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Some Economic Aspects of Zero Tillage Experience in Blue Nile State of Sudan

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ABSTRACT
Zero tillage is an extreme form of minimum tillage and it is also known as no till farming, direct seeding, direct tilling and conservation tillage. Adoption and implementation of zero tillage is one of the alternatives for increasing production and productivity. This paper attempts to shed light on some of the economic aspects of zero tillage experience in Blue Nile State of Sudan. The paper finds that the productivity of all crops cultivated under zero tillage in Blue Nile State was higher than the productivity of the same crops cultivated under conventional tillage during the same periods. The cost of production of Sorghum under zero tillage was higher than under conventional tillage because of high cost of inputs such as machinery and chemicals, while for Sesame the cost of production was lower under zero tillage than under conventional tillage due to high cost of harvesting operations in conventional tillage. Total revenue under zero tillage was higher than that under conventional tillage and it fluctuated from one year to another due to instability of productivity and prices. Zero tillage is more profitable than conventional tillage and the fluctuations that took place in net profit were because of fluctuations in productivity and marketing prices instability. It is recommended that the efforts which have been made by the Arab Authority for Agricultural Investment and Development (AAAID) should be encouraged and supported by the Sudanese government to overcome the current bleak reality of agriculture in the Sudan. Investors have to co-operate with the Arab Authority to develop and modernize the means of farming in the rainfed semi-mechanized sub-sector of Sudan generally and Blue Nile State particularly.
Keywords: *Experience, Zero Tillage, Blue Nile State, Sudan.*

INTRODUCTION
Sudan is located in the northeastern part of the African Continent between longitudes 21° 54' E and 38°43' E and latitudes 3° 53' N and 21° 55' N (Osman, 2010). It is bordered by Egypt to the north, the Red Sea, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west and Libya to the northeast. Khartoum is the capital of the country which is a sparsely populated with only 33 million people in an area of over 700,000 square miles. Arabic is the major language and Islam is the major religion. The country became independent on first January 1956 and has had several changes in government since then. The United Nations Development Program (UNDP) annual human development report for 2010 estimated a national income per capita of US$ 2,051 for the country. During the same period poverty incidence was estimated at 46.5% (B.B.C-Sudan Country Profile, 2018). Sudan climate is tropical and is characterized by high temperature throughout the year. Sudan has several ecological zones with variable climatic conditions (Osman,2010).

Agriculture in Sudan is the principal source of income and livelihood for between 60% and 80% of the population and the engine of growth for other economic sectors such as trade, industry and transport (Farida, 2014). Agriculture in Sudan is composed of three main farming systems, namely traditional rainfed farming, mechanized rainfed farming and irrigated farming. Traditional rainfed farming is practiced by family households and it grows about 95 percent of the country's millet, 38 percent of sorghum, 67 percent of groundnut and 38 percent of sesame. The sub-sector also grows gum Arabic, roselle and melon seeds for export. Productivity in rainfed cropping systems is declining due to land degradation, reduced soil fertility, traditional tillage practices, lack of seed quality control and lack of knowledge on improved management practices. Use of improved seeds, zero tillage and water harvesting in pilot projects have clearly demonstrated room for major improvements in crop yields (www.fao.org). Blue Nile is one of the eighteen states of the republic of Sudan . It is located in the Southeastern part of the country and bordering Sinnar state, White Nile state, Ethiopia and South Sudan Republic.

