and Osibanjo, 1999). Osibanjo and Bamgbose (1991) detected the presence of some organochlorine pesticides in 94 samples of 25 marine fish species, 14 samples of 7 shellfish for a period of 2 years. The fish samples contained higher concentrations of Aldrin, Heptachlor, HCB and Lindane and lower concentrations of DDT and PCBs compared to shell fish.

A range of concentration levels of pesticides have been found in animals including humans. Animals are exposed to pesticides through various means including consumption of foods, contact, inhalation, and absorption. Biological indicators of pesticides include: urinary residues and their metabolites, adipose and serum residues, breast milk residue, skin and hair residue. In less developed countries such as Pakistan, the presence of pesticide residues has been reported in the blood of Karachi people (Azmi *et al*., 2005). Cruz *et al*. (2003) also

reported the presence of pesticide residue in an urban and two rural populations in Portugal while the effect of pesticide residues on health and different enzyme levels in the blood of farm workers from rural area of Karachi, Pakistan was reported by Azmi *et al.* (2006).
Over 98% of sprayed insecticides and 95% herbicides reach a destination other than their target species, including non-target species, air, water and soil. Pesticides usage is one of the causes of water pollution; some are persistent organic pollutant and contribute to soil contamination (Bradman, 1999). The incidence of pesticides poison can result from the misuse, storage of pesticides close to consumable food stuff, the use of pesticides containers for household, improper disposal of used containers, treatment of food stuff with pesticides, transport of food and pesticides in the same lorry and cars such as in the case of Iraq 1970 (WHO, 1990). Identifying and determining the level of trace contaminants in our food and environment is critical to protecting and improving human health and the environment. The accurate measurement of residues helps to better protect our community and develop superior production practices. In view of the public health significance of pesticides residues and the uncertainty that exist regarding the long-term effects of low dose exposure to these pesticides to human and the environment, it is relevant to investigate their presence. Therefore, the aim of this first part of this project is to investigate the presence of pesticide (residue) in some soil and water samples collected from farming area of Kano State.

Methodology

Study Area

The study was conducted in some irrigation areas of Kano state. Six local government areas (LGAs) of Kano State were selected along the Wheat and Tomato value chain. These are Bagwai, Bunkure, Danbatta, Kura, Garun Malam, and Warawa. In all the LGAs, 14 locations/villages were visited which include; Dakasoye, Danhassan (Kura), Dorawar Sallau, Kadawa, Garun Babba, Kwanar Gafan (G/Malam), Bunkure, Shimar (Bunkure), Tomas (Danbatta), Gishiri Wuya, Larabar Gadon Sarki, Katarkawa (Warawa) and Bagwai (Bagwai).

Collection of samples

Soil samples were collected from nine (9) farming areas namely: Dambatta, Bagwai, Alkamawa, Kwanar Gafan, Danhassan, Garun Malam, Gishiri Wuya, L/Gadon Sarki and Dorawa Sallau. In each area, soil samples were collected from three different farms. In each farm five grab top soil (0-25 cm) samples were collected using a cleaned trowel from the four corners of a quadrat of 50 × 50 m and one sample from the intersect of their diagonals; these samples were then mixed to form a single composite sample of about 1 kg. A total of 27 samples were collected, all these samples were kept in well-labelled plastic polythene containers and transported to the laboratory for analysis.

Water samples were collected from same 9 farming areas as above. In each area 3 water samples were collected from different water sources depending on the one that is available (stream, open well or borehole). The sampling bottles were rinsed with the water before taking the water samples. The samples were labeled and transported to the laboratory within 24–48 hours on ice in clean ice chests and stored in the refrigerator at 4^0 C until they were analysed for pesticide residues. A total of 27 water samples were collected.

Sample Preparation

The soil samples were oven–dried at 105 °C to constant weight and sieved using 2 mm nylon mesh. Sub-samples of the sieved soils were then taken (using coning and quatering method) for pesticide residues analysis. For the water samples, they were just kept frozen before the extraction.

For this first part of the project, nine soil samples were chosen one from each farming areas. The codes and locations are shown in table 3. For water samples, the three samples collected in each area were mixed together to form a single composite sample.

Table 28: Soil sample code and location

SOIL CODE	FARM CODE	LOCATION
S1	YGB	DAMBATTA
S2	SIA	K/GAFAN
S3	ANM	BAGWAI
S4	AWL	KATSINAWA DANHASSAN
S5	YHU	SAMAWA G/MALAM
S6	IS	BUNKURE
S7	MZ	L/GADON SARKI
S8	SLD	D/SALLAU
S9	DGL	GISHIRI WUYA

Extraction of soil samples

The extraction of the pesticide was carried out by the EPA method 8081A. Ten grams (10 g) of soil samples were weighed and quantitatively transferred into 250 mL separating flasks. 10 mL of hexane was added to each of the soil samples in the flasks and ultrasonicated for 5 min. An additional 10 mL of hexane was added, and the flasks closed tightly. The samples were placed on a horizontal mechanical shaker and set to shake continuous for 30 min at 300 mot/ min. The contents were then allowed to stand for 10 min to sufficiently separate the phases or layers. A 10 mL of the supernatants were carefully taken by pipette and dried over 2 g anhydrous magnesium sulphate through filter paper into 50 mL round bottom flasks. The concentrates were then adjusted to about 2 mL using the rotary film evaporator at 35^0 C, and made ready for silica clean up.

