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Effects of sowing date and intercropping on yield, yield components and oil content of sunflower and groundnut in a desert environment in northern Sudan

Ammar W. Hammad[1], Ibrahim E. Mohamed[2] and Siddig E. Idris[2]

[1]National Institute of Desert Studies, University of Gezira, Wad Medani, Sudan
[2]Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan

ABSTRACT

The summer season in the Northern State, Sudan, is characterized by its limited field activities. The present and future expansion of agricultural production is targeted in desert plain soils away from the River Nile bank. This study was conducted during seasons 2014/15 and 2015/16 with the objectives of determining the effects of sowing date and intercropping system on yield, yield components and oil content of sunflower and groundnut. Split-plot design with randomized complete arrangement with four replicates was used. The main plots were assigned to the three sowing date namely: 1st June, 1st July and 1st August. The sub-plots were assigned to intercropping system: *viz*: sole cropped and intercropping (two rows of groundnut alternate with two rows of sunflower). The interaction between sowing date and intercropping had a significant ($p \leq 0.05$) effect on yield component, total yield and oil content of both crops in both seasons. The highest seed yield was obtained by intercropped sunflower and sole groundnut for 1st June and 1st August, respectively. The highest oil content was attained by intercropped groundnut and sole sunflower, respectively, for 1st August. First June sowing date resulted in the best land equivalent ratio in both seasons. Based on these results, to obtain high seed yield of high oil content, it could be recommended that 1st of June and 1st of August were optimum sowing dates for sunflower and groundnut, respectively in the desert environment of north Sudan. It was also recommended to intercrop sunflower with groundnut and sow them on the first of June for the highest LER.

INTRODUCTION

The summer season in northern Sudan is characterized by its limited field activities and its narrow cropping composition. Limited areas are planted with some forage crops (cowpea and forage sorghum) as sole crop or intercropped. Due to area limitation and little cropping activities in summer season in the Northern State of Sudan, present and future expansion of agricultural production is targeted to desert plain soils away from the River Nile banks.

In many parts of the world, intercropping is the most common agro-ecosystem use. It has lots of advantages in comparison with sole crops (Banik *et al*., 2006). Mousavi and Eskandari, (2011) stated that success of intercrops in comparison with a pure cropping can be determined by ultimate density, planting date, resources availability and intercropping models.

Daffalla *et al*. (2013) reported that, 20th of October sowing date significantly increased seed yield of sunflower, when compared to the 20th of November and 20th of December sowings. However, Lazim and Ali (1990) found that sowing date had no significant effect on seed yield of sunflower. Ahmed (2013) found that sowing date had a significant effect on pod yield of groundnut. The highest yield was obtained by the 15th of June planting.

Imran *et al*. (2011) reported that sunflower seed yield was significantly affected by intercropping sunflower with mung bean. Elobu *et al.* (2013) stated that yields of intercropping sunflower with beans, groundnuts, maize and sorghum at different ratios were significantly lower than yields in pure stands. Osman (2002) reported that intercropping groundnut with cowpea or guar resulted in lower yields than pure stand.

Abouziena (2013) found that 15th April sowing gave the highest oil yield, followed by 1st May and the lowest oil yield was recorded for 16th May. Early sowing produced significantly more oil yield than the later sowing by 26%.

El-Sawy *et al*. (2006) reported that intercropping sunflower with groundnut produced higher land equivalent ratio. Priya *et al*. (2009) reported that intercropping groundnut with sunflower had a LER of more than one.

This study was conducted with the objectives of examining the effect of intercropping and sowing date on yield, yield components and oil content of sunflower and groundnut in the desert environment.

MATERIALS AND METHODS

This study was conducted during seasons 2014/15 and 2015/16 at the National Institute of Desert Studies Research Farm (NIDSRF), in New Hamdab Agricultural Scheme of El-Multaga, Northern State, Sudan. The area lies between longitudes 31º 06′ and 31º 13′ E and latitudes 17º 55′ and 17º 58′ N (Land and Water Research Center, 1999) . The soil was described as El-Multaga soil series, which is a vertic haplocambids, member of fine loamy, mixed, hyperthermic soil. The soil had a pH of 7.9, nitrogen 0.027 %, available phosphorus 3.0 mg/ kg soil and potassium 0.79 mol $^{(+)}$ kg/ soil (Hammad *et al.*, 2012).

The experiment comprised 6 treatments, namely: Three sowing dates *viz:* 1st of June, 1st of July and 1st of August and two intercropping systems, namely, sole cropping and intercropping (two rows of groundnut alternate with two rows of sunflower). Split plot design was used, with sowing dates assigned to main plots and intercropping system to the sub-plots. The size of the sub-plots was 3.5× 4.0 m (14 m^2).

