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Adoption Rate of National Integrated Solutions Package for Rainfed Sorghum among Small-Scale Farmers in Gezira State, Sudan

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ABSTRACT

Sorghum is one of the most important crops of Sudan according to its economic and nutritional value. The climate change and use of traditional cultural practices are the major problems of sorghum production in the rainfed sector of Sudan and consequently, the yield of the crop did not exceed two sacs/feddan. The Federal Ministry of Agriculture has designed and financed a special programme for the traditional rainfed sector of the country called the National Integrated Solutions Package Programme (NISP) as the main adaptation strategy to solve these problems since the 2014 growing season with the objective to diversify and increase production and productivity of crops cultivated in traditional rainfed areas in each State of the country such as sorghum, sesame, millet and sunflower. This study aims to investigate farmers' adoption of the National Integrated Solutions Programme Package for rainfed sorghum farmers in South Gezira Locality, Gezira State, Sudan. A Field survey was used to collect data from 50 rainfed farmers who participated in the programme and an equal number of non-participant farmers from the study area were selected for comparison using the simple random sampling technique. A close-ended questionnaire was constructed and the personal interview technique was used to administer the questionnaire. The collected data were coded, fed to a computer and statistically analyzed using (SPSS), discussed interpreted using descriptive statistics. The results showed that the participant farmers adopted the programme components. Based on the findings of this study, the NISPP can be considered a very effective agricultural extension policy for the rainfed sector, which will assist rainfed farmers in increasing their income through participation in its various activities. The study recommends that NISPP should become the main national policy specially designed for the agricultural rainfed sector of the country, the needed agricultural inputs should be available at a reasonable price to increase the adoption rate of NISPP, The curriculum of NISPP should be updated and developed regularly to solve the constraints that might emerge and face the programme, in-service training should be organized regularly to train agricultural extension officers on various aspects related to the rainfed sector, various means for conducting the programme should be available, further agricultural extension research should be conducted.

Keywords: Solution packages, Rainfed Sorghum, Small-scale Farmers, Gezira State, Sudan

1. Introduction

Sudan depends on agriculture sector as a cornerstone of crop production for local consumption, food security, and export. The majority of Sudanese people live in rural areas and depend on agricultural production as the main source of their income and food security. The country has two main agricultural subsectors irrigated and rainfed (traditional and mechanized) subsector. The traditional rainfed sector represents 60% of the total cultivated area in the country. Sorghum, sesame, and millet are the main cultivated crops in this sector in addition to other crops such as sunflower, groundnut, and cotton. The total yields of the rainfed sector vary from season to season according to the variability of rainfall (Abdel Rahman *et al*., 2013).

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The effect of climate change on African agriculture represents a major challenge to continental agricultural development including food security, nutrition, and management. Climate change is one of the major challenges to Sudan's agricultural sectors as in other Sub-Saharan African countries (Ifeanyi *et al*., 2012). Changes in temperature, rainfall, water availability, increased outbreak of pests and diseases, land degradation, soil erosion, shrinking of grazing and cultivable areas, ongoing desertification, and the other aspects of climate change have a direct significant impact on agricultural production, productivity, and cultivated crops of Sudan (Abdel Rahman and Hamid 2013). The most suitable option for Africa to manage the impact of climate change is adaptation strategies, but the continent's low adaptive capacity serves as a major constraint facing its ability to adapt. These major constraints include limited financial resources and low technical awareness to adapt to climate change (Nyong *et al.,* 2006).

Sorghum is one of the most important crops of Sudan according to its economic and nutritional value. Climate change and the use of traditional cultural practices are the major problems of sorghum production in the rainfed sector of the country. In Sudan, the yield of rainfed crops is characterized by high variability due to the high variability in seasonal rainfall, and production did not exceed two sacs/feddan because the rainfed farmers adopted low-input rainfed agriculture as a risk management option which led to reduce in the yield per unit of land and water (Shamseddin, 2011). Shamseddin (2009) reported that the low yield of rainfed crops in Sudan is mainly due to rainwater mismanagement. The soils are characterized by moderate to poor mineral fertility due to low content of nitrogen, available phosphorus, and sometimes potassium. In spite of these deficiencies, rainfed farmers, whether in the traditional or mechanized sector, do not use fertilizers in order to reduce the cost, i.e. rainfed farmers, especially traditional farmers, receive a very low percentage of all formal agricultural credit, besides that they receive few support services such as research and extension (FAO, 2008). Shamseddin, (2009) cited that due to the lack of supporting services such as agricultural extension, rainfed farmers depend entirely on their own acquired knowledge, traditional technology, traditional varieties, and cultural practices. In spite of the low adoption rate of rainwater harvesting techniques (RWHT) by rainfed farmers, this adoption differs from one region to another in Sudan, only 0.05% of the farmers adopted RWHT in the Sinnar region. However, the adoption rate in western regions of Central Sudan (Kordofan and Darfur) is relatively high since farmers became more willing to adopt RWHT as a direct result of the witnessed historical drought events in the region. Therefore, there is a high need for conducting solid research on proper sowing dates, increasing formal credit to traditional rainfed farmers, and initiation of nationwide RWHT capacity-building programmes (Shamseddin, 2009).