Clean-up of soil extract

In order to remove the matrix compounds that could interfere in the GC analysis, there was the need for clean-up. Extracts clean up were done, using polypropylene cartridge columns, packed with one-gram silica gel previously activated for 10 h in an oven at 130^0 C, which have one centimeter thickness layer of anhydrous $MgSO_4$ on top and conditioned with 6 mL acetonitrile. The concentrated extracts were then loaded onto the columns/ cartridges, and 50 mL flat bottom flasks placed under the columns to collect the eluates. A 10 mL hexane was used to elute the columns afterwards. The total filtrates collected were concentrated to dryness at 40^0 C using the rotary evaporator. The residues were redissolved in 1 mL ethyl acetate by pipetting and transferred into 2 mL standard opening by gas chromatography (GC). All extracts were kept frozen until analysis was required.

Extraction of water samples

The water samples were filtered using the Whatman filter paper to remove debris and suspended material, 1000 mL portions of the filtered water samples were transferred into two litre capacity separating flasks. A 30 mL of saturated solution of (NaCl) was added to each to produce a salt out effect in order to adjust the pH to 7. A 50 mL volume of hexane was introduced into a 2 litre separating funnel containing 1 litre of filtered water and were shaked manually for 5 minute and allowed to settle. After complete separation, the organic phase was drained into a 250 mL conical flask, while the aqueous phase was re-extracted twice with 50 mL of hexane. The extracted organic phases were combined and dried by passing through a glass funnel containing anhydrous sodium sulfate. The organic fraction was concentrated using rotary evaporator and subjected to silica clean up.

Clean-up of water Extract

Extracts clean up were done, using polypropylene cartridge columns, packed with one-gram silica gel previously activated for 10 h in an oven at 130^0 C, which have 2 g layer of anhydrous sodium sulphate on top and conditioned with 6 mL hexane. The concentrated extracts were then loaded onto the cartridges, and 100 mL round bottom flasks were placed under the columns to collect the eluates. A 20 mL hexane was then used to elute the columns/cartridges afterwards, and the total eluents collected were concentrated just to dryness using the rotary evaporator set at 40^0 C. It was then redissolved in 2 ml ethyl acetate, prior to analysis by gas chromatography (GC) equipped with electron capture detector. All extracts were kept frozen until quantification was achieved.

Analysis (Gas Chromatography-mass spectrometry-GC-MS)

Sample extracts from the clean-up were analysed by gas chromatographymass spectrometry (GC-MS) using Agilent GCMS model: GC 7890B, MSD 5977A (Agilent Tech, USA).

Results and Discussions

The results of the GCMS chromatogram show the presence of over 100 compounds (soil and water being real samples). These compounds were searched in a pesticide data base known as Pesticide Properties Database (PPDB). This database was launched in 2007 as a free-to-access website. It is currently holding data for almost 2300 pesticide active substances and over 700 metabolites. For each substance around 300 parameters are stored, covering human health, environmental quality, and biodiversity risk assessments. Out of these compounds only two pesticides (Heptachor and Dichlorvos) were found as pesticides. The pesticide residue detected in the soil and water samples are shown in tables 5 and 6 respectively.

Table 29: Pesticide residue in the soil samples

Sample	Pesticide residue
W1	ND
W2	Dichlorvos
W3	Dichlorvos
W4	ND
W5	ND
W6	ND
W7	ND

ND- not detected

Table 30: Pesticide residue in the water samples

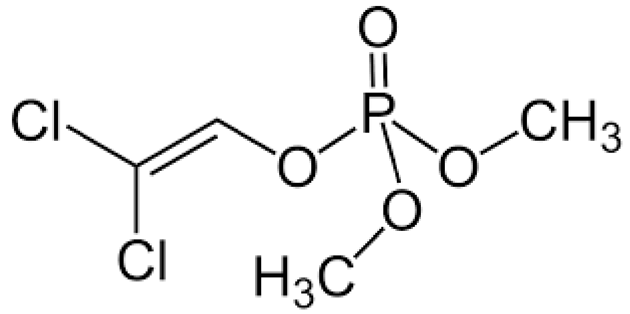
Sample	Pesticide residue
S1	Heptachlor
S2	Heptachlor
S3	Dichlorvos
S4	Dichlorvos
S5	ND
S6	ND
S7	Dichlorvos
S8	ND
S9	ND

ND- not detected

The results of the analysis indicated that about 55.6% of the soil samples had pesticide residue while about 28.6% of the water had pesticide residue. Below is the summary of the chemistry, toxicities, literatures and their environmental impacts of the two pesticides detected in the samples from these farming areas.

