Vol.12(2), pp. 36-47 April-June 2020
DOI: 10.5897/JAERD2020.1154
Articles Number: AC788C164027
ISSN: 2141-2170

http://www.academicjournals.org/JAERD

ACADEMIC JOURNALS

Journal of Agricultural Extension and Rural Development

Full Length Research Paper

Status of pests and diseases of sorghum and their management practices by "Fadama" III participating farmers in Abuja, Nigeria

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Received 20 April, 2020; Accepted 27 May, 2020

A diagnostic survey was carried out at the end of 2018 and early 2019 to assess the status of sorghum pests, diseases and their management strategies by the "Fadama" III participating farmers in the Federal Capital Territory (FCT), Abuja, Nigeria. Data were collected from the 28 production clusters in 10 Fadama Development Areas in the six Area Councils. Instruments used were semi-structured interview, farm visits and the diagnosis of collected specimens from infested and diseased sorghum. The results indicated that up to 97.95% of the farmers had one form of formal education. On sorghum farms, corn rootworms (*Diabrotica virgifera*), *Striga* spp. weed and straying cattle were the major pests encountered. The incidence of Striga weed was 20.97%, while that of anthracnose disease was 76.84% though often left uncontrolled. Indigenous knowledge used for managing sorghum pests included field spraying with goat faeces slurry and placement of neem and *Blumea* leaves in corn granaries. Sorghum seeds were locally dressed with berry bark exudate, neem extract + pepper pre-planting. Due to the high severity of anthracnose on sorghum in the FCT, Abuja, there is need to embrace integrated disease management practices against this endemic disease. Routine monitoring of sorghum pests and disease prevalence, incidence and severity at different growth stages and implementation of sorghum pests management plan emanating from this study across Fadama Development Areas in Guinea Savannah agro-ecological zone is expected to enable the attainment of sustainable sorghum productivity.

Key words: Abuja-Nigeria, Fadama, incidence, insects, Integrated Pest Management (IPM), sorghum, weeds.

INTRODUCTION

The National Fadama Project in Nigeria is financed by World Bank, the African Development Bank and the Nigerian Government (Gourichon, 2013; Ani, 2014). This agricultural development project has an intention of increasing the incomes of *Fadama* land users on a sustainable basis and reduce their poverty level (Ogunlela and Ogunlela, 2008; Afolabi, 2010; Effiong and Asikong, 2013). The project is designed to be a participatory and socially inclusive approach that empowers the farmers, to take control of and manage

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their resources for their own development (NFDO, 2007; Ani, 2014).

One of the mandate crops by the FCT Fadama farmers under the Fadama III Additional Financing (AF I) is Sorghum [*Sorghum bicolor* (L.) Moench; Family: Poaceae]. They are often produced in the Savannah including the periphery of expanse of Fadama lands and processed into sorghum value added products in different forms across the territory (Pande et al*.,* 2008). The interest by the Project in promoting sustainable sorghum production through adequate protection against pests and diseases in Nigeria is not unconnected with sorghum immense economic and comparative advantages. Sorghum is used for food (as grain and in sorghum syrup or "sorghum molasses"), fodder, the production of alcoholic beverages, and biofuels (Adegbola et al*.,* 2013). However, some important challenges to sorghum production are insect pests, diseases and weeds and impact of harmful chemicals that threaten the environment and human health alike (Chunshan et al., 2011). Pests of sorghum include insects, rodents, nematodes, birds and any form of plant, animal or any pathogens that adversely affect the crop and its products, and people (Abrol, 2013).

In order to proffer appropriate management options of pest and diseases of sorghum and to enable optimum yield, there is need to determine the status of pests and diseases of the crop. Thus the objectives of the study are to: (i) evaluate the knowledge and awareness of participating farmers about sorghum pests and diseases. (ii) identify and determine the incidence of insect pests, diseases and weeds build-up on sorghum farms in the FCT, Abuja (iii) assess the management practices of pest and disease on sorghum among the participating farmers and (iv) recommend effective mitigation measures based on the IPM diagnostic survey of Fadama sites in the FCT, Abuja, Nigeria. The findings from this study are expected to be useful in decision making in future sorghum pest management planning and implementation.

MATERIALS AND METHODS

Study area

The study area is the Federal Capital Territory (FCT), Abuja in the North Central part of Nigeria. There are six Area Councils in the FCT, Abuja and the pest survey covered 10 Fadama Development Areas (FDA) as shown in Figure 1. The FCT has a land area of 8,000 km^2. It is bounded on the north by Kaduna State, the west by Niger State, the east and southeast by Nasarawa State and the southwest by Kogi State. It falls within latitudes 70 20′ north of the Equator and Longitudes 60 45′ and 70 39′.

