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Impact of Some Technological Interventions on Sorghum and Sesame Yields Under Small Scale Rain Fed Areas of Sinnar State, Sudan

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Abstract

Representative data for evaluating some technological interventions in small scale rain fed farming in Sinnar, State, Sudan during 2012, 2013 and 2014 summer rainy seasons were collected and evaluated. The technologies were transferred through a technical cooperation program between the Agricultural research Corporation, Sudan and an IFAD- Government of Sudan project. The implemented technologies included the use of chisel plow for in situ water conservation and sowing of improved released cultivars of sorghum, sesame, groundnut, millet cowpea/ forage legumes in a three course rotation. The objectives were to improve crop productivities for the poor farmers, diversify their income to help alleviate their poverty and to maintain soil fertility. Data obtained revealed that the use of chisel plow had resulted in deeper water penetration in the soil than the wide level disc (WLD) and together with sowing of improved cultivars had substantially boosted sorghum and sesame yields. The overall average sorghum yield in the project areas for the three seasons, where technologies were implemented was 1249 kg/ha while it was only 548 kg/ha in neighboring non-participating farms. Likewise, the project average of sesame yield was substantially increased amounting to 613 kg/ha using improved technologies compared to only 282 kg/ha in the traditional ones.

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The technological interventions had resulted in sorghum yield advantages of 267, 102.5 and 145% over Sudan's traditional sector average in 2012, 2013 and 2014 seasons, respectively and sesame yield increases of 267 and 173% for season 2012 and 2014, respectively. The remarkable yield increases of these crops in small farmer's field in the three seasons reflected the success of the released technologies in fulfilling the project objectives.

Keywords: small scale; Rain fed; Technology transfer; Chisel; WLD; Sorghum; Sesame.

1. Introduction

The author in [13] stated that the majority of the world's rural people depend on rain fed crop and livestock systems for their food and incomes. When the productivity of these systems is low, as is the case, food security, impoverished livelihood and land and water degradation often prevail. Over the past 50 years, expansion of land under rain fed agriculture has been a key driver of the degradation of ecosystem services. Food security and poverty alleviation for small scale farmers can only be achieved through implementation and adoption of technological packages that can enhance crop productivities and diversify farmer's income.

Constraints to crop production in rain fed small scale farms in Sinnar State, Sudan are poor soil fertility due to lack of crop rotation, mono cropping, repeated use of wide level disc (WLD) in land preparation leading to formation of hard pans that increase surface runoff and soil erosion. The erratic nature of rain fall both in quantity and distribution and sowing of traditional crop cultivars are additional constraint factors that negatively influenced crop productivities.

Sorghum productivity in traditional rain-fed agriculture in Sudan can hardly exceeds 1-2 sacks approximately 215-430 Kg/ ha. This low productivity is attributed to number of factors among which are the use of inappropriate machinery such as wide level disc that accelerates soil erosion by constituting hardpans and causing poor soil water retention. The author in [16] stated that continuous use of WLD is believed to have led to the deterioration of the soil physical properties and may have created a hard pan at the depth of cut. A number of factors seem to stem out jeopardizing crop yield. These include improper land preparation, mono cropping, continuous cultivation in absence soil fertilizer amendment, spread of weeds particularly Striga hermonthica, erratic rain fall and long dry spells.

The wide level disk (WLD) with seeder box constitutes the only machine used for sorghum cultivation in all mechanized farming areas of the Sudan and small scale farmers' fields. On the other hand, Chisel plow is a subsoil cultivation technique that cuts soil deeper than achieved with conventional tillage. The authors in [3,12] reported that chisel plow had improved grain yield by infiltrating more rain fall deeper the soil profile particularly in soil with compacted sub layer and hence enhancing root growth.

The authors in [2] studied the effect of some tillage and seeding methods on grain yield of rain fed mechanized sorghum in Gadaref area, Sudan, they found that sorghum yield was highest under chiseling compared to the others and that WLD gave significantly the lowest grain yield. Similar findings were reported by the authors in [1, 6, 9].