Dichlorvos

Dichlorvos, also known as DDVP (2,2-dichlorovinyl dimethyl phosphate) is an orgnophosphate insecticide). It is traded under names such as DDVP, Dedevap, Nogos, Nuvan, Phosvit, Vapona, Sniper and Daksh. Dichlorvos has the molecular formula $C_4H_7Cl_2O_3P$, molecular weight of 220.98, vapor pressure of 1.2×10^{-2} mmHg at 20°C, and density of 1.415 g/ml at 25°C. It has a structural formula:

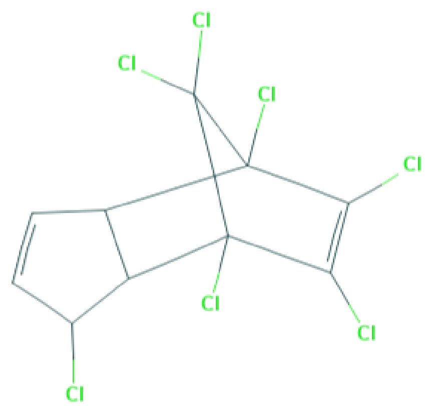


It is classified by the WHO as a class 1B, "highly hazardous" chemical (WHO, 1992). Dichlorvos is usually used as a household and agricultural pesticide. It is the most commonly used organophosphate pesticide in developing countries (Binukumar and Gill, 2010). It has been in use since the early 1960s and has been the subject of many toxicity studies (Durkin & Follansbee, 2004). Dichlorvos present a legislative challenge as the body of experimental result relating to its safety and non-safety continues to expand. Different countries view both sides of the argument differently while considering the economic implications. In some countries Dichlorvos has been restricted e.g. USA, Kuwait (ICAR-RC, 2015) or banned e.g. Bangladesh, Cambodia (FAO-UN, 2013). In Nigeria, Dichlorvos is not registered among the banned pesticide (table 2).

One of the routes of exposure of dichlorvos is inhalation. Farmers spraying it and those selling it or those using it as domestic pesticide could be potentially exposed to its inhalation. Another possible route of exposure is skin contact with soil contaminated with dichlorvos or body splash. There is also possible oral exposure by ingesting food items contaminated with dichlorvos or direct ingestion (Gallo and Lawryk, 1991). Exposure to dichlorvos could result in acute or chronic toxicity. Because dichlorvos is volatile, inhalation is the most common route of acute toxicity. There was no available study on death via inhalation of dichlorvos by humans. However, Hayes (1982) documented the case of a woman who died a day after ingestion of dichlorvos. There is also no available literature on the reproductive effect of dichlorvos in humans. However, a study on the effects of dichlorvos on fertility of male mice via intraperitoneal injection reported significant decrease in sperm number and increase in sperm abnormalities (Faris, 2008). In another study, Ezeji and Collegues (2015) reported significant reduction in testosterone levels of adult male rats fed water contaminated with dichlorvos. Mathur *et al*., (2000) reported respiratory irritation following dichlorvos exposure in children. This study showed a strong correlation between acute respiratory symptoms and exposure to dichlorvos.

Heptachlor

Heptachlor is an orgnochlorine insecticide. It is traded under names such as , Heptamul, Heptox, Termide, Chlorohepton, Heptagran, Basaklor, Drinox, Soleptax, and Velsicol 104. Heptachlor has the molecular formula $C_{10}H_5Cl_7$, molecular weight of 373.3, vapor pressure of 4.0×10^{-4} mmHg at 25°C, it is insoluble in water but soluble in the following solvents with solubilities: g/100ml solvent@ 27°C: acetone 75, benzene 106, carbon tetrachloride 112, cyclohexanone 119, alcohol 4.5, xylene 102. It has a structural formula:



The use of heptachlor in the United States was banned by the USEPA in 1988, the only commercial use still permitted is for fire ant control in power transformers (USEPA, 1990). Later, the Stockholm treaty of 2001 restricted or banned the use of heptachlor, as this compound was recognized as a so-called persistent organic pollutant (http:// www.chem.unep.ch/pops/). In Nigeria it has also been listed among the banned pesticides by NAFDAC (Table 2). The predominant target compartments for heptachlor in the environment are soil and sediment (about 43% and 55%) and, to a lesser extent, water (about 2%). Due to its chemical stability, low aqueous solubility, and high lipophilicity, heptachlor become concentrated along the food-chain, reaching higher concentrations at higher trophic levels. It reaches the human body in the daily diet and is deposited and accumulated in adipose tissues. In an intense monitoring programme in 21 counties in California, USA, 332 wells were sampled for heptachlor and 335 wells were sampled for heptachlor epoxide. Neither compound was detected (CEPA, 2000). González-Farias *et al.* (2002) found heptachlor in single agricultural drains at high concentrations, although officially the pesticide was not being used. In other studies, much higher concentrations were found in the Göksu Delta (Ayas *et al.,* 1997).