The estimated number of population is 850,000. The state is constituted of six localities i.e. Aldamazine, Bao, Rosairse, Altadamon and Alkormok. It is a true mixture of various tribes such as Funj, Maban, Oduk, Kadalo, Hamaj, Angasana, Wataweet, Fulani, Hawsa and Gumuz. The state is considered as one of the most affected states by the civil war in Sudan(Abdelfadil,2010). Agricultural activities are undertaken by 79 percent of the Blue Nile population. Sorghum is by far the most popular crop, but maize, groundnuts, sesame and cowpea are all important complements (WFP,2010). The Arab Authority for Agricultural Investment and Development (AAAID) which was established in 1976 by a number of Arab states adopted zero tillage cultivation for developing and modernizing rain-fed agriculture in Blue Nile State(ELHassan et.al (2017). The objectives included the Production of strategic crops to ensure Arab food security, being a model for investment in the rain-fed sub-sector of Sudan and other Arab countries, adopting and transferring agricultural technologies to develop the sub-sector, developing manpower and agricultural practices and enhancing the capacity building in the sub-sector (Sulaiman, 2004). The zero tillage System has been based on implementing a full Technological package for all agricultural operations supported by an efficient management system. Great efforts exerted to promote this technology in Agadi-Blue Nile State and other areas since 2003(ELHassan et.al (2017).This experience represented an attempt to move rainfed semi-mechanized farming in the state towards full mechanization (Sulaiman, 2004). The aim of this paper is to identify the economic aspects of zero tillage experience in Blue Nile state of Sudan. The rest of the paper is structured into a literature review, methodology, Analysis and conclusion.

LITERATURE REVIEW

Concept of Zero Tillage

Zero tillage is an extreme form of minimum tillage and it is also known as no till farming, direct seeding, direct tilling and conservation tillage. It is an agricultural technique which increases the amount of water that enters or gains access into the soil. (www.slideshare.net). Zero tillage refers to a farming system of Crop production where the soil is not traditionally tilled. It is a system in which farmers avoid any mechanical

tillage of the soil. Zero tillage is planting crops in previously unprepared soil by opening a narrow slot, trench, or band of the smallest width and depth needed to obtain proper coverage of the seed (AbdulRazak, 2006) . According to United States Department of Agriculture, USDA (1994), zero tillage production systems are those that do not use tillage or other soil-disturbing, residue-burying activities before and after planting. Nutrients, lime, pesticides, and other farm products are band or broadcast on soil surface. The narrow band of disturbed soil created by a planting unit provides the only opportunity to incorporate nutrients, pesticides, and other farm inputs (Osman, 2010). Zero tillage refers to a way of practicing agriculture through minimum soil disturbance, incorporation of crop residues and use of suitable crop rotations. FAO (2007) defined zero tillage as 'resource saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while conserving the environment (Lotfie et.al (2015).

Literature Review

Zero tillage was adopted in 1999 on about 45 million ha worldwide. This area was expanded rapidly to 105 million ha in 2008. The fastest adoption rates have been experienced in South America (Rolf and Theodor,2009). Zero tillage is practiced in United States, Canada, Brazil and Australia and Europe is the developing continent regarding zero tillage adoption. In the world more than 100 million hectares of crops are now planted using zero tillage or Minimum-tillage with enormous economic and environmental benefits. But Africa, a Continent that needs these practices most, only represents 0.8% of this total, (Chikakula, 2010). All crops can be grown adequately under zero tillage system. Zero tillage achieved economic, social and environmental advantages and it is a truly sustainable farming system that should be transferred to areas where adoption is still low. The reliance of zero tillage on the use of herbicides and the alleged increased input of herbicides and other chemicals for disease and pest control are the main constraints for the full acceptance of zero tillage as sustainable crop production concept (Rolf and Theodor,2009). Zero tillage and minimum till practices are efficient conservation practices. The stagnation of productivity growth in the rice-wheat systems of the Indo-Genetic Plains in South Asia has led to increased calls for technologies based on zero tillage. The review of zero tillage in India found that there was an increase in wheat yield and cost saving. Zero tillage primarily has had positive effects on the environment in the Indo-Gangetic Plains. Brazil is adopting zero tillage since 1970s and it has the second largest area cultivated using this agricultural technique after the United States (i.e. 25.5 million hectares or more than 60 per cent of the country's cultivated surface). It increased its grain production from 57.8 million tons to 125 million tons from a cultivated area of 42 million hectares, 22 million of which was under zero tillage (Osman,2010).In Russia no-tillage is often referred under the umbrella term "Resource Saving Technology". No-tillage is a very profitable cultivation system compared to conventional tillage in Germany because of the lower machinery costs and lower operating costs. The adoption of no-tillage technologies was very fast in Finland and in less than ten years no-tillage grew from some hundred hectares to 200.000 ha in 2008. Switzerland has made remarkable progress in terms of research, development and adoption of no-tillage practices. No-tillage in Spain was found to be advantageous in terms of energy consumption and moisture conservation, as compared to both,

