GENDER DIFFERENCES IN FARMERS' INDIGENOUS KNOWLEDGE OF VEGETABLES DISEASE MANAGEMENT: IMPLICATIONS FOR ARTIFICIAL INTELLIGENCE-ENABLED FARMERS' DECISION SUPPORT SYSTEM

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ABSTRACT
The study was carried out in Osun State, Nigeria with the aim to analyse male and female vegetable farmers' indigenous knowledge of disease management. It specifically assessed the indigenous knowledge of male and female farmers on the symptoms, causes, curative, and preventive measures of the vegetable crop diseases. This was done with the aim to provide gender-responsive benchmark data that could enhance the effective adoption of AI-enabled decision support system for crop disease management. Structured interview schedule was used to elicit quantitative data from 106 respondents (59 males and 47 females) for the study. Descriptive statistics was used to analyse the data. Majority of the male and female farmers used indigenous knowledge in identifying the symptoms, causes, curative and preventive measures of most common vegetable crop diseases. Expert/Extension professional-based human intelligence was also a major source of information on crop disease management among the male and female farmers, but the female farmers experienced lower extension contacts than the males. Scientific study and integration of gender responsive and enabling indigenous knowledge on crop disease management into the AI-enabled farmers' decision support system involving experts and extension professionals is recommended for effectiveness and sustainability.
Keywords: Crop disease management, Gender analysis, Artificial intelligence, Indigenous knowledge

INTRODUCTION

Vegetables play a vital role in human nutrition; they provide the body with dietary fibre and are good sources of essential vitamins, minerals, and trace elements. Consumption of vegetables is beneficial to the human body as they boost the immune system, heart, nervous system, and the muscles. (Bruso, 2018). Diseases infestation at all the stages of vegetable production and value chain is the major challenge to the farmers and compromises the quality and quantity of the vegetable. Farmers face many problems as a result of diseases caused by environmental changes and pathogens. Thus, they need competent and comfortable advice from agricultural extension and advisory experts as part of ways to combat the diseases.

In most developing countries like Nigeria, the naked eye observation of extension and advisory experts is the conventional approach adopted for detection, identification as well as prescription of solutions for plant diseases (Weizheng *et al*., 2008). The most currently used audio-visual tools among the farmers' extension and advisory experts are the pictorial newsletter, and audio-visual messages via mobile phones. Developed countries have scaled up from the use of pictorial and audio-visual Information and Communication Technologies into the use of Artificial Intelligence technologies in agricultural advisory services and information exchange (West and Allen 2018).

Artificial intelligence (AI) is intelligence displayed by machines in contrast to the natural intelligence displayed by humans and other animals. Automatic detection of plant diseases is a feature of AI technology that automatically detects the symptoms of diseases as soon as they appear on plant leaves, even on large fields of crops (Al-Bashish *et al*., 2011; Hillnhuetter, 2008). This machine-enabled intelligence is a fast, automatic, less expensive, and accurate method to detect plant diseases (Prasad and Srinivasarao, 2010; Hillnhuetter, 2008). Artificial intelligence-based detection and recognition of crop diseases can provide clues to identify and treat the disease in its early stages (Hillnhuetter, 2008).

Farmers in the developing world are not left out in this technological move. Recent research shows that every household in developing countries like Nigeria, both in the urban and rural communities, has access to at least a mobile phone (Blimpo and Malcolm 2019).

An average male or female farmer in Nigeria possesses at least a mobile phone. Hence the appropriateness and timeliness of integrating mobile phone embedded AI into Extension-based Decision Support Service (EDSS) to farmers in Nigeria. However, for the effective integration of AI into EDSS in Nigeria, there is a need to understand the existing potentials and available opportunities among the farmers in Nigeria as there is dearth of information to serve as gender- responsive benchmark data that could enhance the adoption of AI-enabled EDSS for crop diseases management in Nigeria. Hence, this study focused on vegetable farmers due to emerging economic and nutritional opportunities in the cultivation and consumption of vegetables at the household level in Nigeria. The study assessed the indigenous

knowledge of male and female vegetable farmers on symptoms, causes, curative, and preventive measures of crop diseases. Identified common diseases affecting vegetables as perceived by the farmers and described the implications of the gender differentials in farmers' Indigenous Knowledge for their adoption of AI-enabled EDSS for crop diseases management.