The overall goal of the agriculture and technology transfer component is to alleviate the constraints currently faced by the traditional rain-fed small-scale producers so that they can increase their crop , gain food self-sufficiency and improve their livelihoods by having additional source of revenues while conserving the resource base.

1.1 study objectives are

To assess implementation of improved agriculture technological packages in land preparation represented by use of chisel plow instead of current conventional practices tillage which is plowing with wide level disc (WLD) on soil water conservation

To compare yield responses of improved cultivar of sorghum (Arfaa Gadamak) and the traditional local sorghum cultivars suck Korakolo, Abu Gabish etc. used by farmers.

To compare yield responses of improved cultivar of sesame (Promo) and traditional local sesame cultivars such as Abu sandoog, mixed abuNaama, etc.

2. Materials and Methods

The project activity area was covering five extension units in three localities in Sinnar State of which 100 villages were selected based on their relative poverty levels. Thirty five farmers from each village would benefit from 2 year demonstration phase of the duration after which a scaling up phase will follow. Sixty seven villages were covered in seasons 2012, 2013 and 2014. The extension units were based at Abu Hugar, Mazmoum, Dali, in the wesern side of the Blue Nile and Dinder East and West on the eastern side.

Performance indicators were chosen to assess the effect of the technological interventions among them were the wetting depth and crop yield. From the performance indicators taken only wetting depths were and sorghum and sesame yield are addressed in this paper. Data were collected as follows

2.1 Wetting Depth

The wetting depths or water penetration depths were taken as indicators for water conservation and were only taken in seasons 2012 and 2013. In 2012, the wetting depths under chisel and wide level disc – plowed fields were compared from two randomly selected villages in each extension unit, three improved fields/village and equivalent number from traditional ones. In five diagonal sampling locations / field an auger was used to dig the soil to reach the dry depth and a graduated stick was used to record the wetting depth in cm. Wetting depth was recorded after reaching the effective rain fall amount permissible for rain fed sowing in Central Sudan (100 mm). The same random selection procedure was adopted for season 2013 but in three villages.

2.2 Yield Data

The demonstration fields were selected according to the relative village’s abundance in each extension units and three to four villages were randomly selected for data collection. In each village nine farms were likewise selected. Three replicates from an effective area of (3 meters x 3 meters) from each field were taken for grain yields measurement. Corresponding number of fields were taken from non-participant neighboring farms. The same data collection procedure was used for sorghum and sesame. Data were statistically analyzed and T- test was adopted to compare means.

3. Results and Discussion

3.1 Site Description

Sinnar State lies in the south eastern part of Sudan covering an area of 40,680 km2; it lies between latitudes 12.5° and 14.7. ° N and longitudes 35.42° and 58.32° E. The author in [15] pointed out that Sinnar State lies in the transitional belt between poor and rich Savannah and is characterized by a tropical climate with two distinct wet and dry seasons. Rainfall varies between 250 mm per year in the northern parts and 700 mm in the southern parts of Sinnar State. Owing to the tropical nature of the climate, rainfall shows enormous variations in space and time with drought being a normal feature of the climate. Vertisols, heavy clay cracking soils, are the dominant soils in the state. (Some physical and chemical soil characteristics are given in appendix 2)

Supporting Traditional Rain fed Small- Scale Producers in Sinnar State (SUSTAIN) ,Sudan, is an International Fund for Agricultural Development (IFAD) project that responds to an alarming levels of land degradation that present direct threat to the livelihood of small scale farmers in the Sinnar State, Sudan. A technical cooperation between SUSTAIN and the national Agricultural Research Corporation (ARC) in Sudan through which some released technologies to rain fed agriculture was implemented in three localities in Sinnar State.

Figure 1.1 shows the project location in Sinnar State, Sudan. As could be seen the project area extends in Eastern and Western banks of the Blue Nile.

