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Effect of Conservation Agriculture System on Yield Components and Yield of Sorghum Cultivars (*Sorghum bicolor L*), cowpea (*Vigna unguiculata*) and Safflower(*Carthamus tinctorius*).

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Abstract
The experiment was carried out for two consecutive rainy seasons, 2018-19 and 2019-20 at Alsabot Village farm the site is located in semi – arid zone, Southern Gedarif mechanized rain-fed area. The study designed in Randomized Complete blocks design replicated fourth time, to determine the effect of conservation agriculture system on yield components and yield of sorghum cultivars (*Sorghum bicolor L*), cowpea (*Vigna unguiculata*) and safflower(*Carthamus tinctorius*).Three crops; sorghum of three cultivars (Wad Ahmed=V1), Tabat=V2 and Wad Baku=V3), cowpea and safflower local varieties were used. The treatments of agricultural systems were; a- conservation agricultural system(CA), zero tillage and after 70% emergence of weeds, first round of spraying using Pre & post emergence herbicides, (by using double disc row precise planter).1- intercropping cowpea (legume crop) between rows of planted sorghum, 2-intercropping of safflower with sorghum ,b- applied of conventional agricultural farming,(CF) by ploughed, leveled and ridged the soils, fertilizers were used, no herbicides, weed controlled by hands weeding.
The result of intercropping cowpea and safflower with three cultivars of sorghum under conservation agriculture system(CA) showed highly significant difference for all yield and yield components parameters taken compared with conventional farming system (CF). The result of yield reported the superiority of V1, for intercropping with cowpea under CA (4296.0 kg\ha and2961.3 kg\ ha) than CF (1803.5 kg\ ha) for first and second season, also the same result when intercropped with safflower under CA, V1 obtained were (4161.6 kg\ ha and 2891.3 kg\ha) for first and second season respectively. Cowpea yield and yield components appear highly significant result among three cultivars of sorghum and the highest value with V1 for number of pods\plant (9.5), weight of pods\ plant (190.9 kg),weight of seeds\plant (79.07 gm)100 seed weight(18.8 gm) and yield (378.25 kg\ha) in first season. In second season there were no significant differences among yield and yield components but yield of V1 revealed high production compared with first season production (583.0 kg\ ha). Safflower intercropped with three cultivars of sorghum in CA showed poor number of plants\m^2 and yield for both season, with no significant difference.

Keyword: intercropping, cowpea, safflower, conservation agriculture, sorghum

Introduction

Sorghum (*Sorghum bicolor* L.) is a major cereal grown for food and beverages by resource-poor farmers in sub-Saharan Africa (SSA) and has been regarded as a future crop due to its ability to withstand climate change-induced stress (Nciizah *et al*., 2020) and has the potential to boost food security (Mabhaudhi *et al*., 2016; Ulian *et al*., 2020). In the context of climate change and variability, increasing small grain yield is critical for food and nutrition security (Mathew, 2015; Ndlovu *et al*.,2020). In order to address global food demands sustainably, striking a balance between food production and environmental impacts is essential.

Edralin *et al*., (2017) found that the years of intensive tillage have caused significant decline in agriculture's natural resources that could threaten future of agricultural production and sustainability. Conventio-nal tillage could cause rapid loss of soil organic matter, leading to a high potential for soil degradation and decline of environmental quality (Demirel and Turgut,2022)). Drought and low soil fertility are common in semi-arid regions trapping smallholder farmers in cycle of poverty Nciizah *et al*., 2020**).** Hence, a better soil organic matter, leading to a high potential for soil degradation and decline of environmental quality in the long run (Edralin *et al*. 2016). Conventional agriculture is the greatest enemy of health soil, its wasn't designed for betterment of soil, but rather for rapid economic growth(Stanojevic,2021). Conservation agriculture is based on principles of minimal soil disturbance, continuous soil cover, and crop diversity (Entz *et al*.,2022). Under the CA treatment had a higher probability of rating better than non-CA fields (Entz, *et al*., 2022). Results demonstrate that CA is especially positive for yield under drier growing conditions (Steward *et al*. 2018), where soil surface**.**