Data collection

The study was carried out by survey through the instrument of flexible semi-structured interview survey. This was employed to elicit information on sorghum farming activities, awareness of pests and diseases on sorghum farms and level of practice of Integrated Pest Management (IPM) by the respondents. A total of four hundred and eighty five questionnaires were purposively distributed by the assigned Fadama office facilitators to the respondents from 10 Fadama development areas in the six Area Councils. The number retrieved was 480 copies that is 48 questionnaires per development areas and used for data collation and analysis. Questionnaires prepared were test run and administered to randomly selected groups and clusters in the six Area councils namely Abaji, AMAC, Bwari, Gwagwalada, Kuje and Kwali. In addition, personal observation on sorghum field was employed. An accurate geo-referencing coordinate and mapping of sampling points or selected sites and area of mass infestation/infection were carried out between November – December 2018, using GPS MAP 76CSX, (2001) manufactured by Garmin International Inc. USA. Such GPS allowed for the visitation of the same location next time and can help to manage more persistent disease problems.

Insect pest collection and identification

For farm insect sample collection, live specimens were captured by using nets for flying insects. For other insects, a cup or margarine container was placed over the insects and allowed to crawl in. They were then safely picked up and covered with lid or paper towel. The insects caught were then immediately placed in ≥ 95% ethanol or rubbing alcohol (isopropyl). Each of them was labeled with date, location, and your name. They were then placed in freezer and stored at -20°C until ready for proper identification in the laboratory and insect museum in the Department of Crop Protection, Ahmadu Bello University, Zaria. The insects collected were classified into order using an on-line identification key or cereal insect pest identification manual. Miscope attached with a computer was also used to sort insects into morphospecies (Tuzun, 2010).

Sorghum disease assessment

Sorghum samples were assessed to check if they have disease, any abnormality such as discoloration, spots or holes on the leaf, if the plants are smaller than usual or if parts of the plant are dead, if the plant has holes, spots or discoloration in the stem or in the panicles/grains. Diseased samples were collected with sterile sharp knife and identified with hand lens and camera for taking close-up digital photos before being compared with crop diseases identification manual. Pests infested and diseased sorghum samples were collected from the sorghum farms by the engaged field technologists.

If symptoms or signs cannot provide enough specific or characteristic information to decide the cause of an infectious disease on sorghum, samples were taken to the laboratory for further tests to isolate and identify the causal agent. Equipment such as microscope, autoclave and identification manuals for cereal crop diseases and weed were used for confirmation (Federico et al., 2015).

Pest and disease incidence

Pest and disease incidence were visually rated on at least three spots in a farmer's field or store visited. Percentage incidence was calculated as the number of infected crop stand over the total number of crops stands sampled as indicated in formula (*i*) as used by Ogolla et al*.* (2019):

$$\text{Pest/disease incidence} = \frac{\text{number of infested /diseased plant x 100}}{\text{total number of sampled plant}} \quad (1)$$