conventional or minimum tillage techniques. Several farmers started with the system of zero tillage in Argentina and then gave up because of the lack of adequate herbicides and machinery which together with knowhow, constituted the main constraint for early adopters. In Colombia the area under no-tillage (100.000 ha) has virtually remained static and no increase in the area under this system has been reported because of the political situation of this country and the insecurity in rural areas, this has nothing to do with the merits of this practice. Many African Countries, particularly in Southern and Eastern Africa have been exposed to no-tillage system for the last decade and some of them have included this into their government policies. The main barriers to zero tillage adoption continue to be, knowledge on how to do it, mindset, inadequate policies as commodity based subsidies, availability of adequate machines and availability of suitable herbicides to facilitate weed management (Rolf and Theodor,2009).

Zero tillage helps farmers to increase productivity and conserve their natural resources by spending less time on land preparation, and it provides a higher yield at less cost and also saves on fuel use and tractor wear and tears (Elhassan et.al (2017). Proponents of zero tillage stated that zero tillage reduces soil erosion, saves money and increases profits, reduces fuel and equipment operation, conserves water, increases crop yields and level of beneficial insects and soil microbes. Opponents on the other hand indicated that zero tillage is not appropriate for every soil type, no baling or heavy grazing, special machinery is required, nitrogen-based fertilizers may still be needed, it increases risk of fungal diseases and herbicide use and application and intensive management of crops and soil is needed (Greentumble ,2016).

METHODOLOGY

This paper relies heavily on secondary data. The data used is generated from secondary sources such as textbooks, journals, papers, websites and publications. Descriptive statistics is used to analyze the data.

ANALYSIS

The rainfed semi-mechanized farming activity in Sudan has expanded greatly during the last two decades and this expansion has been associated with some problems such as weeds, land degradation, soil fertility deterioration, and monoculture, lack of labour, high cost and low production and productivity. So there is a need for vertical expansion and this can take place through modernization of agricultural machines, use of herbicides, pesticides, fertilizers and improved seeds. One of the alternatives for increasing production and productivity is the adoption and implementation of zero tillage or direct seeding (Alhassan, 2007). Zero tillage depends on using herbicides before, during and after seeding instead of using machines for harrowing and weeds cleaning. A modern machine specially designed for the system of zero tillage is used to operate the process of seeding, spraying and fertilizing concurrently. The factors which affect zero tillage are soil, rainfall, weeds and crop residues which help in spreading insects and diseases. The agricultural research results indicate that the productivity average of the rainfed semi-mechanized sub-sector ranges between 6 and 8 sacks/ feddan(0.42 hectares) and this can be achieved by implementing the recommended technological packages which includes crop rotation, improved seeds, seed treatment, reasonable time of planning and planting

in rows, required crop density, soil conservation, fertilizing, weeding, pest control, early mechanized harvest and good farm management. The Arab Authority for Agricultural Investment and Development achieved an average of 12- 16 sacks/feddan in Blue Nile State. These promising results represent a positive indicator for the continuity of the experience in the State (Sulaiman, 2004).

Adoption of Zero Tillage Worldwide

In 1973/74 zero tillage was used only on 2.8 million ha worldwide. In 1983/84 the area had grown to 6.2 million ha. By 1996/97 the area under zero tillage had reached 38 million ha. Farmers' interest in this technology increased worldwide during the last ten years and the area under this technology reached 106 million in 2007/2008. As table 1 below shows 46.8% of this technology is practiced in South America, 37.9 is practiced in North America, 11.5% in Australia and New Zealand, 2.4% in Asia, 1.1% in Europe and 0.3% in Africa.

Table 1: Area Under Zero Tillage by Continent in 2007-2008

Continent	Area(hectares)	Total(%)
South America	49,579,000	46.8
North America	40,074,000	37.9
Australia and New Zealand	12,162,000	11.5
Asia	2,530,000	2.4
Europe	1,150,000	1.1
Africa	368,000	0.3
World Total	105,863,000	100%

Rolf and Theodor, (2009).