Inter-cropping is the agronomic practice of growing two or more crops simultaneously in the same field (Mazzafera *et al*., 2021, Glaze *et al* ,2020). Inter-cropping creates an ecologically strong agricultural system by reducing the use of external harmful chemical input and utilizing natural resources more efficiently, which produces healthy and good quality food (Kumawat *et al*.,2021). Advantage of intercropping in crop production in comparison with pure cropping are due to the difference in compotation for use of environmental resource (Mazzafera *et al*.,2021). By having different types of crops soil built it is resilience and become more staple (Stanojevic, 2021). However, several non-cash plants are now used as cover crops to improve soil quality (Crusciol *et al*., 2012). The vulnerable environmental condition and poor cultivation practices led to a drastic reduction in agriculture production system. The need now, therefore, is for farmers to take up more sustainable, productive and profitable ways of production that do not damage the soil, land and environment. The objective of the study to show the effect of intercropping of cowpea (*Vigna unguiculata*) under conservation agriculture on yield and yield components of sorghum cultivars (*Sorghum bicolor L*) in Semi-arid Region.

Materials and Methods

The experiment was carried out for two consecutive rainy seasons, 2018\19 and 2019\20 at Alsabot Village Farm (AVF), the site is located in semi – arid zone, and Southern Gedarif mechanized rain-fed area. The soil is heavy clay soil alkaline (PH= 8.3) with 0.29 EC and 0.0014% Nitrogen content. The area receives its rainfall mainly in summer with most of effective rainfall occurring within June to October the rainfall Distribution is erratic within the year and from year to year. The long term average annual rainfall is above 600 mm

Three crops; sorghum of three cultivars (Wad Ahmed=V1), Tabat=V2 and Wad Baku=V3), cowpea and safflower local varieties, at seed rates (7.14, 19.04 and 10.50) kg/ha, respectively were used. Before sowing the seed; were treated by

Safener and Consep 111 960 ES at rate of 0.4 ml/kg of seed (to protect sorghum, cowpea, safflower), at a rate of 3 g/kg of seeds. The experiment was sown in the 3th of July in the first season and in 10th of July in the second season.

Broadcasting of Diammonium phosphate (DAP) fertilizer at rate of 38 Kg/ha and urea fertilizer at rate of 71 Kg/ha, (by using fertilizer broadcaster). The treatments of agricultural systems were; a-conservation agricultural system(CAS), zero tillage and after 70% emergence of weeds, first round of spraying were using and post spraying herbicides were also used immediately after planting not exceeding 48 hours (by using double disc row precise planter).1- intercropping cowpea (legume crop) between rows of planted sorghum, manual in holes 2 cm depth and 40 cm spacing between holes and 40 cm between rows, 2-intercropping of safflower with sorghum manual in holes 2 cm depth and 40 cm spacing between holes and 40 cm between rows ,b-applied of conventional agricultural farming,(CF), residues was removed, first disking on bare soil (5–8 cm depth), ploughed leveled and ridged was done, fertilizers applied as above doses, no herbicides was used, weed controlled twice by hand 3 weeks after emergence of crops(CF).

The experiment was laid in Randomized Complete Block Design RCBD with four replications. The main plots were allocated for cultivars of sorghum and the subplots were allocated for agricultural systems. The subplot size was 8 ×9 m. The pass way between subplots was two meters; while it was three meters between replications. The treatments were randomly distributed in the subplots.

Crop parameters for sorghum determined were; four head of plants were randomly selected from each subplot at harvest head length and width in cm. Head length (cm), Four head plants were randomly selected from each subplot at harvest to determine head length. Head width (cm), Thousand Seeds weight (g) by counting 1000 seeds randomly from the grain yield of each plot and their weight was obtained using sensitive balance. Yield (kg/ha), crops yield was determined from an area of two-meter square. Parameters yield and yield components were taken for cow pea, five plants were selected to determine the number of pods\plant, weight of seeds\plant, 100 seed weight and yield kg\ha also determined. The collected samples were naturally dried, threshed and weighed. The yield was determined in kilograms per hectare. In safflower the number of plants \m2, plant high in cm and yield kg\fed were accounted. The obtained data were statistically analyzed by using SAS software, version 80-2011. Analysis of variance (ANOVA) was used to explore the differences between the tested treatments. In addition, Duncan's Multiple Range Test (DMRT) was used to distinguish between the treatments mean when there is a significant difference.