Vegetables from Jaipur City, Rajasthan, India, analyzed at the end of the season, contained much higher levels of heptachlor plus heptachlor epoxide: up to about 15.9 (tomatoes), 16 (cabbage), 9.3 (okra), 9.4 (spinach), and 1.5 (cauliflower) mg of heptachlor plus heptachlor epoxide per kilogram (Bakore *et al.,* 2002).

The major source of exposure of infants to heptachlor and its metabolites appears to be breast milk, in which the concentrations can be much higher than those found in dairy milk. Heptachlor in breast milk from women from different countries have been found e.g. Nigeria (Osibanjo, 2003), Jordan (Alawi & Khalil, 2002). There has recently been concern that the observed increase in breast cancer could correlate with the accumulation of organochlorine pesticides in human breast adipose tissues or serum, although there is little evidence at present to support this (Zheng *et al.*, 2000).

In this present work, despite being banned in Nigeria, Heptachlor was detected in soil samples collected from Danbatta and Kwanar Gafan farming areas. This shows that despite the banned of this pesticide that is found critical which have detrimental effects on human health by NAFDAC (National Agency for Food and Drug Administration and Control), some farmers still procure and use it. World Bank-West Africa Agricultural Productivity Program (World BankWAAPP, 2013) reported that about 72% of farmers in Nigeria procured their inputs from open markets which have high chance of adulteration and fake input products. Its presence may also be due to its moderately persistent in soil, where it is mainly transformed into its epoxide. It binds to soil particles and migrates slowly. The soil half-life of heptachlor under certain conditions may be as long as 2 years (Vročinsky, *et al*, 1980).

Heptachlor was not detected in any of water sample analyzed. This is likely because, under environmental conditions, heptachlor will not be prone to wash out from soil, as its K_{oc}

value of about 16 000 (Johnson, 1991) indicates a low mobility in soil; together with its limited water solubility, this would restrict its potential for leaching to groundwater.

The presence of heptachlor in some of the soil samples is of concern, because it shows that some of farmers still have access to some these banned pesticides. Therefore there is need to monitor the presence of this pesticide in soil, water, vegetables etc and possibly other banned pesticides.

Dichorovos in this work has been detected in soil samples collected from Bagwai, Katsinawa Danhassan and Laraban Gadon Sarki. Dichlorvos like other organophosphorus compounds easily breaks down rapidly in the environment. Hayes and Laws (1990) reported an average half-life of 16 days in silty clay soil; therefore, the presence of dichlrvos in these samples shows the possible misuse of this pesticide in these farming areas.

Dichlorvos has been detected in water samples collected from Katsinawa Danhassan and Gishiri Wuya farming areas. The occurrence of the pesticide in the sample collected from Katsinawa Danhassan is not surprising as it has been detected in the soil sample collected from that area. However, the occurrence of this pesticide in the water samples collected from Gishiri Wuya was surprising, since it was not detected in soil samples. This suggests possible contamination through spray drift during pesticides application and possible pesticides misuse as those water sources were in close proximity to the farms.

Conclusion

The results from this first part of the work has revealed the presence of two pesticides- Heptachor and Dichlorvos- in some of the soil and water samples collected from these farming areas. Heptachlor, even though banned in Nigeria, it was still detected in some areas and this shows that banned agrochemical are being used illegally. The presence of the pesticide residues in the soil and water samples could be as a result of pesticide use by farmers in the study areas. Farmers therefore use these chemicals indiscriminately and as such could lead to atmospheric transport of volatilized pesticides or wind drift, direct spillage, leaching, direct overspray and run-off due to application from fields and surroundings. If left unmonitored these pesticides may buildup and find their ways into the food chain and thereby harming humans.