Productivity

Zero tillage technologies are being developed for the cereal production systems to address the multifaceted problems of decelerating agricultural productivity, resource scarcity, climate change, and negative environmental externalities generated by the conventional production system (Krishna and Veettil 2015).

Table 2: Productivity of Cotton, Sorghum and Sunflower in Agadi experimental farm (2001)

Crop	Productivity/feddan (Zero tillage)	Productivity/feddan (conventional farming)
Cotton	470 kg	329 kg
Sorghum	1080 kg	522 kg
Sunflower	509 kg	261 kg

Source: (AAAID, 2003)

Different crops had been cultivated in Agadi experimental farm in 2001. Table-2 above shows that the productivity of Cotton, Sorghum and Sunflower under zero tillage was 470 kg, 1080 kg and 509 kg respectively compared to 329 kg, 522 kg and 262 kg consecutively in conventional farming.

Table 3: Sorghum Productivity (kg/feddan) Under Zero Tillage and Conventional Tillage Systems.

Season	Zero Tillage	Conventional Tillage
2005	1100	405
2006	693	216
2007	514	216
2008	616	211
2009	318	149

Source: Osman, (2010).

Table 4: Sesame Productivity (kg/feddan) Under Zero Tillage and Conventional Tillage Systems.

Season	Zero Tillage	Conventional Tillage
2007	140	112
2008	113	90
2009	150	121

Source: Osman, (2010).

According to table (3) and table (4) above the highest productivity of Sorghum under both zero tillage and conventional tillage systems was recorded in 2005 (i.e.1100 kg/feddan for zero tillage, and 405 kg/feddan for conventional tillage), while the least productivity was recorded in 2009 (i.e.318 kg/feddan for zero tillage, and 149kg/feddan for conventional tillage). For Sesame under both zero tillage and conventional tillage systems, season 2009 showed the highest productivity (i.e.150 kg/feddan for zero tillage and 121 kg/feddan for conventional tillage), while season 2008 indicated the least productivity(i.e.113 kg/feddan for zero tillage and 90 kg/feddan for conventional tillage). It is clear that the productivity of all crops cultivated under zero tillage during 2001 in Agadi Experimental farm and 2005-2009 in Agadi Scheme-Blue Nile State was higher than the productivity of the same crops cultivated under conventional tillage during the same periods.

Production Cost

The average cost of production in table 5 and table 6 below has been calculated for both Sorghum and Sesame under zero tillage and conventional tillage systems in Agadi-Blue Nile State. Sorghum is the main food crop and Sesame is an important cash crop in the State and that is why they have been selected. The cost of production for zero system included seeds cost, mechanical operations cost, fertilizers cost, herbicides cost, labor cost, and administration cost. While the cost of production for conventional tillage system included land preparation and planting cost, agricultural inputs, crop care cost, harvesting cost, and administration cost.

Table: 5 Average Production Cost(SDG/feddan) for Sorghum and Sesame under Zero Tillage(2005-2009).

Season / Crop	2005	2006	2007	2008	2009	Average
Sorghum	196	160	149	144	171	164
Sesame	-	-	96	109	132	112

Source: Adapted and Modified from Osman (2010).

Table: 6 Average Production Cost(SDG/feddan) for Sorghum and Sesame under Conventional Tillage(2005-2009).

Season / Crop	2005	2006	2007	2008	2009	Average
Sorghum	93	93	100	103	105	99
Sesame	-	-	93	126	164	128

Source: Adapted and Modified from Osman (2010).

Table (5) and table (6) above indicate that the average cost of production of sorghum per feddan under zero tillage (i.e. 164 SDG) was higher compared to that of conventional tillage (i.e. 99 SDG) during 2005-2009. High cost of inputs such as machinery and chemicals was behind the high cost of production under zero tillage. On the other hand the results for Sesame show that the average cost of production per feddan in 2007-2009 under zero tillage was 112 SDG. This average was low than that of conventional tillage (i.e. 128 SDG) during the same period because of the high cost of harvesting operations in conventional tillage. The limited period of Sesame harvesting makes it labor-intensive process.