Result and Discussion

Figs. 1 and 2 clearly showed that application of conservation agriculture had well growth of sorghum and no evidence of striga as compared with conventional farming. This result confirmed by many researchers Mzzafera, *et al*., (2021), Galaze *et al*., (2020), and Stanojevic, (2021).

Fig.1 Conventional farming (CF) for three cultivars of sorghum.

Fig 2. Conservation Agriculture intercropping sorghum with cowpea

Fig3. Conservation Agriculture intercropping sorghum with safflower

The result of Intercropping cowpea and safflower with three cultivars of sorghum under conservation agriculture showed highly significant difference for all yield and yield components parameters taken, Tables1,2,3and 4**.** For all results intercropping three cultivars of sorghum with cowpea and safflower gave the highest values compared with sorghum grown alone. In two seasons, head length of sorghum cultivars intercropped with cowpea revealed that V2 displayed the biggest head length (27.1 cm and 26.6cm) and (20.6cm and 13.9cm) when grown alone for two season respectively. Also the same result noticed when intercropped with safflower, V2 (27.6 cm and 20.6cm) followed by V1(20.6cm and 15.7cm) for both season respectively. The result of yield reported the superiority of V1 for intercropping with cowpea (4296.0 kg\ha and 2961.3 kg\ha) for first and second season also the same manner when intercropped with safflower V1(4161.6 kg\ha and 2891.3 kg\ha) for first and second season respectively. Mono agriculture showed the same result and V1is the highest yield value for both season, V1 (1803.6 kg\ha and 988.49 kg\ha). The results obtained revealed high yield and yield components of three sorghum grown for two seasons under conservation agriculture system than conventional system. Ella, *et al*.,(2016) suggested that conservation agriculture had appositive impact on soil quality and exhibited higher rate of soil organic carbon, while till systems negatively impact soil characteristics.

Table 1. yield and yield components of sorghum cultivars intercropped with cowpea under conservation agricultural system season 2018\19.

	Head length		Head width		100seed seed weight		Yield Kg\ha	
	CA	CF	CA	CF	CA	CF	CA	CF
V1+C	21.4b	15.7b	6.8a	4.1a	29.2b	29.2b	4296.0a	1803.5a
V2+C	27.1a	20.6a	6.8a	3.2b	27.3c	27.4c	3536.6a	1481.0a
V3+C	11.6c	09.1c	6.0a	4.1a	30.0a	30.4a	2594.5b	1029.3b
SE	0.8	0.69	0.6	0.38	0.16	0.2	3.38	158.6
CV%	2.06	1.7	1.61	0.93	0.40	0.53	8.27.1	3.88

CA, conservation agricultural system, CF. Conventional farming system V1,WadAhmed, V2,Tabat, V3, Wad Bako

Table2. Yield and yield components of sorghum cultivars intercropped with cowpea season 2019\20.

	Head length		Head width		100 seed weight		Yield Kg\Ha	
	CA	CF	CA	CF	CA	CF	CA	CF
V1+C	20.4b	10.8b	6.5ab	2.1c	27.3b	27.4b	2961.3a	988.4a
V2+C	26.6a	13.9a	6.7a	3.1b	25.2c	25.2d	2015.6ab	1006.4a
V3+C	12.1c	8.2b	5.8b	4.1a	29.1a	29.3a	1270.0b	713.5b
SE	0.6	1.13	0.34	0.23	0.07	0.12	419	46.9
CV%	1.51	2.7./6	0.84	0.56	0.19	0.29	10.25	11.4

CA, conservation agricultural system, CF. Conventional farming system V1,WadAhmed, V2,Tabat, V3, Wad Bako

Table3. Yield and yield components of sorghum cultivars intercropped with safflower under conservation agricultural system, season 2018\19.

