Effects of mixed cropping with cowpea and nitrogen source on growth and yield of sunflower (*Helianthus annuus* L.)

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ABSTRACT

Field experiments were conducted during winter (2011/12) and summer (2012/13) seasons. The objective of the study was to examine the effects of mixed cropping with cowpea, nitrogen and chicken manure on growth and yield of sunflower. Randomized complete block design with four replicates was used. The experiment comprised 8 treatments; two sunflower cultivars namely, Hysun33 and Damazin-1, and three nitrogen sources *viz*: mixed cropping with cowpea, urea (43kgN/ha), chicken manure (5t/ha) plus control. Results showed that the two cultivars were significantly different in plant height, days to 50% flowering, 1000-seed weight and empty seed percentage in both seasons. Hysun33 had taller plants, late to flower, heavier seeds and lower empty seeds percentage than Damazin-1. They were also significantly different in LAI, head diameter, number of filled seeds/ head and total yield in the summer season only. Fertilizers significantly influenced plant height and stem diameter in both seasons. In the winter season, however, fertilizers had significantly affected LAI, days to 50% flowering, head diameter, number of filled seeds/head and total yield. Chicken manure resulted in the tallest plants and largest stem diameter in both seasons. Chicken manure expressed the largest LAI, biggest head diameter, highest number of filled seeds/head and highest total yield. The three-way interaction(seasonx fertilizerx cultivar) showed significant effects on percentage of empty seeds and total yield. The highest total yield was obtained by Hysun33 in the summer season when chicken manure was applied. The mean total yield of the summer season was higher than that of the winter season. To obtain high total yield of sunflower, it is recommended that sowing should be commenced during the summer season and chicken manure should be applied at the rate of 5 t/ha for both Hysun33 and Damazin-1.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) ranks third after soybean and rape seed with an area of 23 million ha in the world (Seiler *et al*., 2008). In the Sudan, the extensive production of sunflower was initiated by the private sector in the mid 1980's with the introduction of hybrids: Hysun, Seedtec and PAN-7351 (ElAhamdi, 2003; Nour *et al*., 2005). The total area cultivated in the Sudan (1987/88) was about 63000 ha grown under rainfed conditions increased to 146000 hactres in 1988/89 (Ishag, 1988). Lately, the irrigated agricultural schemes of Gezira, New Halfa and Elsuki have become sunflower production areas (Mohamed *et al*., 2005; Ahmed, 2013). In season 2008/09, the area under sunflower cultivation in the Sudan was increased to 304166 ha (Ministry of the Cabinet Central Bureau of Statistics, 2009).

Khashmelmous (2004) reported that the optimum level of fertilizer for irrigated sunflower at Sennar was 40 kg N/fed.+20 kg P/fed. Mohamed *et al*. (2003) concluded that increasing nitrgen increased seed yield of sunflower at Gezira. Similar results were recorded for New Halfa by Ali (2000). The large quantities of chicken manure (C.M) produced every year from the growing poultry industry in the Sudan encourage its use as fertilizer. C.M is an excellent organic fertilizer to improve soil physical and chemical properties and fertility. It contains all the essential nutrients necessary for increasing crop yield and quality (Gabir, 1984).

Intercropping is planting two or more crops simultaniously on the same piece of land to promote their interaction and maximize their productivity by avoiding dependence on only one crop (Sullivan, 2003). For instance, cowpea can fix nitrogen through the mutual living rhizobia and can provide nitrogen to cereal crops grown in rotation especially in areas with poor soil fertility. Information about suitable crop mixtures and chicken manure and their effect on seed yield of sunflower in the irrigated sector is meager. Therefore, the objective of this study was to examine the effects of mixed cropping with cowpea and nitrogen source on growth and yield of sunflower.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan. Latituade 14 6 N, longitude 33 38 E and altitude 406 masl, for two seasons, winter of (2011) and summer of (2012) to examine the effects of mixed cropping with cowpea and nitrogen source on growth and yield of sunflower. The soil of the experimental site is typical sulemi soil series, dark brown, deep cracking clays with very low permeability when moist. Soil pH ranges from 7.9–8.4, nitrogen 0.03% and available phosphorus ranges from 4.3–6.9 mg/kg of soil. The soil is non-saline and non- sodic (Soil Survey Staff, 1999).

Seeds of the two sunflower cultivars Hysun33 and Damazin-1 were obtained from the Central Trade Company (CTC) and Faculty of Agriculture and Natural Resources, University of Gezira, respectively. The experiment comprised 8 treatments, two sunflower cultivars namely: Hysun33 and

Damazin-1 and three nitrogen sources, *viz*:Mixed cropping with cowpea, urea fertilizer, chicken manure plus control. Randomized complete block design with four replicates was used. The plot size was 4x5m. The experimental site was disc ploughed, harrowed, leveled and ridged into 80 cm apart. Intra-row spacing was 25cm. Chicken manure at the rate of 5 t/ha was broadcast and incorporated manually by a rake.

Nitrogen (43kg/ha) in form of urea was applied manually at sowing. Mixed cropping was carried out by mixing the seeds of sunflower (2 kg/ha) with seeds of cowpea (10 kg/ha), then the mixed seeds were sown manually at a rate of 4–8 seeds/hole. Seeds of sunflower cultivars were sown 3–5 seeds/hole. Sowing was carried out on the 28th November 2011 and 20th July 2012 for winter and summer seasons, respectively. The field was irrigated immediately to ensure establishment and subsequent irrigations were given at two weeks intervals. Plants were thinned four weeks later to one plant/hole and two plants /hole (one plant for sunflower and cowpea each) for the pure and mixed cropping, respectively. Weeds were checked manually. Insect and disease control measures were not undertaken.