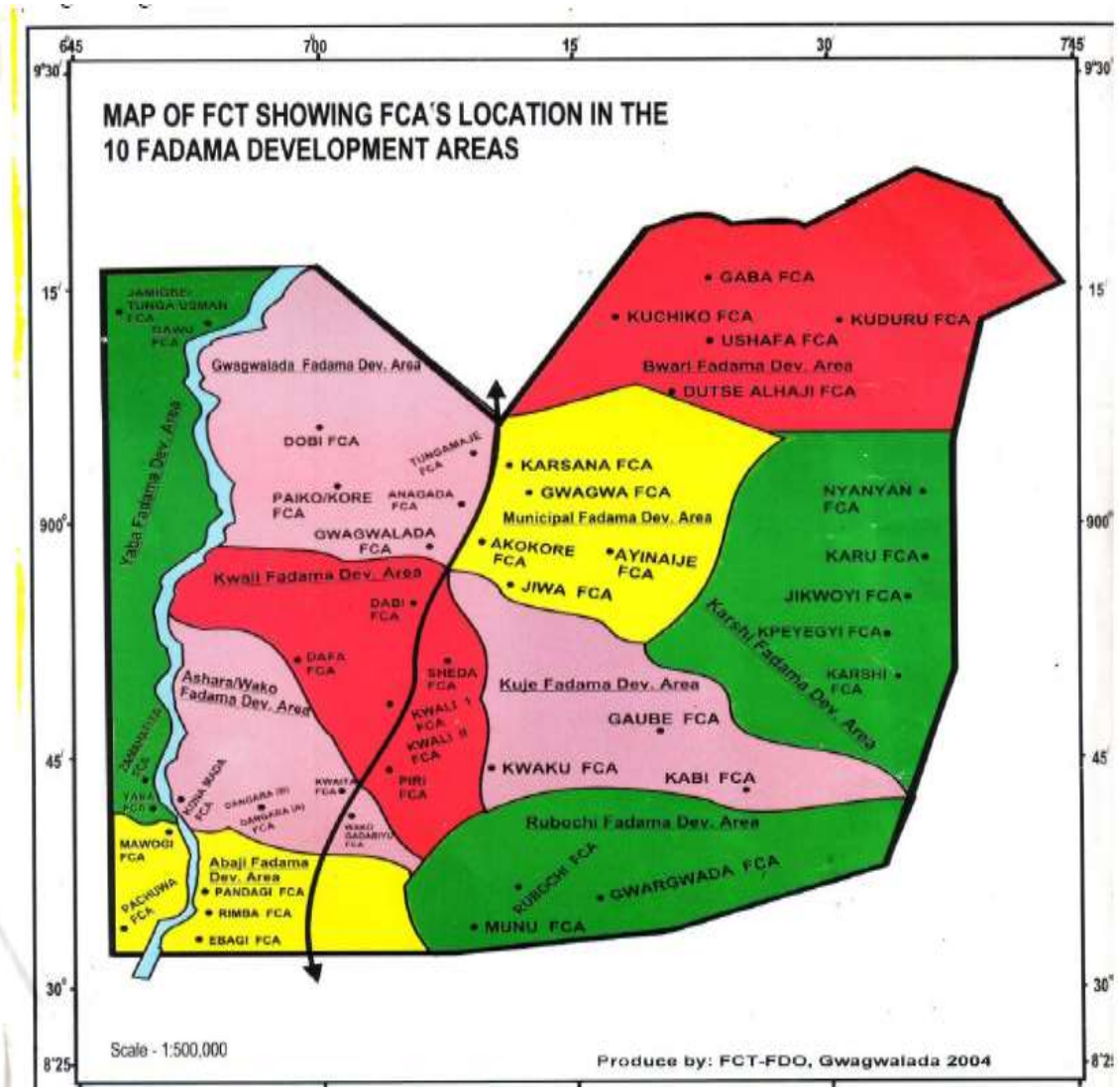

Figure 1. Map of FCT showing Fadama Development Areas within the Area Council.
Source: FCT Fadama.

Statistical analysis

Data obtained from retrieved questionnaires were coded and inputted into Microsoft excel (IBM SPSS version 20) and analysed using the Statistical Package for Social Sciences. Most results including observations on the pest and disease incidence were presented in frequency and percentages. The plates of major insect infested and disease infected specimens and weed specimens are shown.

RESULTS AND DISCUSION

Socio-economic characteristic of respondents

Majority of the respondents - the sorghum farmers were males (93.18%), while the female was 6.82%. It was revealed that most of the production activities such as ridging were carried out by the males while the planting and processing were mostly carried out by the female. Balogun et al. (2013) reported that there was a significant difference in all the activities performed by male compared to their female counterparts in Fadama Crop Production Project in Kwara State.

Most of the respondents were adults between 31 and 40 years (38.76%) with only 6.40% above 60 years old (Table 1). This indicated that most of the farmers that participated in sorghum production under the programme were in their active productive years. The age of the farmer according to Adewumi and Omotesho (2002) is expected to affect his productivity, output and the adoption of innovations in farming. Only about 12.05% of the respondents have informal education while higher groups had secondary education (26.50%) and tertiary education (24.17%) respectively. The attainment of any

Table 1. Socio-economic data of sorghum farmers in the FCT, Abuja.

Parameter	Frequency (%)
Age (year)	
21- 30	15.41
31-40	38.76
41-50	17.61
51- 60	11.95
51- 60	11.72
61- above	6.40
Level of education	
Informal	12.05
Quaranic	13.07
Primary	23.88
Secondary	26.50
Tertiary	24.17
Farm size/annum	
<1 Ha	38.32
1 – 3 Ha	43.23
>3 Ha	18.45

Table 2. Sorghum cropping practices in three of the area councils of the FCT.