Many adaptation strategies have been tried to enable farmers to adapt to climate change particularly in the agricultural rainfed sector in Sudan including good agricultural management systems, drought-resistant varieties, crop diversification, and efficient water harvesting techniques. One of these strategies is the National Integrated Solutions Package Programme for the rainfed sector. To achieve the goal of this strategy, the Administration of Agricultural Extension and Technology Transfer in each State has an important role to play by transferring appropriate adaptation technologies to farmers to be adopted by them that in turn will keep and raise the production of their cultivated crop in this sector (Abdel Rahman and Hamid, 2013). The Sorghum ((Sorghum bicolor L. Moench) is the main food crop for most of the population in Sudan, as it represents 70% of the nutritional needs of the Sudanese and occupies the largest cultivated areas in the country in both irrigated and rainfed sectors. It is also a source of concentrated fodder for animals and is used in the manufacturing of starch, glucose, alcohol, and flour. The surplus is exported to fill the shortage in the neighboring countries, especially the Arab Gulf states, so it is therefore considered a pillar of food security and social stability (Alzein and Alasha, 2013). The main objective of this study was to assess the adoption rate of national integrated solutions package for rainfed sorghum among small-scale farmers in Gezira State, Sudan.

1.2. Programme description:

The Federal Ministry of Agriculture has designed and financed a special programme for the traditional rainfed sector of the country called the National Integrated Solutions Programme as the main adaptation strategy for the 2014/ 2020 growing seasons to diversify and increase the production and productivity of crops cultivated in traditional rainfed areas in each State of the country such as sorghum, sesame, millet and sunflower. This programme was implemented by the Administration of Agricultural

Extension and Technology Transfer in each State in collaboration with the Sudan Agricultural Research Corporation (ARC) and the Agricultural Bank of Sudan.

1.3. Technologies recommended:

Water harvesting techniques: Different types of local rainwater harvesting techniques such as ridging and high terracing were recommended to store rainwater in the field after each rainfall throughout the rainy season.

Improved seeds: Climate change has a direct effect on cropping systems; thus adapting food production systems to rapid change in climate conditions is important to local and global food security. In some cases, rainfed farmers need to cultivate new crop varieties as an adaptive method to reduce the losses in yield of existing crops which can result from the variability of climatic conditions. Hence two new sorghum varieties; Arfaa Gadamac and Butana were recommended for the traditional rainfed sector.

Use of chemical fertilizers: Some chemical fertilizers were recommended for the traditional rainfed sector such as urea and DAP.

Cultivation method: Cultivation on furrow was recommended for the traditional rainfed sector which will help in keeping continuous and suitable irrigation for all rainfed crops throughout the rainy season.

Weeding: Manual weeding was recommended for the traditional rainfed sector.

1.4. **Extension methods used:** The following extension methods were used as the main extension activities in implementing the programme: Method and result demonstrations, field visits, extension meetings such as workshops, seminars, lectures, and panel discussions. Field days, and mass communication.

Objective of the study:

The present study seeks to investigate farmers' adoption of integrated solutions programme package for rainfed sorghum small-scale farmers in South Gezira Locality, Sudan.

2. Materials and Methods

2.1. Area of the study:

This study was conducted in South Gezira Locality. The South Gezira Locality as mentioned in the literature is one of eight Gezira State localities, it is located South of Wad Medani and North of Sinnar, East of Elmangil, and West of the Blue Nile which a considered the biggest part of the Gezira Scheme the largest agricultural Scheme in Sudan, with 70,000 Km long irrigation canals, 210000 feddans, 2000 villages, and 500 camps. The majority of the people work in agriculture and animal rearing.

2.2. Population and sample size:

The number of participant farmers in the programme (NISP) in the study area for the 2019/2020 growing seasons was estimated to be 100 using the full count method. Fifty percent of them and an equal number from non- participant farmers (for comparison) were selected using the simple random sampling technique to be used as the study sample.

2.3 Data Collection:

A close- ended questionnaire was constructed and the personal interview technique was used to administer the questionnaire. A pretest for the questionnaire was made with 15 farmers. The interview continued from October to November 2019 the secondary data were collected from different sources such as journals, reports, and papers.