METHODOLOGY

Osun State was the study area. The State is classified into three agro-ecological zones by the Osun State Agricultural Development Project (OSSADEP) which are Iwo, Ife/Ijesa and Osogbo zones. Three stage sampling technique was used to select respondents for the study. At the first stage, two local government areas each were randomly selected from Ife/Ijesa and Osogbo agro-ecological zones. At the second stage, two communities in each local government areas were selected to make a total of four communities. At the third stage 106 respondents (59 males and 47 females) were selected through accidental sampling techniques from the communities. Smartphone embedded structured interview schedule was use to collect data. Data were collected from the sampled vegetable farmers in the study. Relevant information regarding determinants of Artificial Intelligence (AI) integration into extension services for Vegetable crop disease identification and management were elicited from the farmers using interview schedule. Images of diseased and healthy vegetable leaves were taken during the rainy season using smartphone. Descriptive statistics such as frequency counts, percentages, mean score and standard deviation were used to describe the collected data on vegetable farmers' indigenous knowledge on the symptoms, causes, prevention and cures for the identified vegetable, on gender basis.

RESULTS AND DISCUSSION

Sources of information on vegetable crop diseases identification and management

Result in Table I shows that majority of vegetable farmers (74.6% MVF and 63.8% FVF) obtained information from extension agents. Also, 71.2 per cent MVF and 31.9 per cent FVF obtained information through television. About 78 per cent MVF and 60 per cent FVF obtained information on vegetable disease management through radio. Furthermore, about 37 per cent MVF and 21 per cent FVF got information through the internet, while 86.4 per cent MVF, 80.9 per cent FVF got information through input dealers. The results show improvement in farmers' contacts with the extension agents and sourcing information through television and internets, Also, the use of mobile phones, television, and internets as sources of information on crop disease management is an indication of a positive and enabling environment for effective integration of mobile-app based AI into Extension-based Decision Support System (EDSS) for farmers in Nigeria. Furthermore, the prevalent use of extension agents as sources of information among male and female farmers is an indication that the AI integration will be more effective when embedded in the existing extension and advisory system for farmers in Nigeria. Hence there is a need for a curricula paradigm shift to e- extension and advisory curricula at the tertiary education level in Nigeria to equip the prospective extension and advisory scientists and support effective integration of AI in the system.

Table 1: Sources of information on vegetable crop diseases management

Variables	MVF(n=59)		FVF (n=47)	
	Freq	%	Freq	%
Extension agent	44	74.6	30	63.8
Television	42	71.2	15	31.9
Radio	46	78.0	28	59.6
Internet	22	37.3	10	21.3
Input dealers	51	86.4	38	80.9

Freq. = Frequency, %= Percentage MVF-Male Vegetable Farmers, FVF-Female Vegetable Farmers
Source**:** Field survey, 2018

Gender Differences in the Farmers' Indigenous Knowledge on the Symptoms, Causes, Preventive and Curative measures for the diseases

Results in Table 2 shows that 35.6 per cent MVF and 51.1 per cent FVF indicated drought as the cause of anthracnose mosaic disease. About 40.7 per cent MVF and 51.1 per cent FVF indicated that irrigation as the cure for anthracnose leaf spot. There was gender differential in the preventive measure as perceived by the farmers. About 34 per cent MVF and 30 per cent FVF indicated application of insecticides as a preventive measure against anthracnose leaf spot, while, 36.2 per cent FVF and 32.2 per cent MVF indicated irrigation as a preventive measure against anthracnose leaf spot. There was a gender differences in the preventive measure as perceived by the farmers. About 37 per cent MVF and 31.9 per cent FVF indicated fertilizer application as a preventive measure against cercospora leaf spot, while, 32.2 per cent

MVF and 48.9 per cent FVF indicated irrigation as a preventive measure against cercospora leaf spot.