3.2 Wetting Depth (cm)

Table 1: Overall wetting depth (cm, at different SUSTAIN Extension units, 2012

	AbuHaggar	Almazmoum	Dali	Dinder East	Dinder west
Improved	74.5	71	72	75	81
Traditional	38.5	42.5	46.5	43	55.5

Table 2: Overall wetting depth (cm, at different SUSTAIN Extension units, 2013

	AbuHaggar	Almazmoum	Dali	Dinder East	Dinder west
Improved	22.3	58.5	44.2	16.42	18.7
Traditional	13.9	44.3	20.3	9.5	11.9

Wetting depth was taken as performance indicator for the effect of the two implemented tillage systems on oil moisture conservation. Wetting depths of the two seasons as presented in tables 1 and 2 were significantly greater under chiseling in all extension units compared to WLD. As could be noticed from the two tables the wetting depth were greater in 2012 than in 2013, which was mostly attributed to the higher amount of rain fall received in 2012. Chisel plow was reported by the authors in [10, 14] to lessen surface runoff which is therefore allowed for deep water penetration. Taking into account that the soil bulk densities in these adjacent farms and for each extension unit are almost identical the calculated water content would only vary with the wetting depth. This means that more water was conserved under chisel than the traditional practice of land preparation. The results so obtained were in agreement with those of authors in [3, 6, 12], who reported that chisel plow is a subsoil cultivation technique that cuts soil deeper than achieved with conventional tillage and that it improves grain yield by enhancing root growth and infiltrating more rainfall deeper in the soil profile particularly in soils with compacted low permeability sub-layers. A study comparing the effect of different tillage practices on soil physical properties in Pakistan [11] reported that the highest soil moisture content and lowest bulk density or soil penetration resistance were recorded for soil tilled with chisel plow or moldboard plow at both soil depths. Soil physical conditions were generally improved with time as moisture conservation in soil increased while soil bulk density and soil penetration resistance decreased at both soil depths in second year as compared to first year of study.