2.4 Data analysis:

The data were coded, fed to a computer, and statistically analyzed using Statistical Packages for Social Sciences (SPSS), discussed interpreted using descriptive statistics (percentage, frequency distribution).

3. Results and Discussion

3.1 Selected socio-economic profile of farmers:

The socioeconomic characteristics investigated in the study cover: education level, age, and farm size. In terms of education level, (8%, 6%) of the participants and non- participants farmers were illiterate respectively, (4%, 6%) had acquired Khalwa education respectively, (30%, 24%) had primary education respectively, (42%, 38%) had acquired secondary education respectively, and (16%, 26%) of them possessed university education and above respectively. This indicates that the farmers in the study area obtained the basic education required for a better understanding and ability to embrace the adoption of farm technologies. It is generally thought that the level of education enhances the ability to comprehend and adopt relevant agricultural information, which is in conformity with Sennuga *et al.* (2020).

The age of participants and non-participants farmers ranged from 15 to 46 above years. (12%, 10%) of the participants and non-participants within the age of 15-25 years respectively, (18%, 14%) of them within the age of 26-35 years respectively, (26%, 40%) of them within the middle age of 36-45 years respectively, and (44%, 46%) of them within the age of 46 years and above respectively. Generally, the assumption is that younger people tend to be more productive than their older counterparts.

In terms of farm size, (32%, 34%) of the participants and non-participants their farm size was 1-5/fed respectively, (20%, 16%) of them their farm size was 6-10/fed respectively, and (48%, 50%) of them their farm size was 11/fed and above respectively. Generally, the assumption is that farmers with large farm sizes tend to adopt recommended agricultural practices more than other farmers with small farm sizes.

Table 1: Distribution of farmers according to their selected socioeconomic profile

Socioeconomic profile	Participants		Non-participants	
Educational level	Frequency	%	Frequency	%
Illiterate	04	08	03	06
Khalwa	02	04	03	06
Primary schools	15	30	12	24
Secondary schools	21	42	19	38
University and above	08	16	13	26
Age group	Frequency	%	Frequency	%
15-25	06	12	05	10
26-35	09	18	07	14
36-45	13	26	20	40
46 and above	02	44	18	36
Farm size/fed	Frequency	%	Frequency	%
1 – 5	16	32	17	34
6 – 10	10	20	8	16
11 and above	24	48	25	50

Source: Field survey, 2019

3.2. Type of agricultural equipment used in land preparation:

Table (2) shows the type of agricultural equipment used in land preparation as a rainwater harvesting technique. (14%, 30%) of the participants and non-participants used disc harrow only for land preparation respectively, (20%, 22%) of them used disc plow only respectively, (66%, 46%) of them used disc plow and disc harrow respectively as recommended by Agricultural Research Corporation (ARC), and (2%) of the non-participants used other equipment for land preparation. In Sudan, different types of local rainwater harvesting techniques such as ridging and high terracing were recommended to store rainwater in the field after each rainfall throughout the rainy season. The result of this study is not in line with results obtained by Akpoikpe *et al*. (2010) who cited that the majority

of respondent farmers in Sudanian areas (North Benin, Togo, and Ghana with southern Burkina and Niger) did not adopt the use of plowing as soil water management adaptation technology.

Table 2: Distribution of the participants and non-participants according to type of agricultural equipment used in land preparation

Type of agricultural equipment	Participants		Non-participants	
	Frequency	%	Frequency	%
Disc harrow only	7	14	15	30
Disc plow only	10	20	11	22
Disc harrow & Disc plow	33	66	23	46
Did not use	0	0	1	2
Total	50	100	50	100

Source: Field survey, 2019

3.3. Cultivation method used:

Table (3) showed that (32%, 52%) of the participants and non-participants cultivated their crop on the bottom of the ridges (Furrow) as recommended by ARC respectively, (26%, 46%) of them cultivated their crop on the top of the ridges respectively, and (42%, 2%) of them did not use the ridges in cultivating their crop respectively.