	Head length		Head width		100 seed weight		Yield Kg\Ha	
	CA	CF	CA	CF	CA	CF	CA	CF
V1+S	20.6b	15.7b	6.7 a	6.7 a	29.3 b	29.2b	4161.6 a	1803.5a
V2+S	27.6 a	20.6a	6.3ab	6.3ab	26.9c	27.4c	3292.1 a	1481.a
V3+S	11.3 c	9.1c	5.5b	5.5b	30 aa	30.4a	2329 .6b	1029.3b
SE	1.03	0.69	0.44	0.44	0.18	0.2	362.6	158.6
CV%	2.5	1.7	1.09	1.09	0.45	0.53	887.25	388

CA, conservation agricultural system, CF. Conventional farming system V1,WadAhmed, V2,Tabat, V3, Wad Bako

Table4. Yield and yield components of sorghum cultivars intercropped with safflower under conservation agricultural system, season 2019\20.

	Head length		Head width		100 seed weight		Yield Kg\Ha	
	CA	CF	CA	CF	CA	CF	CA	CF
V1+S	19.8 b	10.8b	5.4 a	2.1c	27.0b	27.4b	2891.3 a	988.4a
V2+S	26.6 a	13.9a	5.9 a	3.1b	25.1c	25.2d	2044.5 b	1006.4a
V3+S	11.2c	8.2b	6.0 a	4.1a	29.2 a	29.3a	1259.2 c	713.5b
SE	0.87	1.13	0.31	0.23	0.23	0.12	273.8	114.8
CV%	2.14	2.76	0.78	0.56	0.57	0.29	6.70	4.6

CA, conservation agricultural system, CF. Conventional farming system V1,WadAhmed, V2,Tabat, V3, Wad Bako

Cowpea yield and yield components showed in Tables, 5 and 6 for two season, the results appear highly significant result among three cultivars in first season as affected by intercropping of cowpea and V1showed the highest value in number of pods\ plant(9.5), weight of pods\ plant (190.9 kg),weight of seeds\plant (79.07 gm)100 seed weight(18.8 gm) and yield (378.25 kg\ ha). In second season there were no significant difference among yield and yield components but yield of cowpea intercropped with V1 revealed high production compared with first season production (583.0 kg\ ha). Salomons , *et al*., (2018) confirm the above result and found that legume intercropping would not only provide biological and nutritional diversity, it may also provide an in situ cover, thereby reducing the amount of mulch required for soil and water conservation . Many researchers had reported a yield increase as a result of intercropping sorghum with cowpea. This could be related to the benefits of the trap crop (cowpea) in reducing Striga infestation besides its contribution in soil moisture retention and low competition to sorghum plants for nitrogen its capability of fixing its own nitrogen similar results were mentioned by Gbehounou and Adango, (2002) and Hassan and Elasha (2008).

Mzzafera, *et al*.,(2021), and Stanojevic, (2021) illustrated the importance of intercropping in conservation agriculture increasing health of soil and therefore, lead to increase yield and income of farmers.

Table 5. Yield of cowpea intercropped with sorghum cultivars season under conservation agricultural system, 2018\19.

	Number of pods\plant	Weight of pods/plant	Weight of seeds/plant	100 seed weight	Yield kg\ha
V1+C	9.5 a	190.92a	79.073 a	18.8 a	378.25a
V2+C	8.5 ab	152.76 b	55.20 b	18.4 ab	332.73b
V3+C	7.0 b	152.76 b	46.59 b	18.0 b	306.75c
SE	11.31	5.20	11.31	1.79	17.51
CV%	9.5	19.0	3.4	0.16	10.33

V1,WadAhmed, V2,Tabat, V3, Wad Bako

Table 6. Yield of cowpea intercropped with sorghum cultivars under conservation agricultural system, season 2019\20

	Number of pods\plant	Weight of pods/plant	Weight of seeds/plant	100 seed weight	Yield kg\ha
V1+C	20.25 a	385.34 a	112.7 a	18.15 a	583.0 a
V2+C	14.00 a	327 a	93.70 a	18.20 a	419.0 b
V3+C	18.50 a	431 a	127.7 a	18.50a	525.0 b
SE	40.63	34.08	37.81	2.43	18.41
CV%	5.05	9.1	29.8	0.31	6.6

V1,WadAhmed, V2,Tabat, V3, Wad Bako

Safflower intercropped with three cultivars of sorghum showed poor number of plants\m^2 and yield for both season Table 7, with no significant difference. This may attributed to ecological factors or climatic condition related to safflower growth in this area, Burhan, *et al*., (2001) found that one of the key points for optimizing safflower productivity is a choice of location and the appropriate sowing date. Safflower not recognized in this area it well known in Northern Sudan and Khartoum area Khalil, *et al*.,(2015)