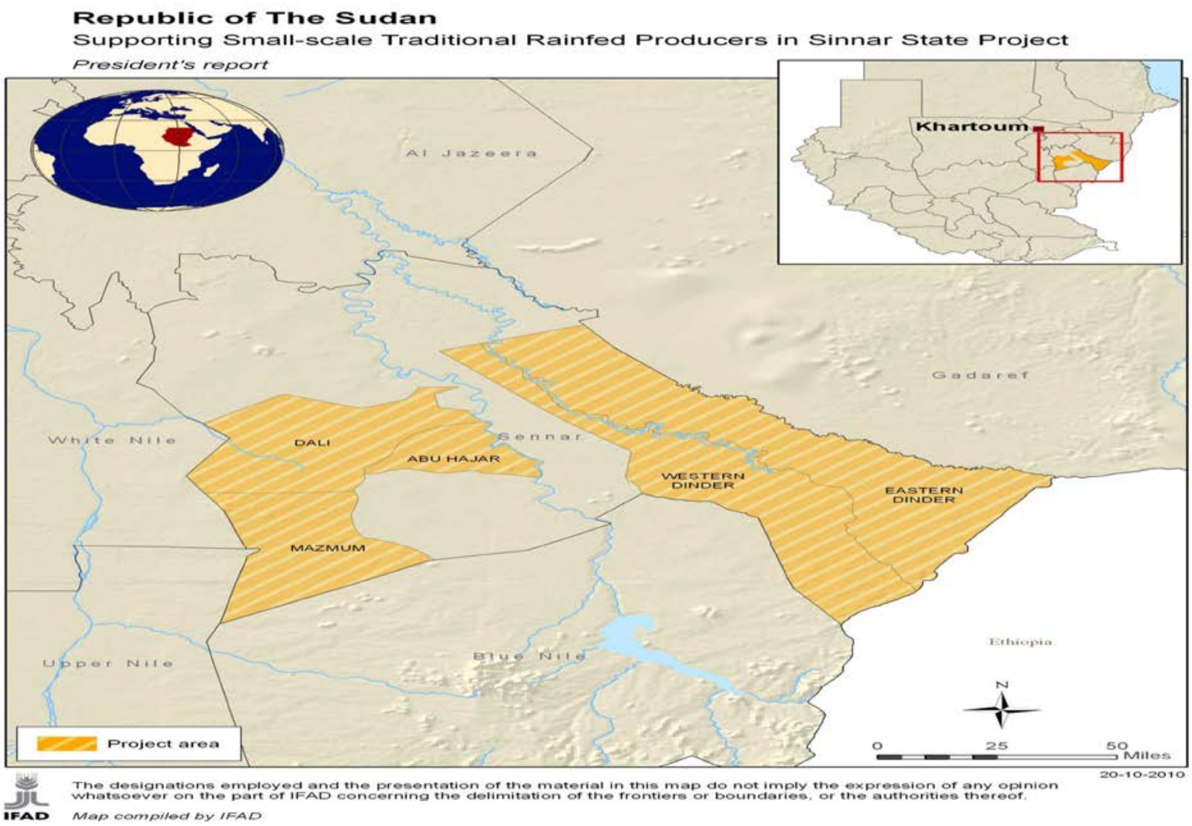

Figure 1.1: project location in Sinnar State

3.3 Sorghum grain yield

Table 3: Average sorghum yield (kg/ha, at different SUSTAIN Extension units, 2012

	AbuHaggar	Almazmum	Dali	Dinder East	Dinder west	Project Average
Improved	1007	1435	1349	1764	1821	1473
Traditional	164	693	621	635	593	547
t-calculated	10.2	5.03	4.21	5.95	6.02	
Probability	0.001	0.001	0.001	0.001	0.001	

Table 4: Overall sorghum yield (kg/ha, at different SUSTAIN Extension units, 2013

	AbuHaggar	Almazmum	Dali	Dinder East	Dinder west	Project Average
Improved	474	844	1806	347	550	809
Traditional	0	439	826	29	55	270
t-calculated	26.4	3.62	6.07	17.78	4.81	
Probability	0.003	0.04	0.03	0.001	0.009	

Table 5: Overall sorghum yield (kg/ha, at different SUSTAIN Extension units, 2014

	AbuHaggar	Almazmum	Dali	Dinder East	Dinder west	Project average
Improved	1303	748	1938	1405	1946	1468
Traditional	697	322	1154	709	1047	786
t-calculated	3.66	3.83	6.97	6.07	4.36	
Probability	0.005	0.004	0.001	0.001	0.001	

Table 6: Overall Average sorghum yield kg/ha in SUSTAIN project areas (seasons, 2012, 2013 and 2014)

	AbuHaggar	Almazmum	Dali	Dinder East	Dinder west	3 - seasons average
Improved	928	1009	1698	1172	1439	1249
Traditional	287	485	867	537	565	548