Revenue and Profit

Table: 7 Total Revenue of Sorghum and Sesame (SDG/feddan) under Both Zero Tillage and Conventional Tillage at Different Prices (2005-2009).

Season / Total Revenue	2005	2006	2007	2008	2009
Total Revenue of Sorghum in Zero Tillage	611	424	291	595	339
Total Revenue of Sorghum in Conventional Tillage	203	112	70	166	156
Total Revenue of Sesame in Zero Tillage	-	-	446	454	444
Total Rrevenue of Sesame in Conventional Tillage	-	-	163	250	305

Source: Adapted and Modified from Osman (2010).

Table: 8 Net Profit of Sorghum and Sesame(SDG/feddan) under Both Zero Tillage and Conventional Tillage at Different Prices(2005-2009).

Season / Net Profit	2005	2006	2007	2008	2009
Net Profit of Sorghum in Zero Tillage	415	264	142	451	168
Net Profit of Sorghum in Conventional Tillage	110	19	-30	63	51
Net Profit of Sesame in Zero Tillage	-	-	350	345	312
Net Profit of Sesame in Conventional Tillage	-	-	70	124	142

Source: Adapted and Modified from Osman (2010).

Table (7) above shows that total revenue of Sorghum(SDG/feddan) under zero tillage in 2005-2009 was higher than that under conventional tillage in all seasons i.e. 611, 424, 291, 595 and339 compared to 203, 112, 70, 166 and 156 respectively. Total revenue fluctuated

from one year to another due to instability of productivity and prices. Total revenue of Sesame under zero tillage during 2007-2009 was higher than that under conventional tillage in all the three seasons (2007-2009) i.e. 440,454 and 444 compared to 163, 250 and 305 consecutively. There was an increase in Sesame revenue under both zero tillage and conventional tillage in 2007-2009. According to table 8 above net profit of Sorghum (SDG/feddan) under zero tillage was higher than that under conventional tillage in all seasons of 2005-2009 i.e. 415, 264, 142, 451 and 168 compared to 110, 19, -30, 63 and 51 respectively. Net profit differed from one season to another because of up and down movement of productivity and prices. Net profit of Sesame under zero tillage was higher than that under conventional tillage in all seasons of 2007-2009 i.e. 350, 345 and 312 compared to 70, 124 and 142 consecutively. Generally speaking, zero tillage is more profitable than conventional tillage and the fluctuations that took place in net profit were because of fluctuations in productivity and marketing prices instability.

CONCLUSION

Farmers' interest in zero tillage technology increased worldwide during the last ten years and the area under this technology reached 106 million in 2007/2008. Adoption and implementation of zero tillage is one of the alternatives for increasing production and productivity. The productivity of all crops cultivated under zero tillage in Blue Nile State was higher than the productivity of the same crops cultivated under conventional tillage during the same periods. Fluctuations in crop productivity were due to fluctuation in rain distribution and average rainfall. Regarding Sorghum, the highest cost of production was under zero tillage than conventional tillage because of high cost of inputs such as machinery and chemicals, while for Sesame the cost of production was lower under zero tillage than under conventional tillage due to high cost of harvesting operations in conventional tillage. Total revenue of both Sorghum and Sesame under zero tillage was higher than that under conventional tillage. Total revenue fluctuated from one year to another due to instability of productivity and prices. There was an increase in Sesame revenue under both zero tillage and conventional tillage in 2007-2009. Zero tillage is more profitable than conventional tillage and the fluctuations that took place in net profit were because of fluctuations in productivity and marketing prices instability. It is recommended that the efforts which have been made by the Arab Authority for Agricultural Investment and Development (AAAID) should be encouraged and supported by the Sudanese government to overcome the current bleak reality of agriculture in the Sudan. Investors have to co-operate with the Arab Authority to develop and modernize the means of farming in the rainfed semi-mechanized sub-sector of Sudan generally and Blue Nile State particularly.

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