Area council	Varieties of sorghum planted	Indigenous knowledge used in managing Sorghum pests	Major challenges	Common insecticide	Common herbicide
Bwari	Samsorg 47 local var. : *Zauna inuwa*, Samsorg 48	Early planting, trapping, wood ash,	Striga and goat weed; inadequate fertilizer	Mancozeb for seed dressing	Gramazone
Gwagwalada	Samsorg 47; Kaura	Catapult, gwaska + salt, scare crow; fencing in Ledi; Hyptis leaf, neem seed powder; occasional heating to rhombus to repel insect pest.	Bird pest (e.g. quela) Anthracnose disease; *Hyptis* spp weed	DDforce, coniz, use dichlorovous	Paraquat and glyphosate
Kuje	Samsorg 47 are red sorghum, black eye sorghum, sorghum short or long kaura Samsorg 58 and Samsorg 53.	Goat/cow faeces, trap, locust bean extract, dialogue with herdsmen, lime water, salt, tobacco powder and seed coating with bitter lemon bitter lemon, crop rotation and ordeal tree bark powder, timely planted, early weeding, crop rotation,	*Wutawuta* parasitic weed (*Striga* spp) monkey, weaver bird, bad road e.g. in Fogbe and Shitumu villages; high cost of hiring tractor, labour; smut diseases	Neem, wood ash,	Thrips; Grain borer

type of formal education is expected to have a favourable attitude towards the adoption of agricultural innovations (Agwu, 2004; The Agriculture Promotion Policy, 2020). Majority of the sorghum farmers -43.23%, cultivate between 1 and 3 ha annually, while only 18.45% have over 3 ha. This was slightly lower than the farm size cultivated by the Fadama farmers in Orire Local Government Area of Oyo State-Nigeria, where about 40% of them farmed between 1.61 and 3.2 ha annually (Akangbe et al*.,* 2012).

Sorghum cropping practices in the FCT

Higher percentage of the farmers planted improved sorghum varieties (92.50%) while the rest 7.50% planted local varieties (Table 2). Major varieties of sorghum planted were Samsorg 47, 48, 53, 58 and *kaura inuwa* and this were mostly planted in the month of July every year. Up to 93.17% of the respondents sourced their Fadama programme and just 6.83% from other sources. Majority of the farmers (67.56%) do plant their sorghum

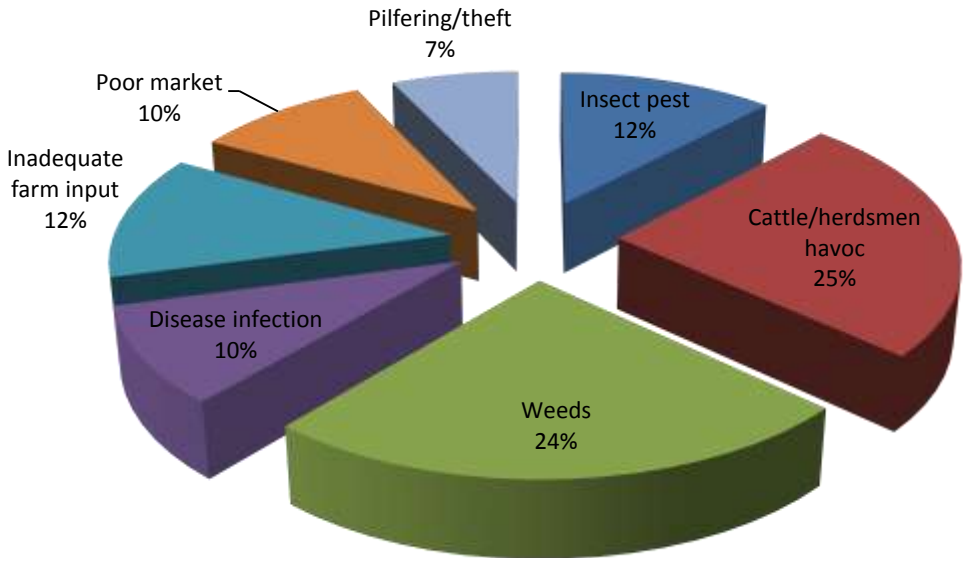

Figure 2. Rating of challenges to sorghum production by the FCT Sorghum farmers.
Source: Fadama Farm Survey (2019).

in July (Table 2). It was indicated that only 34.73% of the farmers cropped their sorghum farm from fallowed field in the previous year. As high as 65.60% of the farmers planted sorghum in the previous year on their present farm. This implied that most sorghum farms were cropped in the previous years. Weaver and quela bird was serious pest on sorghum farms located near a river or a forest. The high prevalence of anthracnose and leaf blight diseases and midge insect pest often led to low panicle formation and reduced yield but most farmers were not aware of this. This might be due to lack of awareness among farmers and inadequate extension agents (Sylla et al., 2019).

Indigenous knowledge used for managing sorghum pests included coating or spraying of leaves with goat faeces slurry on the field and use of neem and *Blumea* leaves in corn granaries. Sorghum seeds were locally dressed with wood ashes, *fukai* and *gwaska* extracts, Christmas berry bark exudate, neem extract + pepper before planting; also tobacco powder and ordeal tree leaf/bark powder were used for seed coating. Striga weeds were locally managed with locust bean extract, delayed planting and crop rotation and intercropping sorghum with millet. The efficacy, development and usage of indigenous knowledge of crop and diseases management should be encouraged and their efficacies confirmed.