Recommendations

- Extension officers should ensure routine monitoring of pesticide residues in the farming area for the prevention, control, and reduction of environmental pollution, so as to minimize health risks to the people.
- Health education programme concerning the safe use of pesticides, effects on the farmers' health when misused and other synthetic organic chemicals in crop production in the areas should be conducted to prevent health risks of farmers.
- The Government should enact laws to ban the sale of these pesticides by quacks.
- Good agricultural practices such as integrated pest management must be encouraged by the extension workers.
- With the detection of heptachlor- a banned pesticide- in some of the soils, investigations should be carried to determine whether there is current used of the banned pesticides and their sources.
- The water used in irrigation should be monitored to avoid the contamination of vegetables.
- Future work should be conducted other than the pesticide residues, for example there is the need to check the levels of potential toxic elements such as arsenic, cadmium, chromium, cobalt, copper, nickel, manganese, lead, zinc etc. that may be present in the water and soil samples around the farming areas. The bioavailability and bioaccessibity of these elements in the soils need to be investigated. Most the pesticides and fertilizers applied to the soil and crops contain these elements that could be harmful soil microorganism and human at certain concentrations.

References

Ajayi, O. and Oboite, F.A., 2000. Importance of spittle bugs, Locris rubens (Erichson) and Poophilus costalis (Walker) on sorghum in West and Central Africa, with emphasis on Nigeria. Annals of applied biology, 136(1), pp.9-14.

Adeyeye, A. & Osibanjo, O. (1999). Residues of organochlorine pesticides in fruit, vegetable and tuber from Nigeria market. *Science Total Environment* 231:227.

Aikpokpodion, P.E., Lajide, L., Ogunlade, M.O., Ipinmoroti, R., Orisajo, S., Iloyanomon, C.I. and Fademi, O. (2010). Effect of Endosulfan on soil and root-knot nematodes in cocoa. *Journal of Applied Biosciences* **26,** 1640- 1646.

Alawi MA, Khalil MW (2002) Regional distribution of organochlorine pesticides in human breast milk from Jordan. *Fresenius Environmental Bulletin,* 11(11):1023–1029.

Ayas Z, Barlas NE, Kolankaya D (1997) Determination of organochlorine pesticide residues in various environments and organisms in Göksu Delta, Turkey. *Aquatic Toxicology*, 39:171–181.

Azmi, M.A., Naqvi, S.N.H., Azmi, M.A., 2005. Pesticide residue in the blood of rural population from Gadap, Karachi and related health hazards. *J. Exp. Zool.* 8, 343– 351.

Azmi, M.A., Naqvi, S.N.H., Azmi, M.A., Aslam, M., 2006. Effect of pesticide residues on health and different enzyme levels in the blood of farm workers from Gadap (rural area) Karachi-Pakistan. *Chemosphere* 64 (10), 1739–1744.

Bakore N, John PJ, Bhatnagar P (2002) Evaluation of organochlorine insecticide residue levels in locally marketed vegetables of Jaipur City, Rajasthan, India. *Journal of Environmental Biology*, 23(3):247–252.

Binukumar BK, Gill KD. (2010). Cellular and molecular mechanisms of dichlorvos neurotoxicity: cholinergic, noncholinergic, cell signaling, gene expression and therapeutic aspect. *Indian Journal of experimental Biology* 48: 697–709

CEPA (2000) Sampling for pesticide residues in California well water — 1998 update of the well inventory database. Sacramento, CA, California Environmental Protection Agency, Department of Pesticide Regulation, pp. 1–68 (EH00-03).

Cruz, S., Lino, C., Silveira, M.I., 2003. Evaluation of organochlorine pesticide residues in human serum from an urban and two rural populations in Portugal. *Sci. Total Environ.* 317, 23–35

Durkin PR, Follansbee MH. (2004). Control/Eradication agents for the gypsy moth-human, health and ecological risk assessment for DDVP (Dichlorvos) final report. New York: Syracuse Research Corporation

Eskenazi, B., Rosas, L.G., Marks, A.R., Bradman A and.Harley, K. (2008). Pesticide toxicity and the developing brain. *Basic Clin.Pharmacol.Toxicol.,* 102: 228-236

Ezeji EU, Ogueri OD, Udebuani AC, Okereke JN, Kalu OO. (2015). Effects of Dichlorvos on the fertility of adult male albino rats. *Nature and Science* 13(12): 1–5.

FAO-UN: Food and Agriculture Organization of United Nations Regional Office for Asia and the pacific. (2013). Advancement of pesticide regulatory management in Asia. RAP Publication 2013/08. pp 298.

Faris SK. (2008). Effects of dichlorvos pesticide on fertility of laboratory male mice (Mus musculus L.). *Bas J Vet Res* 7(1): 9–18.

Food and Agriculture Organization (1999). Inventory of obsolete stock in Nigeria: A Country Report.

Gallo MA, Lawryk NJ. (1991). Organic phosphorus pesticides. In: Hayes WJ, Laws ER, eds. Handbook of pesticide toxicology. Vol 2. Classes of pesticides. New York, NY: Academic press. Pp. 917–1123.

González-Farias F, Cisneros Estrada X, Fuentes Ruis C, Diaz González G, Botello AV (2002) Pesticides distribution in sediments of a tropical coastal lagoon adjacent to an irrigation district in northwest Mexico. *Environmental Technology*, 23(11):1247–1256.