Table 7. Growth of safflower intercropped with three cultivars of sorghum under conservation

	Season one			Season 2		
	Number of plant/m2	Plant height/ cm	Yield kg/ha	Number of plant/m2	Plant height/ cm	Yield kg/ha
V1+S	5.0 a	82.7 a	0	4.5 a	83.0 a	0
V2+S	4.8 a	78.4 a	0	5.0 a	80.7 a	0
V3+S	5.0 a	76.3 a	0	5.0 a	78.7 a	0
St	0.21	5.92	0	0.16	2.74	0
CV	6.51	11.02	0	6.90	45.80	0

agricultural system,seasons(2018\19-2019\20).

V1,WadAhmed, V2,Tabat, V3, Wad Bako

Conclusion

Intercropping is a sustainable practice that can improve resource use efficiency for both nutrients and water, thereby facilitating low-input agricultural practices. Result of this study illustrate the potential of conservation agriculture with intercropping of cowpea and safflower to increase yield components and yield of sorghum cultivars under semi-arid region of Sudan. Overall, the results obtained in this study could serve as a significant take off point for further study.

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أثر نظام الزراعة الحافظة علي مكونات الانتاجية والانتاجية لثلاثة أصناف من الذرة الرفيعة *Sorghum bicolor*) واللوبيا (*Vigna unguiculata*) والقرطم (*Carthamus tinctorius*).

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المستخلص

اجريت تجربة لموسيمين متتاليين2018\19–2019\20 في قرية السبوط منطقة الزراعة الالية جنوب القضارف في حزام المنطقة الجاف.صممت التجربة بتصميم القطع العشوائية الكاملة مكررة اربعة مرات لتحديد اثر الزراعة الحافظه علي مكونات الانتاجية والانتاجية لثلاثة اصناف من الذرة الرفيعة واللوبيا والقرطم. استخدمت ثلاثة محاصيل : الذرة الرفيعة بثلاثة اصناف ود أحمد (V1)وطابت (V2) ووباكو (V3) واللوبيا والقرطم اصناف محلية.معاملات النظم الزراعية كانت: أ–الزراعة الحافظة ,حرث صفري ثم الرش بمبيد للحشائش قبل وبعد ظهور 70% من الحشائش عند الزراعة مباشرة بالزّراعة (ثنائية الديسك),1–تحميل اللوبيا(محصول بقولي) بين سطور أصناف الذرة الرفيعة, 2–تحميل القرطم بين سطور أصناف الذرة الرفيعة.ب–تطبيق الزراعة التقليدية بالحرث بالتقليب والتسطيح وتقطيع السرابات والتسميد مع عدم استخدام مبيد للحشائش التي تم التحكم فيها بالعزيق اليدوي.

اظهرت النتائج فروقات معنوية عالية لقراءات الزراعة الحافظة بالتحميل للاصناف الثلاثة للذرة الرفيعةمقارنة مع الزراعة التقليدية .وكانت الأفضلية للصنف (V1) في الانتاجية كجم\للفدان مع التحميل باللوبيا (4296.0كجم للفدان و2961.3كجم للفدان) للموسمين مقارنة مع (1803.5كجم للفدان) للزراعة التقليدية, نفس الأنتاجية تم الحصول عليها بالتحميل بالقرطم للموسمين علي التوالي (4161.6كجم للفدان و2891.3).انتاجية اللوبيا ومكوناتها اظهرت النتائج فروقات معنوية عالية في الموسم الاول وأعلي قيمة للصنف (V1) بالنسب لعدد القرون للنبات (9.5)ووزن البذور للنبات (79.07جم) ووزن القرون للنبات (190.9 جم) ووزن المائة حبة (18.8جم) والأنتاجية (378.25جم للفدان).الموسم الثاني لاتوجد فروقات معنوية ولكن أنتاجية (V1) كانت الأعلي (583.0كجم للفدان) .القرطم اعطي عدد بسيط للنبات في المتر المربع وضعف للنمو للموسمين.