Challenges to sorghum production

Majority (47.50%) of the respondent farmers considered cattle/herdsmen menace as the most problematic pests on their farm (Figure 2). Weeds were rated first by 46.67% of the respondents. There is no doubt that weeds are important problems in crop production fields and the respondents were knowledgeable about the adverse effects of weeds as reported by Banjo et al. (2010) and Abang et al. (2014). Other problems including diseases of sorghum were rated first by only 18.33%. This perception showed that diseases such as sorghum anthracnose, despite their pathological importance, are seldom recognized as so by the farmers, possibly due to ignorance.

Pests, diseases and weeds of sorghum in the FCT

The incidence of pests, diseases and weeds and mean % yield reduction associated with sorghum is as shown in Tables 3 to 5. In terms of pest identification, all farmers in most sites were able to identify stem borer and shoot fly larvae when shown a picture. Although farmers in Yaba Abuja could identify the ‘‘small insects‟ that fly around the panicle during flowering and also could easily identify the symptoms of midge damage, they could not differentiate the two.

Sorghum stalk borer had the highest incidence of 38.91%. The farmers could not actually quantify the mean percentage crop yield reduction of these insect pests but indicated that *Sitophilus graminae* can cause up to 57.11% reduction on the grains if not well managed. They in addition revealed that a mean of 59.22% yield reduction could result from cattle/goat attack. The mean incidence of anthracnose (foliar, head, root and stalk rot) was 76.84% but the mean percentage yield reduction is uncertain. This is on the high side and its management requires urgent attention. Striga (witch weed) infestation

Table 3. Incidence and mean % yield reduction by insect pests associated with sorghum on FCT farm.

S/N	Common name	Causal genus	Prevalence in (In 6 AC)	Incidence (%)	Mean % yield reduction
1	Caterpillars	*Helicoverpa armigera*	4/6	18.85	59.09
2	Midge (cause blast on panicle)	Stenodiplosis sorghicola	3/6	6.25	Don't know
3	Sorghum corn borer	*Chilo* spp	5/6	38.91	‘’
4	Sorghum weevil	*Sitophilus graminae*	6/6	24.55	57.11

Table 4. Incidence of other pests associated with sorghum on the field.

Common name	Class/Genus	Prevalence in 6 AC	Incidence (%)	Mean % yield reduction
Birds (bush fowl, weavers)	Aves	2/6	26.76	32.41
Cattle/goat	*Bos*/*Capra* spp	4/6	24.45	59.22

Table 5. Incidence and mean percentage yield reduction of diseases associated with sorghum.

Causal organism	Common name	Causal Genus	Prevalence (in 6 AC)	Incidence (%)	Mean % yield reduction
Fungi	Anthracnose (foliar, head, root and stalk rot)	*Colletotrichum* spp.	6/6	76.84	Don't know
	Brown leaf spot	*Cercosporidium* spp.	3/6	20.99	‘’
	Kernel/grain smut	*Sporosorium sorghii*	2/6	5.58	1.01
	Leaf rust	*Puccinia purpurea*	3/6	2.05	Don't know
	Loose kernel smut	*Sporisorium cruentum*	2/6	1.75	1.14
	Head smut	*Sporisorium reiliana*	2/6	0.20	0.49
Virus	Yellow sorghum stunt	Yellow sorghum stunt phytoplasm	1/6	0.99	0.33

(Plate 9) was a major problem on sorghum farm in the FCT. The mean incidence is as high as 25.97% and could cause a mean percentage yield reduction of 87.32%. Striga has growth inhibitory activity on *Sorghum* (Rana and Rana, 2016; Akomolafe et al., 2018). The results thus indicated that the extension agents have shallow knowledge of identifying sorghum pests and diseases, thus needed to be retrained.

Major insect pests and diseases identified on sorghum in the FCT

Some common insect pests and samples of sorghum with diseased symptoms in the FCT are shown in the infographics below. Army worm (Plate 1) is sheltered in the axils of plants and their larvae feed and damage young plants. Faecal pellets, damaged and chewed leaf margins were signs of damage. Ching bug (Plate 2) resides in grassy weeds and moves to seedling plants. They attach sorghum and feed on the stem and large leaf veins and sometimes lead to wilting and stunted growth and can kill seedling. The high prevalence of anthracnose disease and midge insect pest often lead to poor panicle formation and low yield. This is associated with lack of awareness among farmers and inadequate extension agents.