The experimental site was disc plowed, harrowed, leveled and ridged 60 cm apart from east to west to avoid shading of sunflower to groundnut. Spacing between plants was 20 cm and 30 cm for groundnut and sunflower, respectively. Sowing was carried manually on 1st June, 1st July and 1st August with 3-5 seeds per hole, and later thinned to one and two plants/hole for sunflower and groundnut, respectively.

The two crops received 43 N kg /ha of urea applied after two weeks from sowing and 43 P_2O_5 kg/ha before sowing as a basal dose. Irrigation was immediately applied to ensure crop establishment. Other irrigations were given every seven days. Weeds were controlled manually as necessary. Insects and disease control measures were not undertaken.

The meteorological data including maximum and minimum air temperatures and relative humidity for both seasons were obtained from NIDS Meteorological Station. Data taken consisted of seed yield, biological yield, harvest index and oil content for both crops. Head diameter, 1000 seed weight for sunflower, and number of pods per plant and 100 seed weight for groundnut were determined. The land equivalent ratio (LER) was calculated by the following equation:

$$LER = \frac{\text{Yield of intercropped sunflower}}{\text{Yield of sole sunflower}} + \frac{\text{Yield of intercropped groundnut}}{\text{Yield of sole groundnut}}$$

Standard analysis of variance for the split plot design using MSTAT statistical computer package was used to analyze the data and Duncan's Multiple Range Test was used for means separation.

RESULTS AND DISCUSSION

Microclimate of the experimental site

The second season (2015/16) was hotter than the first season (2014/15) with mean maximum and minimum temperatures of 44˚C and 18 ˚C in the first season 45˚C and 22 ˚C in the second season. Overall mean of relative humidity (%) indicated that the first season was more humid than the second season.

Yield attributes of groundnut

Number of pods / plant

Effects of sowing date and intercropping on number of pods / plant and 100-seed weight of groundnut are shown in Table 1. The results showed that the interaction between sowing date and intercropping had significant effects on number of pods per plant in the second season only. The highest number of pods per plant (21) was obtained by 1st August intercropping in the second season. These results disagree with those reported by Priya *et al*. (2009) who reported that the highest number of pods was recorded under pure stand when groundnut was intercropped with sunflower.

Table1. Effects of sowing date and intercropping on number of pods/plant and 100-seed weight (g) of groundnut during 2014/15 and 2015/16 seasons.

Treatment	Number of pods/plant		100-seed weight (g)	
	First season	Second season	First season	Second season
Sole June1st	15.5a	09.5c	30.3c	39.5b
Inter June 1st	17.8a	09.0c	32.5bc	39.7b
Sole July 1st	16.3a	17.5ab	32.8bc	38.2b
Inter July 1st	18.0a	15.0b	32.2bc	37.4b
Sole August 1st	18.0a	20.0a	41.6a	45.2a
Inter August 1st	18.3a	21.0a	36.3b	43.4a
Mean	17.3	15.3	34.3	40.6
SE±	1.3	1.5	1.5	1.1
C.V. (%)	22.7	33.0	15.0	09.2

Means followed by the same letter (s) are not significantly different at 0.05 level of significance according to DMRT.

100- Seed weight

Effects of sowing date and intercropping on 100 seed weight of groundnut were significant in both seasons (Table 1). The highest 100-seed weights (41.6 and 45.2 g) were attained at August 1st coupled with sole crop in the first and second seasons, respectively. These results were in line with the findings of Ahmed (2013) who reported that the 100 seed weight of groundnut was significantly affected by sowing date. However, they disagreed with the findings of Osman (2002) who found no significant differences in 100 seed weight of intercropping groundnut with guar.

Seed yield

Effects of sowing date and intercropping on seed yield of groundnut were significant (Table 2).The highest seed yield of 1.29 and 1.84 t/ha was attained by sole groundnut in 1st of August in the first and second seasons, respectively. These results were in agreement with those stated by Osman (2002) who report that, in intercropping groundnut with cowpea or guar, yields were 1015 kg/ha of pure stand of groundnut and 864 kg/ha of intercropping at 1:1 row arrangement. The

reduction in yield in intercropping could be due to inter and intra specific competition for light, nutrients and moisture.

Table 2. Effects of sowing date and intercropping on seed yield and biological yield of groundnut during 2014/15 and 2015/16 seasons.