Hayes WJ. (1982). Organic phosphorus pesticides. In: Pesticides study in man. Baltimore: Williams and Wilkins. Pp. 343–351.

ICAR-RC: Indian Council of Agriculture Research-Registration Committee. (2015). Minutes of the 361st special meeting of RC held on 22nd December, 2015. New Delhi. Pp. 1–86.

Johnson B (1991) Setting revised specific numerical values; persuant to the Pesticide Contamination Prevention Act. Sacramento, CA, State of California Department of Food and Agriculture, pp. 1–17 (PB 91-143 130).

Leonila, M.V. (2002). Impact of agrochemical on soil and water quality. National crop protection centre, university of the Philippines at Los Banos.

Liu H, Ru J, Qu J, Dai R, Wang Z, Hu C (2009). Removal of persistent organic pollutants from micro-polluted drinking water by triolein embedded absorbent. *Bioresource Technology*, 100: 12:2995–3002

Mathur ML, Yadev SP, Tyagi BK. (2000). A study of an epidemic of acute respiratory disease in Jaipur town. *J Postgrad Med* 46(2): 88–90.

Okeniyia, S.O., Egwaikhide, P.A., Akporhonore, E.E. & Obazee, I.E. (2009).Distribution of Organochlorine and polychlorinated pesticides residue in water bodies of some rivers in northern Nigeria. *Electronic journal of environment, Agriculture and Food Chemistry* **8,** (11): 1269-1274.

Osibanjo, O. (2002). Organochlorine in Nigeria and Africa. In: Fieldler, H. (ed.) The Handbook of Environmental Chemistry. Persistent Organic Pollutants. Heidelberg, Berlin: SpringerVerlag. 3:321–354

Osibanjo O (2003) Organochlorines in Nigeria and Africa. In: The handbook of environmental chemistry. Vol. 3. Part O. Persistent organic pollutants. Berlin-Heidelberg, Springer, pp. 321–354.

Osibanjo, O. & Adeyeye, A. (1995). Organochlorine Pesticide Residue in Nigeria Market. *Bull Environ. Toxicol.* **54,** 460-465.

Osibanjo, O. & Adeyeye, A. (1997). Organochlorine Pesticide Residue in foodstuff of animal origin in Nigeria. *Bull Environ. Toxicol.* **58,** 206-212.

Osibanjo, O. & Bamgbose, ((1991) Review of chlorinated substance in marine fish and shellfish of Nigeria. *Marine Pollut. Bull*., **21,** 581-586.

Rao P.S.C , R.S. Mansell, L.B. Baldwin, and M.F. Laurent (2012), Pesticides and their behavior in soil and water, Pesticide Safety Education Program, Cornell University, Cooperative Extension.

USEPA (1990). Suspended, Canceled, and Restricted Use Pesticides. Office of Compliance Monitoring, Office of Pesticides and Toxic Substances, US EPA, Washington, DC

Vročinsky KK, Gemetčenko MM, Merežko AI. [Hydrobiological migration of pesticides.] Moscow, Moscow University Press, 1980:8–14, 33–37, 59–63, 87–94, 119–120

WORLD BANK, GHANA-WEST AFRICA AGRICULTURAL PRODUCTIVITY PROGRAM – WAAPP. Project Procurement Plan, Washington DC: World Bank, v. 1, p. 1-35, 2013.

World Health Organisation (1990). WHO recommended classification of pesticide by hazard and guidelines to classification 1990-1991. Environment Health, WHO, 1211 Geneva 27, Switzerland.

WHO: World Health Organization. (1992). International Programme on chemical safety. WHO recommended classification of pesticide by hazards and guidelines to classification 1994–1995, UNEP/ILO/WHO.

Zheng T, Hoford TR, Tessari J, Mayne ST, Zahm SH, Owens PH, Zhang B, Ward B, Carter D, Zhang Y, Zhang W, Dubrow R, Boyle P (2000) Oxychlordane and trans-nonachlor in breast adipose tissue and risk of female breast cancer. *Journal of Epidemiology and Biostatistics,* 5(3):153–160

QUESTIONNAIRE

This questionnaire is designed to seek information on farmers' perception, experience and capacity about pesticides.

Preliminaries
Respondent agrees to be interviewed Yes ( ) No ( )
Enumerator's Name..
Enumerator's Phone Number...
Date of Interview ....
Time Started ....
Time ended ....
Cross- checked by (Supervisor)................................ Phone number..........
Date Checked ....

A, Farmers' Demographic Information
1. Local Government ....
2. Village ....
3. GPS Location N...................... E......................
4. Name of Farmer..........................
5. Phone number of farmer......................
6. Gender Male ( ) Female ( )
7. Age of farmer..
8. Marital status : Single () Married () Widow/ Widower () Divorced
9. Level of Education : No formal () Primary () Secondary () Tertiary () Qur'anic ()
10. Household size.....................
11. Membership of association ....