Moth *(Helicoverpa armigera)* larvae (Plate 3) do feed on the pollen sacs in the flower and feed on developing seeds. The corn root worm - (*Diabrotica virgifera*) (Plate 4) often feeds below the soil line, can cause wilting of seedling and lead to retard growth of the plant. The sorghum midge - *Stenodiplosis sorghicola* (Plate 5) eggs hatch and feed on immature seed, and could hamper development of seed kernel. Stink bugs (*Blissus leucopterus*) were found on developing sorghum ear on Nomadic farm in Bwari (Plate 6). Anthracnose of sorghum (Plate 7) is caused by *Colletotrichum graminicola* and has small, circular to elliptical spots on leaves and leaf sheaths. Older spots have greyish or straw coloured centres with reddish borders and bear black acervuli. The mid-rib infection occurs as elliptical to elongate, discoloured lesions which may coalesce to cover the entire length of the midrib. The use of host plant resistance and crop residue management on the farm is recommended (Pande et al., 2008). Plate 8 shows

Plate 1. Army worm (*Sporodera armygera*) found on sorghum leaf in Ledi Dobi, Gwagwalada.

Plate 3. *Helicoverpa armigera* found on sorghum farm in Pandagi, Abaji.

Plate 2. Chinch bug (*Blissus leocopterus*) found in Sorghum seedling in Bwari, Bwari Area council.

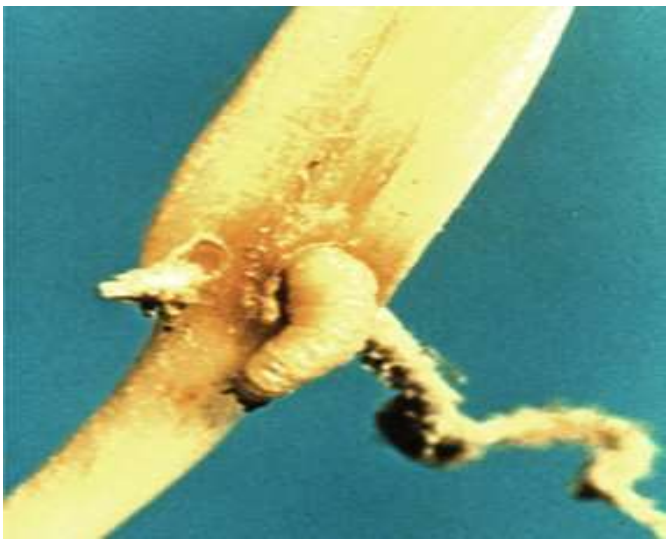

Plate 4. Root worms (*Diabrotica virgifera*) in sorghum root in Lafia Yaba, Abaji.

a loose smut of sorghum on a farm in Sheda Kwali Abuja; it is also found in Gwako Gwagwalada Abuja. The grains are replaced with black powdery materials (sori), while Plate 9 depicts Striga hermonthica flowering on Sorghum in Kwali FCT, Abuja. Plate 10 shows the rust disease of sorghum where rust pustules (uredosori) appear on both surfaces of leaf as purplish spots. The pustules may also occur on the leaf sheaths and on the stalks of inflorescence.

Status of integrated pest management (IPM) of sorghum in the FCT

Integrated Pest Management (IPM) has emerged as a way towards maintaining or increasing crop productivity without over-reliance on synthetic chemical pesticides (Aktar et al., 2009; Abrol, 2013). Out of the nine

Plate 5. Sorghum midge (*Stenodiplosis sorghicola*).

Plate 6. Stink bugs (*Blissus leucopterus*) found on developing sorghum ear on farm in Bwari.

Plate 7. Anthracnose of sorghum on a farm in Paiko kore, Gwagwalada.

Plate 8. Loose smut of sorghum on a farm in Sheda Kwali Abuja also found in Gwako Gwagwalada Abuja the grains are replaced with black powdery materials (sori).

management strategies indicated by the respondents, only the management of sorghum seeds/grains insect pest had high awareness with about 71% adopters while none of them was aware of management of the leaf blight and anthracnose diseases (Tables 6 and 7). Anthracnose and leaf blight diseases were the common diseases of sorghum in the FCT, but most farmers left such disease uncontrolled either due to ignorance or due to their cost implication. In order to appropriately recommend pest management practices on the field or in the store, a well detailed information about farmers' awareness and management strategy of pests and diseases is necessary in fashioning more programmes that would aid the actualization of the objectives of the Fadama III Programme (Balogun, 2013).

Smut diseases in sorghum could be managed by chemical seed treatment with systemic fungicide, sowing of clean and healthy seeds, preventing the use of fields with previous infection / rotation with non-host crops and where practicable collect and destroy smutted heads before spores scatter to minimize spread (Agrios, 2005; Wagari, 2019). Others are by avoiding sowing seeds from infected field and using of resistant varieties. Striga weed

Plate 9. *Striga hermonthica* flowering on Sorghum in Kwali FCT, Abuja.