Treatment	Seed yield (t/ha)		Biological yield (t/ha)	
	First season	Second season	First season	Second season
Sole June 1st	0.57d	0.49d	6.82c	8.11d
Inter June 1st	0.53d	0.45d	6.53c	7.63d
Sole July 1st	1.06b	1.45b	10.28a	11.82a
Inter July 1st	0.76c	0.89c	9.51b	10.74b
Sole August 1st	1.29a	1.84a	5.45d	10.02c
Inter August 1st	1.07b	1.27b	4.57e	7.82d
Mean	0.88	1.07	7.19	9.36
SE±	0.05	0.10	0.23	0.18
C.V. (%)	18.6	23.8	17.0	8.4

Means followed by the same letter (s) are not significantly different at 0.05 level of significance according to DMRT.

Biological yield

The interaction between sowing date and intercropping had significant effects on the biological yield of groundnut in both seasons (Table 2). The highest biological yields of 10.82 and 11.82 t/ha were recorded for sole groundnut in July 1st in both seasons, respectively. These results were in line with those stated by Rashid *et al*. (2002). The higher biological yield achieved in pure stands than in intercropping systems, may be due to less competition for light, moisture, nutrients and space.

Oil content

Figure 1 shows that the highest oil content for groundnut (48 3 and 44.2%) was attained by intercropped groundnut in August 1st in the first and second seasons, respectively. These results were in accord with the findings of Priya *et al*. (2009) who stated that intercropping systems had the highest oil content. Generally, oil percentage was higher in the first season than the second one. This may be attributed to the fact that the first season was cooler than the second season.

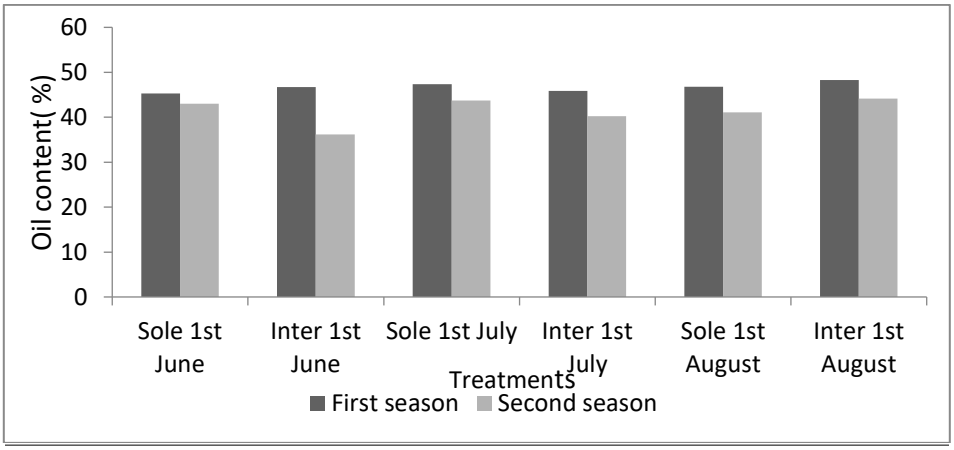

Fig 1, Oil percentage of groundnut for the first (2014/15) and second (2015/16) seasons.

Yield attributes of sunflower

Head diameter

Interaction between sowing date and intercropping had a significant effect on head diameter in both seasons. The head diameter ranged from 10.7 to 14.3 cm in the first season and8.6 and 13.4 cm in the second season. However, the highest head diameter (14.3 and 13.4 cm) was obtained by sole crop and intercropping in the 1st of June sowing in both seasons, respectively (Table 3). These results were in agreement with those stated by Daffalla *et al.* (2013) who reported that sowing date of 20th October significantly increased head diameter when compared to the 20th of November and 20th of December sowings. Dutta (2011) found that head diameter showed a decreasing trend with delayed sowing date. The lowest value of head diameter was recorded for January 15th sowing. However, Priya *et al.* (2009) reported that intercropping sunflower with pigeon pea had no effect on sunflower head diameter.

1000- seed weight

Interaction between sowing date and intercropping had significant effects on 1000 -seed weight of sunflower in both seasons (Table 3).The heaviest seeds (60.97 and 57.47 g) were obtained when sole crop was sown in June 1st in both seasons, respectively. These results support the findings of Imran *et al.* (2011) who reported that the maximum 1000- seed weight was obtained when sole sunflower was sown, with minimum seed rate.

Table 3. Effects of sowing date and intercropping on head diameter and 1000-seed weight of sunflower during 2014/15 and 2015/16 seasons.