Table 3: Distribution of the participants and non-participants according to cultivation method used

Cultivation method used	Participants		Non- participants	
	Frequency	%	Frequency	%
Bottom of the ridge	16	32	26	52
Top of the ridge	13	26	23	46
Did not use	21	42	1	2
Total	50	100	50	100

Source: Field survey, 2019

3.4. Recommended rainfed sorghum varieties used:

Table (4) revealed that (78%, 48%) of the participants and non-participants used Arfa gadamak variety (Early maturing variety) as recommended ARC respectively, (8%, 16%) of them used Butana variety (Early maturing variety) as recommended by ARC respectively, (14%, 20%) of them used Gishaish variety respectively, and (16%) of non-participants used other varieties. Rainfed farmers will need to cultivate early maturing crop varieties or drought-resistant crop varieties as adaptive methods to avoid the variability of rainfall. Similar results were reported by Abdel Rahman *et al.* (2016) who found that (62%) of the respondents adopted the use of improved rainfed sorghum varieties in the Umalgura Locality rainfed area, Gezira State, Sudan. The result of this study also agreed with the results obtained by Anyoha *et al*., (2013) who mentioned that the majority of crop farmers in Umuahia South Area of Abia State, Nigeria are adopting the cultivation of early maturing varieties.

Table 4: Distribution of the participants and non-participants according to recommended rainfed sorghum varieties used

Recommended rainfed sorghum varieties used	Participants		Non-participants	
	Frequency	%	Frequency	%
Arfa gadamak	39	78	24	48
Butana	4	8	8	16
Gishaish	7	14	10	20
Others	0	0	8	16
Total	50	100	50	100

Source: Field survey, 2019

3.5 Kind of chemical fertilizers used:

Table (5) shows that (18%, 52%) of the participants and non-participants used DAP only respectively, (60%, 36%) of them used urea only respectively, (22%, 6%) of them used NPK only respectively, and (6%) of non-participants did not use any fertilizer. All mentioned kinds of fertilizers were recommended by ARC. According to Abu-Sara *et al*. (2002) in recent years sorghum yield in both irrigated schemes and the rainfed sector has been declining, accordingly, research with multi-nutrient

fertilizer has been conducted, in which NPK complex fertilizers such as ASN and AS were compared to urea at Gezira and New Halfa, therefore increase in yield was observed for the higher dose of the NPK treatments in both locations, in comparison to that of the standard fertilization practice using AS fertilizer or urea.

Table 5: Distribution of the participants and non-participants according to kind of recommended chemical fertilizers used

Kind of fertilizers used	Participants		Non- participants	
	Frequency	%	Frequency	%
DAP only	9	18	26	52
Urea Only	30	60	18	36
NPK	11	22	3	6
Did not use	0	0	3	6
Total	50	100	50	100

Source: Field survey, 2019

3.6 Type of weeding used:

As shown in table (6) (82%, 26%) of the participants and non-participants used herbicides as weeds control method respectively, (18%, 84%) of them used the manual weeding as weeds control method as recommended by ARC respectively.

Table 6: Distribution of the participants and non-participants according to type of weeding used

Type of weeding used	Participants		Non- participants	
	Frequency	%	Frequency	%
Manually	9	18	37	84
Using herbicides	41	82	13	26
Total	50	100	50	100

Source: Field survey, 2019

3.7. Production of the crop:

Table (7) showed that (50%) of the participants reported that their production ranges between 6 and above sac/fed compared to (00%) of non-participants. (30%, 6%) of participants and non-participants reported that their production ranges between 4-5 sacs/fed respectively. (18%, 14 %) of the participants and non-participants reported that their production ranges between 3-4 sacs/fed respectively. (2%, 80%) of the participants and non-participants reported that their production ranges between 1-2 sacs/fed respectively. The results clearly showed that the sorghum crop yield obtained by the participants differed significantly in comparison to the yield obtained by non-participants. Similarly, according to the Ministry of Agriculture and Natural Resources, Gezira State report (2017), the rainfed farmer`s average yield in the State before the programme implementation is 1.5 -2/ sac/feddan, and after the programme implementation is 5 sac/feddan.

Table 7: Distribution of the respondents according to their production

Production Sac/feddan	Participants		Non-participants	
	Frequency	%	Frequency	%
1-2	1	2	40	80
3-3½	9	18	7	14
4-5	15	30	3	6
6 and above	25	50	0	0
Total	50	100	50	100

1 sac = 100kg **Source:** Field survey, 2019

4. Conclusion

From this study, it can be concluded that the NISPP is a very effective agricultural extension policy that can be applied in the rainfed sector of the country, which will help rainfed farmers to increase their income through their participation in various activities of the programme.

5. Recommendations

Based on the results of this study and in order to improve the efficiency of NISPP**,** the study recommends the following:

1- NISPP should become the main national policy specially designed for the agricultural rainfed sector of the country.
2- The needed agricultural inputs should be available at a reasonable price to increase the adoption rate of NISPP.
3- The curriculum of NISPP should be updated and developed regularly to solve the constraints that might emerge and face the programme.
4- In-service training should be organized regularly to train agricultural extension officers on various aspects related to the rainfed sector.
5- Various means for conducting the programme should be available.
6- Further agricultural extension research should be conducted.

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