B. Farmers' perception about the use of chemicals for pest management
12. Which crop (s) do you produce among following (tick as many) ? : a) Rice b) Wheat c) Tomato
13. How long have you been producing these crops?
i) Rice … a) <2 years b) 2 to 5 years c) 5 to 10 years d) Above 10 years
ii) Wheat a) <2 years b) 2 to 5 years c) 5 to 10 years d) Above 10 years
iii) Tomato a) <2 years b) 2 to 5 years c) 5 to 10 years d) Above 10 years
14. Do you experience any pest infestation in your farm? Yes No
15. If yes, can you name them?
ai) Rice Diseases

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

aii) Rice Insect Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

aiii) Rice Weed Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

aiv) Rice Rodent Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

av) Rice Bird Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

bi) Wheat Diseases

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

bii) Wheat Insect Pest

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

biii) Wheat Weed Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

biv) Wheat Rodents Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

bv) Wheat Bird Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

ci) Tomato Diseases

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

cii) Tomato Insect Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

ciii) Tomato Weed Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

civ) Tomato Rodent Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

cv) Tomato Bird Pests

SN	Local Name	English Name	Any other Information
1			
2			
3			
4			
5.			

18) Can you estimate the level of loss to these crops due to pest infestation?

a) Rice

SN	Percentage Loss	Response (Tick)
1	0% - 15%	
2	16% - 30%	
3	31% - 45%	
4	46% - 60%	
5	Others (Specify)	

b) Wheat

SN	Percentage Loss	Response (Tick)
1	0% - 15%	
2	16% - 30%	
3	31% - 45%	
4	46% - 60%	
5	Others (Specify)	

c)Tomato

SN	Percentage Loss	Response (Tick)
1	0% - 15%	
2	16% - 30%	
3	31% - 45%	
4	46% - 60%	
5	Others (Specify)	

16. Do you use any traditional method to control these pests?
17. If Yes, which traditional method (s) do you use?

ai) For Rice Diseases ....

aii) For Rice Insect/ Worm Pests…...

aiii) For Rice Weed Pests …..

aiv) For Rice Rodent Pests...
av) For Rice Bird Pests...
bi) For Wheat Diseases..
bii) For Wheat Insect/ Worm Pests…...
biii) For Wheat Weed Pests…..
biv) For Wheat Rodent Pests..
bv) For Wheat Bird Pests...
ci) For Tomato Diseases..
cii) For Tomato Insect/ Worm Pests……..
ciii) For Tomato Weed Pests…..
civ) For Tomato Rodent Pests...
cv) For Tomato Bird Pests..

18. What type (s) of chemical pesticide(s) do you use to control pests for:

a) Rice

SN	Local Name	English Name	Any other Information
1	Disease: i).. ii)... iii)..		
2	Insect/ Worm Pests: i).. ii)... iii)..		
3	Weed Pests: i).. ii)... iii)..		
4	Rodent Pests: i).. ii)... iii)..		
5	Bird Pest: i).. ii)... iii)..		

b) Wheat

SN	Local Name	English Name	Any other Information
1	Disease: i).. ii)... iii)..		
2	Insect/ Worm Pests: i).. ii)... iii)..		
3	Weed Pests:		

	i).. ii)... iii)..		
4	Rodent Pests: i).. ii)... iii)..		
5	Bird Pest: i).. ii)... iii)..		

c) Tomato

SN	Local Name	English Name	Any other Information
1	Disease: i).. ii)... iii)..		
2	Insect/ Worm Pests: i).. ii)... iii)..		
3	Weed Pests: i).. ii)... iii)..		
4	Rodent Pests: i).. ii)... iii)..		
5	Bird Pest: i).. ii)... iii)..		

19. Do you consider the use of chemical necessary for pest management?
Yes ( ) No ( )
20. Are you aware of the health risks of pesticides? Yes ( ) No ( )
21. If yes, which of the following safety equipment do you use for protection during application?
a) Using Eye goggles ( )
b) Using hand gloves ( )
c) Using long sleeve coats
d) Using rain boots
e) Using head veils
f) Any other protective clothing/ substitute for the one(s) above(Specify)..........