Treatment	Head diameter (cm)		1000- seed weight(g)	
	First season	Second season	First season	Second season
Sole June 1st	14.29a	12.93a	60.97a	57.47a
Inter June 1st	12.85b	13.35a	49.24cd	40.99b
Sole July 1st	11.50c	10.95b	56.12ab	36.49b
Inter July 1st	11.52c	11.27b	44.75d	29.52c
Sole August 1st	10.72c	09.70c	53.26bc	48.59a
Inter August 1st	10.80c	08.63d	48.63cd	48.80a
Mean	11.95	11.14	52.16	42.81
SE±	0.26	0.23	1.77	1.73
C.V.(%)	7.67	7.21	11.76	13.96

Means followed by the same letter (s) are not significantly different at 0.05 level of significance according to DMRT.

Seed yield

Table 4 shows that interaction between sowing date and intercropping on seed yield of sunflower was significant. The highest seed yield (2.03 and 1.20 t/ha) was attained by intercropped and sole sunflower in June 1st in the first and second seasons, respectively. The highest seed yield achieved in 1st of June sowing date could be attributed to the heaviest seed weight and the biggest head diameter of sunflower obtained in 1st of June. These results were in agreement with the findings of Daffalla *et al.* (2013) who reported that the 20th of October sowing significantly increased seed yield of sunflower when compared with the 20th November and 20th December sowings.

Biological yield

Sowing date and intercropping interaction had significant effects on the biological yield of sunflower in both seasons (Table 4). The highest biological yield (4.58 and 5.51 t/ha) was attained by sole sunflower sown in 1st of June in the first and second seasons, respectively. These results were similar to those stated by Rashid *et al.* (2002). The highest biological yield in pure stand of sunflower than in other intercropping systems may be due to the less competition for light, moisture, nutrients and space.

Table 4. Effects of sowing date and intercropping on seed yield and biological yield of sunflower during 2014/15 and 2015/16 seasons.

Treatment	Seed yield (t/ha)		Biological yield (t/ha)	
	First season	Second season	First season	Second season
Sole June 1st	1.73b	1.20a	4.58a	5.51a
Inter June 1st	2.03a	1.18a	4.45a	4.92b
Sole July 1st	1.68b	1.04ab	4.11b	4.62b
Inter July 1st	1.95ab	1.01ab	4.28ab	4.76b
Sole August 1st	1.27c	0.90b	3.58c	2.37c
Inter August 1st	1.20c	0.62c	3.40c	2.36c
Mean	1.64	0.99	4.07	4.09
SE±	0.08	0.07	0.09	0.15
C.V. (%)	18.48	22.58	8.16	12.70

Means followed by the same letter (s) are not significantly different at 0.05 level of significance according to DMRT.

Oil content

Oil percentage of sunflower ranged from 39.5 to 46.8% in the first season and between 33.8 % and 43.1% in the second season (Fig.2). The highest oil content (46.8 % and 43.1%) were attained by sole and intercropping of sunflower in 1st August in the first and second seasons, respectively. These results disagree with those of Partal (2010) who reported that oil content of sunflower varied widely between 38.9% and 50.9%. He concluded that early sowing increased oil content when compared with late sowing. Dutta (2011) reported that oil content of sunflower was reduced when sowing was delayed.

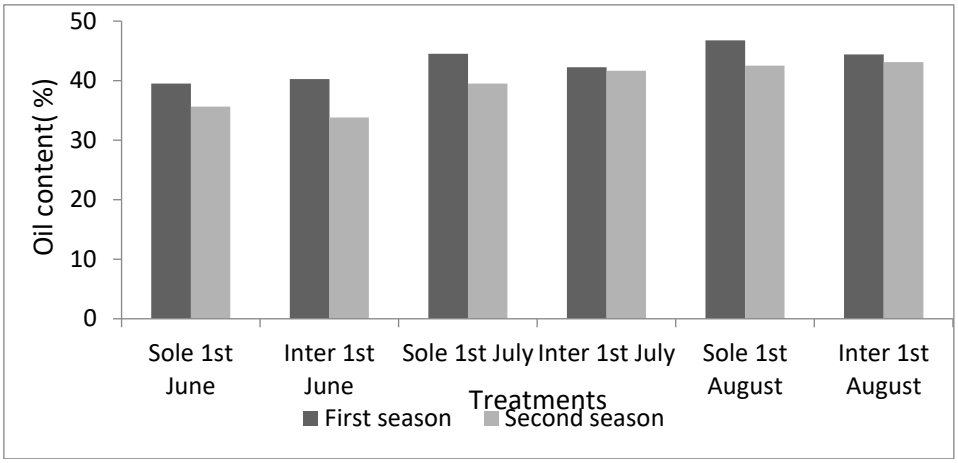

Fig 2. Oil percentage of sunflower for the first (2014/15) and second (2015/16) seasons.