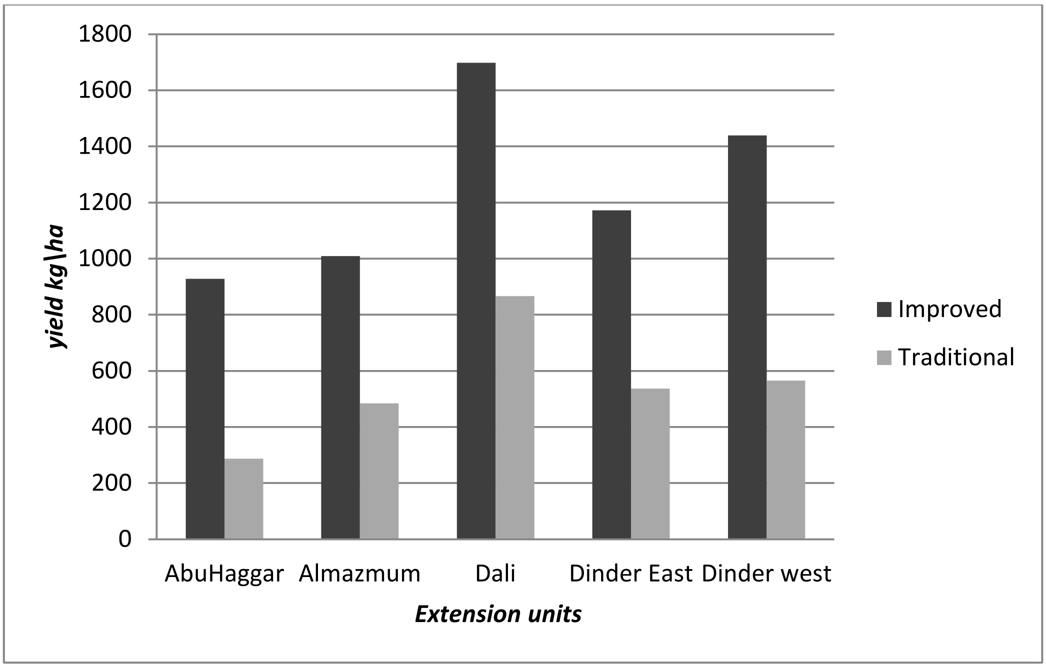

Figure 1.2: Overall Average sorghum yield kg/ha in SUSTAIN project areas (seasons, 2012, 2013 and 2014)

Tables (2, 3 and 4) show mean sorghum grain yield for seasons 2012, 2013 and 2014 in each extension unit while table 5 and figure 1.2 show the average yield of the three seasons. The three years average revealed that the highest yield (1698 kg/ha) was achieved at Dali under the improved practices followed by Dinder west (1439 kg/ha). Considering individual season, the highest yields (1946 and 1938) were recorded in season 2014 at Dinder West and Dali, respectively. The lowest average yield was obtained at Abu huggar, 928 kg/ha while Mazmoum and Dinder East gave comparable average sorghum yields. It could be observed from the table 5 also the inferiority of the traditional practices manifested in significantly lower yield level in each extension unit. The apparently low mean yields could be attributed to the tremendous yield decline in season 2013 due to the delay in rain fall amount and the imbalanced distribution. At Mazmoum water logging 1n 2014 might have added to the observed low average yield. Nevertheless, the yields of sorghum in all extension units were more than doubled as a consequence of the technological interventions. The positive sorghum yield responses to chisel plowing are in agreements with the findings of a number of research workers. The authors in [2] studied the effect of tillage and sowing methods on yield of sorghum in rain fed mechanized condition in Gadaref area. They found that soil moisture and sorghum grain yield were significantly higher under chiseling compared to wide level disc**.** Likewise, the author in [1] reported in a study for evaluating the effect of tillage depth and patterns on grain of sorghum reported that tillage depth of 25cm with chisel plow had resulted in the highest number of grains per panicle, panicle grain weight and grain yield (t/ha), while the no tillage treatment had a lesser grain yield and yield's components. Similar findings were reported by authors in [6, 9]. Increasing in situ water conservation through chiseling was reported to increase sorghum yields by authors in [8], the improving effect of chiseling was further enhanced by the application of chicken manure in their study.

Table 5: Average sorghum productivity (ton/ha) comparisons between the project and Sudan rain fed traditional sector

Area	**Season**			**Average**
	2012	**2013**	**2014**	
Project – improved	1.47	0.81	1.47	1.25
Project –traditional	0.55	0.27	0.79	0.55
*Sudan rain/fed traditional sector average	0.40	0.40	0.6	0.47

**Data from Annual crop and food supply assessment mission for Sudan, 2014 and 2015*

According to the annual crop and food supply assessment mission for Sudan, 2014 and 2015 report submitted to the ministry of agriculture and irrigation by the authors in [4, 5], the cultivated sorghum areas in traditional rain fed sector of Sudan were 2319, 1586 and 2687 thousands ha in (2012/13), 2013/14 and 2014/15 respectively with sorghum grain yields of 0.4, 0.4 and 0.6 ton/ha for the three seasons, respectively. The corresponding average sorghum yields in the project improved areas as shown in table 6 were 1.47, 0.81 and 1.47 ton/ha for the three seasons, respectively. The percent increases in the average sorghum yields over the whole Sudan traditional rain fed sector average were 267.5, 102.5 and 145% for seasons 2012, 2013 and 2014, respectively. The observed yield depression in season 2013 could largely be attributed to poor rain fall amount and distribution.