Plate 10. Rust disease of sorghum in Yangoji, Kwali.

on sorghum farm could be managed by the use of resistant varieties, crop rotations, weeding, raising the fertility of soils and the use of trap crops (Akomolafe et al., 2018).

In general, a four-step approach to IPM for sorghum protection is advocated. Firstly, action thresholds should be set at the point at which infestation by pests requires action. This involves a level of understanding about the

Table 6. Incidence and mean percentage yield reduction of major weeds/ alternative weed host associated with sorghum field.

Common name	Prevalence (in 6 AC)	Incidence (%)	Mean % yield reduction
Witch weed (Striga spp.*)*	-	25.97	87.32
Pig weed (*Boerhavia diffusa)*	-	15.13	Do not know
Wire grass (*Sporobolus diander)*	-	8.06	Do not know
Goat weed (*Agerantum conizoides)*	-	9.12	Do not know
Sedge (*Cyperus* spp.)	-	8.58	26.11

Table 7. Management status of pests and diseases of sorghum by the FCT farmers.

S/N	Management strategy	Level of awareness	% of adopters	Constraints
1	Rotate crops	Moderate	51	-
2	Select hybrid seeds for planting	Low	15	Ignorance, unaffordable
3	Maintain soil fertility	Moderate	23	Costly fertilizer
4	Early planting	Moderate	42	-
5	Bury previous-crop residue/clean weeding	Moderate	49	Cost of labour
6	Control field insect pests	Very low	10	Cost of insecticide,
7	Manage blight/smut diseases	None	0	Ignorance
	Manage anthracnose disease	None	0	Ignorance
8	Management of Striga on the farm	Low	12	Ignorance
9	Manage of pest of sorghum grains in the store	High	71	Laborious, costly

size of an infestation and at which point crop damage becomes a problem. Secondly, pests should be monitored and identified, to ascertain when levels reach action thresholds and to account for natural enemies. The third step of IPM is cultural methods such as diversification or planting pest-resistant crop varieties, use of disease-free seed and adoption of good practices in the field, such as removal of infected material that could carry the problem over to the next crop (Plate 11). Lastly, is the control through targeted use of pesticides or mechanical means may be required if pest numbers reach action thresholds and less invasive methods are not working or available.

CONCLUSION AND RECOMMENDATIONS

There was indication that the activities of the agricultural extension agents with respect to sorghum crop protection was poor and indeed necessary within the study area in order to educate the farmers on best management practices of the crop pest and diseases. Implementation of sorghum pests management plan emanating from this study is expected to improve the capacity of the benefitting Fadama groups and clusters and FCT farmers and enable the attainment of sustainable crop productivity.

Based on the outcome of this study, it is recommended that routine monitoring of sorghum pests and disease prevalence, incidence and severity at different growth stages across Fadama Development Areas in Guinea Savannah agro-ecological zone is necessary. This is in order to obtain detailed and valid result that can serve as basis for management action to ensure effective sorghum pest and disease management.

Farmers are expected to seek help from an extension worker or an expert in crop protectionist as soon as they see any signs of pest or disease symptoms on their farms. Due to the high severity of anthracnose on sorghum in the FCT, Abuja, there is need to declare a state of emergency toward protecting the crop from this endemic disease.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors wish to express their unalloyed appreciation to the staff and management of FCT Fadama Coordination Office and beneficiaries of the Third National Fadama Development Project (FADAMA III AF I) Credit No: IDA 5293-NG, Federal Ministry of Agriculture

Plate 11. Sorghum leaf blight on farm in Sheda Kwali Abuja.

and Rural Development for their support and cooperation during the diagnostic study.

REFERENCES

Abang AF, Kouamé CM, Hanna R, Fotso AK (2014). Assessing vegetable farmer knowledge of diseases and insect pests of vegetable and management practices under tropical conditions. International Journal of Vegetable Science 20:240-253.

Abrol D (2013). Integrated Pest Management: Current Concepts and Ecological Perspective. San Diego, CA: Academic Press p. 576.

Adewumi MO, Omotesho OA (2002). An analysis of production objective of small rural farming households in Kwara State, Nigeria. Journal of Rural Development Journal of Rural Development/Nongchon-Gyeongje, Korea Rural Economic Institute 25(4):201-211.

Adegbola AJ, Awagu EF, Kamaldeen OS, Kashetu RQ (2013). Sorghum: Most under-utilized grain in the semi-arid Africa. Scholarly Journal of Agricultural Science 3(4):147-153.

Afolabi JA (2010). Fadama Farming as an Environment Friendly and Viable Enterprise in Ondo State, Nigeria. Journal of Human Ecology 30(2):93-97.