Land equivalent ratio (LER)

Results of sunflower - groundnut intercropping at different sowing dates revealed that intercropping at June 1st gave the highest LER of 2.1 and 1.9 for the first and second seasons, respectively. While, the intercropping at August 1st recorded the lowest LER (1.8 and 1.3) in the first and second seasons, respectively (Table 5). These results confirm with those stated by El-Sawy *et al*. (2006) who reported that intercropping sunflower with groundnut produced higher LER (1.67). Priya *et al*. (2009) reported that LER obtained by intercropping system (groundnut with sunflower) was more than one.

Table 5. Land equivalent ratio of intercropping sunflower with groundnut at three sowing dates during 2014/15 and 2015/16 seasons.

Sowing date	First season			Second season		
	LER fraction of sole		Total LER	LER fraction of sole		Total LER
	Sunflower	Groundnut		Sunflower	Groundnut	
First of June	1.2	0.9	2.1	1.0	0.9	1.9
First of July	1.2	0.7	1.9	1.0	0.6	1.6
First of Augus	1.0	0.8	1.8	0.7	0.6	1.3

Recommendations

According to the results of this study, it is recommended to sow sunflower and groundnut for sole or intercropped cultivation in June 1st and August 1st, respectively in the desert environment of North Sudan.

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أثر الزراعة البينية وتاريخ الزراعة علي الإنتاجية و مكوناتها وكمية الزيت لمحصولي زهرة الشمس والفول السوداني في بيئة الصحراء بشمال السودان

عمار وداعه حماد[1] و إبراهيم البشير محمد[2] و صديق عيسى إدريس[2]

[1]المعهد القومي لدراسات الصحراء، جامعة الجزيرة. ود مدني السودان.

[2]كلية العلوم الزراعية، جامعة الجزيرة، ود مدني السودان.

الخلاصة

النشاط الزراعي محدود جدا في الموسم الصيفي بالولاية الشمالية في السودان. وأن التوسع الحالي والمستقبلي في الرقعة الزراعية يستهدف أراضي السهل الصحراوي والتروس العليا البعيدة عن حوض نهر النيل. نفذت هذه التجربة في المناخ الجاف علي تربة السهل الصحراوي في الولاية الشمالية في الموسم الصيفي 15/2014 و16/2015 بهدف تحديد أثر تاريخ الزراعة ونظام الزراعة البينية علي الإنتاجية ومكوناتها وكمية الزيت لمحصولي زهرة الشمس والفول السوداني. نظمت المعاملات إحصائيا باستخدام تصميم القطع المنشقة مع القطاعات العشوائية الكاملة بأربعة مكررات. حيث وضع في القطع الرئيسية ثلاثة تواريخ زراعة (6/1 و1/ 7 و8/1) وفي القطع الثانوية نظام الزراعة البينية: حيث زرع المحصول الواحد بمفرده والمحصولين مع بعض في زراعة بينية (صفان من الفول السوداني يَتناوبانِ مع صفين من زهرة الشمس). أظهرت النتائج أن التداخل بين تاريخ الزراعة والزراعة البينية كان له تأثير معنوي على مكونات الإنتاج والإنتاجية وكمية الزيت لكلا المحصولين في كلا الموسمين. أعلى إنتاجية بذور تحققت للزراعة البينية لزهرة الشمس ولمحصول الفول السوداني منفردا عند زراعتهما في تواريخ الأول من يونيو والأول من أغسطس على التوالي. أعلى نسبة زيت تحققت لمحصولي زهرة الشمس منفردا وللزراعة البينية للفول السوداني عند ما نفذت الزراعة بتاريخ الأول من أغسطس. قيمة مؤشر نسبة الأرض المكافئ أعلي من الرقم واحد في كل تواريخ الزراعة، وتاريخ أول يونيو أعطي أفضل مكافئ في الموسمين علي التوالي. للحصول على أعلى إنتاجية بذور ونسبة زيت لمحصولي زهرة الشمس والفول السوداني توصي الدراسة بأن الأول من يونيو والأول من أغسطس هي الأمثل لزراعة محصولي زهرة الشمس والفول السوداني علي التوالي في البيئة الصحراوية بشمال السودان, كما توصي أيضا بأن الزراعة البينية لزهرة الشمس والفول السوداني في أول يونيو هي الأفضل في استغلال الأرض.