3.4 **Sesame seed yield**

Table 6: Sesame seed Yield (kg/ha) at different SUSTAIN extension units, 2012

	AbuHaggar	Almazmum	Dali	Dinder East	Dinder west	Project Average
Improved	756	945	420	1092	630	769
Traditional	315	420	179	357	315	317
t-calculated	5.64	3.16	3.94	6.15	3.84	
Probability	0.001	0.003	0.010	0.001	0.001	

Table 7: Sesame seed Yield (kg/ha) at different SUSTAIN extension units, 2013

	Dali	Dinder East	Dinder west	Project Average
Improved	221	257	326.	268
Traditional	95	116	110	106
t-calculated	4.12	3.89	4.01	
Probability	0.010	0.001	0.001	

Table 8: Sesame seed Yield (kg/ha) at different SUSTAIN extension units, 2014

	Abu Haggar	Almazmum	Dali	Dinder East	Dinder west	Average
Improved	549	546	723	548	768	627
Traditional	322	232	438	314	398	341
t-calculated	7.64	3.96	2.94	8.15	5.84	
Probability	0.001	0.003	0.010	0.001	0.001	

Table 9: Overall Average sesame yield kg/ha in SUSTAIN project areas (seasons, 2012, 2013 and 2014)

	Abu Haggar	Almazmum	Dali	Dinder East	Dinder west	3 - seasons average
Improved	664	746	452	633	574	613
Traditional	318	326	237	261	274	282

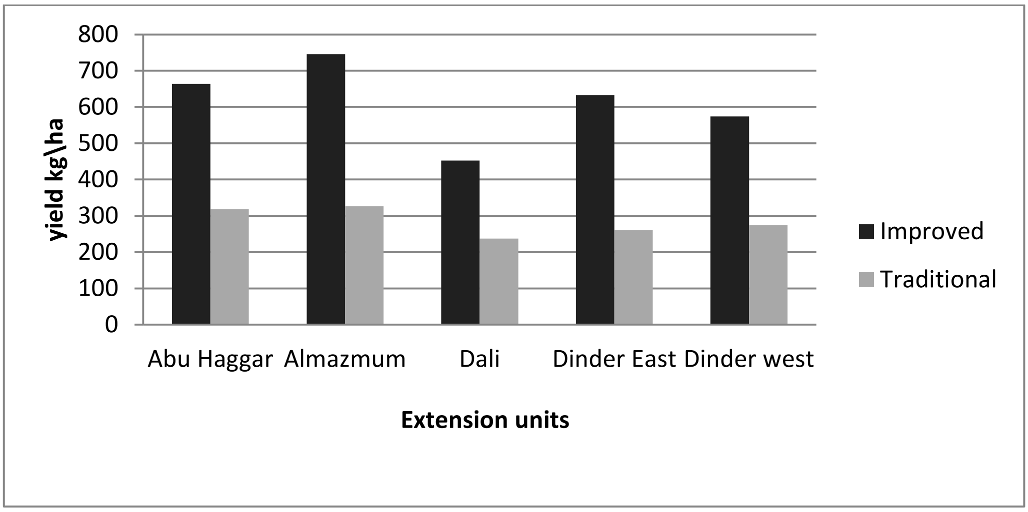

Figure 2: Overall Average sesame seed yield kg/ha in SUSTAIN project areas (seasons, 2012, 2013 and 2014)