Results in Table 2 reveal that most MVF (40.7%) identified in-folding of leaves as the symptom of Telfairia mosaic disease, while, 42.6 per cent FVF identified mottling of leaves as the symptom of the disease. Also 54.2 per cent MVF and 40.4 per cent FVF sprayed insecticides to prevent the disease on their vegetable plots. Results shows that most (50.8% MVF and 38.3% FVF) identified the presence of white spots as a symptom of the Telfaria white leaf spot disease. There was a gender difference in the curative measures used by the farmers. About 34 per cent MVF applied DD-force to control the disease, while, 48.9 per cent FVF applied Gammalin 20 to control the disease. The preventive measure used by most MVF 57.6 per cent was to maintain farm hygiene to prevent the occurrence of the disease while 42.6 per cent FVF sprayed insecticides to prevent the occurrence of the disease.

Table 2: Farmers' indigenous knowledge (IK) on symptoms, causes, preventive and curative measures of various vegetable diseases

Diseases	Farmers' IK	MVF (n=59) %	FVF (n=47) %
AMARANTHUS	**Symptom**		
Anthracnose Leaf spot	Spotted leaves	42.4	44.7
	Cause		
	Drought	35.6	51.1
	Curative Measure		
	Irrigation	40.7	51.1
	Preventive Measures		
	Applying insecticides	33.9	29.8
	Irrigation	32.2	36.2
Cercospora Leaf spot	**Symptom**		
	Grey spots on leaves	47.5	55.3
	Cause		
	Pathogen	37.3	38.3
	Curative Measure		
	Spraying of insecticides	67.8	57.4
	Preventive Measures		
	Fertilizer application	37.3	31.9
	Irrigation	32.2	48.9
TELFARIA	**Symptoms**		
Telfaria Mosaic	In-folding of leaves	40.7	25.5
	Mottling of leaves	22.0	42.6
	Causes		
	Insects	47.5	40.4
	Curative Measure		
	Spraying insecticides	47.5	40.4
	Preventive measure		
	Spraying insecticides	54.2	40.4
White leaf spot	**Symptoms**		
	White spots on leaves	50.8	38.3
	Causes		
	Pathogens	32.2	31.9
	Curative Measures		
	DD Force	33.9	34
	Gammalin 20	27.1	48.9
	Preventive Measures		
	Farm hygiene	57.6	36.2
	Spraying insecticides	15.3	42.6

Freq= Frequency; %= Percentage
MVF = Male Vegetable Farmers; FVF = Female Vegetable Farmers; n = Sample size
Source: Field survey, 2018

CONCLUSION AND RECOMMENDATIONS

The study revealed that majority of the male and female farmers had good knowledge of the indigenous intelligence on crop disease management practices due to their positive features such as available, low-cost, and easy to understand, although not effective for crop disease management. In addition to the Indigenous Intelligence, the extension-based human intelligence was a major source of information on crop disease management among the male and female farmers, but the female farmers experienced lower contacts than the males. The study further revealed gender differentials in farmers' indigenous knowledge on crop diseases management. The perception of the males differs from the females on some vegetable diseases' symptoms, causes, curative, and preventive measures. The design and development of the AI-enabled EDSS should respond appropriately to the gender differences in the farmers' indigenous knowledge to enhance gender inclusive adoption of the technology. There is a need for further rigorous gender- responsive multi-disciplinary research on the indigenous crop disease management knowledge and practices at a more comprehensive coverage and scale. The male and female farmers, the extension professional, and agents should be actively engaged in the development and application of AI technologies among the farmers in Nigeria. There should be active engagement and capacity building of the farmers and the providers of the conventional expert-based human intelligence on crop disease management (the extension agents) in the development, adaptation, dissemination, and application of the AI-technologies. Establishment of AI-enabled Extension-based Decision Support Service (EDSS) centres at strategic locations in Nigeria is an essential enabling factor. The establishment and monitoring of the AI-enabled EDSS should involve experts and extension professionals for effectiveness and sustainability.

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