Agrios GN (2005). Plant Pathology. 5th ed. Academic Press, New York, NY. P. 952

Agwu AE (2004). Factors influencing adoption of improved cowpea production technologies in Nigeria. Journal of International Agricultural and Extension 11:81-88.

Akangbe JA, Ogunyinka W, Ayanda IF, Achem B, Adisa RS (2012). An assessment of effects of Fadama II project on livelihood of farmers in Orire Local Government Area of Oyo State, Nigeria. Nigerian Journal of Agriculture, Food and Environment 8(1):27-32.

Akomolafe GF, Terna TP, Okogbaa JI (2018). Occurrence and growth inhibitory activity of *Striga hermonthica* (Delile) Benth on *Sorghum bicolor* (L.) Moench in Lafia, Nigeria. Nigerian Journal of Basic and Applied Science 26(1):65-69.

Aktar MW, Sengupta D, Chowdhary A (2009). Impact of pesticides use in agriculture: Their benefits and hazards. Interdisciplinary Toxicology 2(1):1-12.

Ani II (2014). Impact of National Fadama II Development Project on Agricultural Productivity in Federal Capital Territory, Abuja. Unpublished post-field seminar M.Sc.Thesis presented to the Department of Agricultural Extension and Communication University of Agriculture, Makurdi, P. 67.

Balogun OS, Aliyu TH, Musa KK (2013). Perception of "FADAMA" III participating farmers on pests and diseases and the use of integrated pest management control strategy in Kwara State, Nigeria. Ethiopian Journal of Environmental Studies and Management 6(6):601-610.

Banjo AD, Aina SA, Rije OI (2010). Farmers' knowledge and perception towards herbicides and pesticides usage in Fadama Area of Okun-Owa, Ogun State of Nigeria. African Journal of Basic and Applied Sciences 2(5-6):188-194.

Chunshan G, Wei G, Xue F, Jianzhou Z, Guihua L (2011). Sorghum insect problems and management. Journal Integrative Plant Biology 53(3):178-192.

Gourichon H (2013). Analysis of incentives and disincentives for sorghum in Nigeria. Technical Notes Series, MAFAP, FAO, Rome, pp. 1-34.

Effiong JB, Asikong AB (2013). Mid-term assessment of the activities of Fadama III Development Project In Cross River State. Global Journal of Agricultural Sciences 12:31-35.

Federico M, Riccardo S, Salvatore D, Stefano P, Giuseppe S (2015). Advanced methods of plant disease detection: A review. Agronomy for Sustainable Development 35(1):1-25.

National Fadama Development Office NFDO (2007). Fadama 11 – Poverty Reduction Through Empowerment. A Publication of PCU – NFDO, Abuja, 2007.

Ogolla M, Muraya M and Onyango B (2019). Incidence and Severity of Turcicum Leaf Blight Caused by *Exserohilum turcicum* (pass.) Leonard and Suggs) on Sorghum Populations in Different Regions of Tharaka Nithi County, Kenya. The Journal of Scientific and Engineering Research 6(1):104-111.

Ogunlela VB, Ogunlela YI (2008). Alleviating rural poverty in Nigeria: A challenge for the National Agricultural Research System. Food, Agriculture and Environment 6(3&4):493-499.

Pande S, Harikrishnan R, Alegbejo MD, Mughogho LK, Karunakar RI, Ajayi O (2008). Prevalence of sorghum diseases in Nigeria. International Journal of Pest Management 3:297-303.

Rana SS, Rana MC (2016). Principles and practices of weed

management, department of agronomy, forages and grassland management College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062 (India), pp. 1-176.
Sylla AY, Al-Hassan RSE, Anim-Somuah H (2019). Perceptions about quality of public and private agricultural extension in Africa: Evidence from farmers in Burkina Faso, Fatih Yildiz (eds). Cogent Food and Agriculture 5:1.
The Agriculture Promotion Policy (2016 – 2020). Building on the successes of the ATA, closing key gaps. Policy and Strategy Document, Federal Ministry of Agriculture and Rural Development, pp. 1-59.
Tuzun A, Dabiri F, Yuksel S (2010). Preliminary study and Identification of insects' species of forensic importance in Urmia, Iran. African Journal of Biotechnology 9(24):3649-3658.
Wagari MK (2019). Importance and management of sorghum smuts with covered kernel smut (*Sphacelotheca sorghi* [Link] Clinton), Loose kernel smut (*Sphacelotheca cruenta* [Kuhn] Potter) and Head smut (*Sphacelotheca reiliana* [Kuhn] Clinton). Greener Journal of Agricultural Sciences 9(4):447-458.