Sesame seed yield resulted from the technological interventions (chiseling and sowing of the improved cultivar, Promo) and those obtained by traditional practices are given in tables 6, 7, 8, while table 9 and fig. 2 present average yield of sesame for the three seasons. Irrespective of the location and season, the three years average clearly demonstrated that the improved technology had remarkably attained the highest sesame seed yield (613 kg/ha) compared to 282 kg/ha produced by the traditional practices. The highest yields of 746, 664 and 633 kg /ha were recorded at Mazmoum, Abu huggar, and Dinder East, respectively, while the lowest average yield was at Dali (452 kg/ha). In season 2013 sesame was not grown at Mazmoum or Abu Huggar due to the delay of the rainy season and farmers fear from crop failure from late sowing. Sesame seed yield was highest at Dinder East

(1092 kg/ha) in 2012 followed that of Mazmoum (945 kg/ha) in the same season. The percent increases in the three years average yields due the implemented technologies were 109, 129, 142 and110% at Abu Huggar, Mazmoum, Dinder East and Dinder West respectively.

Table 10: Average sesame productivity (ton/ha) comparisons between the project and Sudan rain fed traditional sector

Area	Season			Average
	2012	2013	2014	
Project – improved	0.77	0.27	0.63	0.56
Project –traditiona	0.32	0.11	0.34	0.26
*Sudan rain/fed traditional sector average	0.21	0.29	0.23	0.24

**Data from Annual crop and food supply assessment mission for Sudan, 2014 and 2015*

Sesame cultivated areas in Sudan traditional rain fed sector were 1250, 378 and 1315 thousands ha in season 2012, 2013 and 2014, respectively with average sesame seed yields of 0.21, 0.29 and 0.29 ton/ha for the three seasons, respectively. The average sesame yields were 0.77, 0.27 and 0.63 ton/ha for corresponding seasons in the project area (table 10). The severe decline in sesame cultivated areas and yield in season 2013 could largely be attributed to amount and the un usual distribution of rain fall. As could be seen from appendix 1, August received by far most of the rain fall in 2013 season and hence delaying most of the cultural practices. The delay in the onset of the rains had contributed to the tremendous decline in sesame cultivated areas because the optimum sowing date of sesame was recommended to be from 15^{th} to late July. The authors in [7] reported that delaying sesame sowing to early August in Central Sudan had resulted in significantly the lowest yield compared to earlier sowing dates in July.

4. Conclusions

From the resulted presented above, it be could possible to conclude that

1- The implemented package of technologies in land preparation, improved released cultivars have proved to be superior to the traditional farmer practices.

2- Improved cultivars of sorghum and sesame gave higher yields than traditional ones.

3- Chiseling has proved to be a viable practice for in situ water harvesting as manifested in better crop performance

4 - The use of released improved cultivars of sorghum and sesame sustains productivity and secures farmers.

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Appendix 1: Rain fall (mm) at SUSTAIN project areas in seasons, 2012, 2013 and 2014

Extension Unit	Season	June	July	August	September	October	Total
Dinder West	2012	30	152	150	74.4	18.4	425
	2013	17	54	209	23.46	4.8	280
	2014	29.5	190.7	170	68	38	458.2
Dinder East	2012	74	150	197	43.7	0	465
	2013	128	68	176	38.5	0	372
	2014	20	172	199	71	25	487
Abu Huggar	2012	101	136	100	66.4	19.2	423
	2013	41	46	297	17.6	4.8	384
	2014	51.6	140.1	213	68	35	472.7
Mazmoum	2012	0	176	234	116.6	0	527
	2013	30	82	213	75	34.2	325
	2014	86.7	204.2	231.3	68.5	69	590.7
Dali	2012	0	152	204	94	0	450
	2013	54	104	186	16.8	17.1	344
	2014	37	152	223	71	55	483

Appendix 2: Some physical and chemical properties of the soils in the project area

Character	**Value**
Clay (%)	60 – 63
Bulk density	1.7 g/cc
Total porosity (%)	25 -35
Water holding capacity	14 22 cm in 0 – 30 cm 37.4 cm in 30 – 120 cm
pH	7.8 – 8
Organic Carbon (%)	0.37 - 0.60