22. Do you experience any health challenge after application? Yes ( ) No ( )
23. If yes, how do you feel?..
24. How do you rate the quality of the pesticides you use? High ( ) low ( ) poor ()
25. How would you rate the availability of pesticides in your area?
Adequate ( ) Inadequate ( )
26. Where do you source pesticides in your area?
a) Agro service Centre ( )
b) Research Institutes ( )
c) Input traders ( )
d) Licensed vendors ( )
e) Open market ( )
f) Extension/development agent
g) Others (specify)...
27. Do you think chemical pesticides are cheap and affordable? Yes () No( )
28. Do you think using chemical pesticides would improve the quantities of the crops you produce? Yes ( ) No ( )
29. Are you aware of any pesticides regulations? Yes ( ) No ( )
30. How would you rate the use of pesticides in your farm?
a) High ( ) b) Moderate () c) Low ( )
31. In the event of infestation do you use other methods rather than chemical?
a) Yes b) No
32. If Yes, Explain in detail: …………………………………………

C) Farmers' Experience in Pest Management and Capacity on IPM

31. For how long have you been applying pesticides on each of these crops?
a) Rice.......... b) Wheat........... c) Tomato...................
32. Can you read the direction for use provided on the container of the pesticide?
Yes ( ) No ( )
33. If Yes, do you adhere to the directives? Yes ( ) No ( ) Exp
34. If you do not adhere, what quantities do you apply?................................
35. What quantities are directed to use?....................................
36. If you cannot read directions, how do you go about it?
a) Use my discretion b) Seek advice from input dealer c) Seek advice of extension agent d) Ask my co farmer

37. Do you abide by the directives as interpreted to you? Yes ( ) No ( )
38. If No, what quantities of the pesticides do you apply?..............................
39. What are the problems facing pesticide use in your area?
a) Inadequate funds ( )
b) Difficulty in reading the directions for use ( )
c) failure to apply according to directions ( )
d) Poor farming experience ( )
e) Inadequate supply of protective cloths ( )
40. How many times did you receive training on IPM? ....
41. Which organization provided the training?
a) FADAMA III
a) CADP
b) IITA
c) FAO

d) TRIMING
e) VEA's
f) Other(s), Specify ……………………………………………...
42. At which capacity were you trained?
a) Trainer () b) Trainee ()
43. On which method (s) of IPM were you trained? Please tick appropriately

SN	Method	Response
1	Seed Dressing	
2	Crop Rotation	
3	Rogueing	
4	Burning	
5	Planting resistant varieties	
6	Farm Hygiene	
7	Others (Specify)...	

44. Which method (s) do you practice?

SN	Method	Response
1	Seed Dressing	
2	Crop Rotation	
3	Rogueing	
4	Burning	
5	Planting resistant varieties	
6	Farm Hygiene	
7	Others (Specify)...	

45. Which method do you rate as the most effective?

SN	Method	Response
1	Seed Dressing	
2	Crop Rotation	
3	Rogueing	
4	Burning	
5	Planting resistant varieties	
6	Farm Hygiene	
7	Others (Specify)...	

46. How do you rate the training in terms of awareness and adoption?
a) Adequate ( ) b) Inadequate ( )

Thank You

8.2 Focus Group Discussion Tool

Enumerator's Name...
Enumerator's Phone Number..
Date of Interview ....
Time Started ....
Time ended ....
Local Government ....
Village ....
Number of persons in attendance ....
Pictures Available ....
GPS Location N....................... E.......................

Q1 : Which crop (s) do you produce in this area? (List as many) ....

Q2: Do you experience pest infestations? ....

Q3. How do you traditionally manage the pests affecting Rice, Wheat and Tomato in this area?
....

Q4. Do you also use chemical pesticides for managing pests affecting Rice, Wheat and/or Tomato?
....

Q5: How effective are the quantities of the chemical pesticides directed to use by the manufacturers?
....

Q6: How would you quantify the loss of Rice, Wheat and /or Tomato due to pest infestation?
....

Q7: Are you aware of health risks associated with chemical pesticides application and how?
....

Q8: Are you aware of environmental effects associated with pesticides application and how?
....

Q8: How and by who were you trained on Integrated Pest Management? ....

Q9: What other traditional methods do you know that are used for pest management in your
area?..

Q9: How would you recommend ways to reduce the use of chemical pesticides in your area?
....

Thank You

Table 31: Evaluation States and their Respective Villages

Evaluation State		Local Government Area	Participating Village
Kano	**Rano Zone**	Kura	Dakasoye and Danhassan
		Garun Mallam	Dorawar Sallau, Kadawa, Garun Babba and Kwanar Gafan
		Bunkure	Bunkure and Shimar
	Danbatta Zone	Danbatta	Thomas
		Bagwai	Bagwai, Lambar
	Gaya Zone	Wudil	Wudil
		Warawa	GishiriWuya, Larabar Gadon Sarki and Katarkawa

Table 32: Gant Chart Showing Work Plan of Activities for the survey and Time frame for major deliverables

Concluding remarks

The survey on the Integrated Pest Management (IPM) in the focused Local Government Areas has been completed successfully. After the completion of the data collection, the data saved in excel format for cleaning and the data were analyzed using SPSS version 12 or STATA version 11 and subsequent activaties conducted includes the preliminary and final report,