Data were collected at random from the two inner rows. Growth measurements consisted of plant height (cm), stem diameter (cm), leaf area index(LAI) and days to 50% flowering. Yield components were head diameter (cm),1000-seed weight(g), number of filled seeds/head, empty seeds percentage and seed yield (t/ha).

RESULTS AND DISCUSSION

Main effects of cultivar and nitrogen source on growth attributes of sunflower in winter and summer seasons are presented in Tables 1 and 2. Significant ($p<0.05\%$) differences were detected between Hysun33 and Damazin-1 for plant height and days to 50% flowering in both seasons. Hysun33 had the tallest plants. While, Damazin-1 flowered earlier than Hysun33 by 2 and 4 days during winter and summer seasons, respectively (Tables 1 and 2). These results were in line with Daffalla *et al.* (2013) and Abdelrahman *et al*. (2014) in Sudan who concluded that Hysun33 had taller plants than Damazin-1. Khanna(1972) indicated that sunflower varieties significantly differed from each other with regard to plant height. In a field trial in Agadi farm Blue Nile State, Sudan AAAID (1986) reported that some hybrids were significantly taller than open-pollinated varieties.

Table 1. Main effects of cultivar and nitrogen source on growth attributes of sunflower winter season, (2011/12).

Treatment	Plant height (cm)	LAI	Stem dia. (cm)	Days to 50% flowering
		Cultivar		
Hysun33	127.0 a	2.8 a	5.1 a	70.3 a
Damazin-1	108.5 b	2.5 a	5.1 a	67.8 b
Nitrogen source				
Chicken manure	143.5 a	4.1 a	6.8 a	68.6 b
Urea	125.1 b	2.8 b	5.7 b	67.6 c
Mixed cropping	101.5 c	2.0 c	4.1 c	69.1 b
Control	101.1 c	1.8 c	4.0 c	70.8 a
SE±	7.49	0.5 3	0.39	0.54
CV%	12.71	39.75	15.6	1.56

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

Irrespective of nitrogen source, nitrogen fertilizer significantly ($P< 0.05$) increased plant height and stem diameter of sunflower cultivars in both seasons (Tables 1 and 2). The tallest plants and thickest stems were obtained by chicken manure and the shortest plants and thinner stems were recorded for the control and mixed cropping. This could be explained partially by the

competition for the essential requirements i.e. nutrients, water, light….*etc.* between sunflower and cowpea. These results were in line with those of
Ahmed and Jabeen (2009) in Egypt who reported that organic manure significantly increased plant height and stem diameter of sunflower. However, Adebayo *et al*. (2012) found non-significant effects of organic amendments on plant height and stem diameter of sunflower compared to the control.

Table 2. Main effects of cultivar and nitrogen source on growth attributes of sunflower summer seasons, (2012/13).

Treatment	Plant height (cm)	LAI	Stem dia. (cm)	Days to 50% flowering
		Cultivar		
Hysun33	177.6 a	3.5 b	6.8 a	64.4 a
Damazin-1	163.8 b	4.6 a	6.6 a	59.8 b
Nitrogen source				
Chicken manure	181.9 a	5.0 a	7.1 a	60.3 a
Urea	174.1 b	4.1 a	7.3 a	61.4 a
Mixed cropping	169.4 c	3.6 c	6.4 b	63.0 a
Control	157.4 c	3.5 c	6.0 b	63.8 a
SE±	6.29	0.66	0.29	1.6
CV%	7.37	32.8	8.7	5.2

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

Nitrogen fertilizers had significant (P<0.05) effects on days to 50% flowering. Sunflower plants which received chicken manure were earlier to flower by 2 and 4 days compared with the control during winter and summer seasons, respectively.

The main effects of cultivar and nitrogen source on yield components and total yield of sunflower are shown in Tables 3 and 4. Hysun33 and Damazin-1 were significantly different with regard to 1000-seed weight and empty seed percentage in both seasons. While they were significantly different in head diameter, number of filled seeds/head and total yield in the summer season only. Hysun33 had heavier seeds and lower empty seeds percentage than Damazin-1. Hysun33 had more total yield than Damazin-1 in the summer season.

This could be attributed to the bigger head diameter, high number of filled seeds and lower empty seed percentage of Hysun33 compared to Damazin-1.These results agreed with those reported by Ali *et al*.(2003), Daffalla *et al*. (2013) and Abdelrahman *et al*.(2014) working with sunflower in the Sudan, who reported that Hysun33 had lower empty seed percentage, heavier seeds and higher total yield than Damazin-1.

Nitrogen fertilizer source had significant (P<0.05) effects on yield components and total yield of sunflower in the winter season only (Table 3). The bigger head diameter, heavier seeds, higher number of filled seeds and high seed yield were obtained when chicken manure was applied (Table 3). These results were in accord with those of Ahmed and Jabeen (2009), Kulkarni *et al*. (2002) and Adebayo *et al*. (2012) in Nigeria who concluded that addition of organic amendments significantly increased total yield of sunflower.

Table 3. Main effects of cultivar and nitrogen source on yield components and total yield of sunflower winter season, (2011/12).

Treatments	Head diameter (cm)	1000-seed weight (g)	Number of fille seed/head	Empty seed (%)	Total yield (t/ha)
		Cultivar			
Hysun33	10.2 a	47.2 a	444.2 a	21.4 b	4.3 a
Damazin-1	10.4 a	41.4 b	444.7 a	29.7 a	4.4 a
Nitrogen source					
Chicken manure	12.6 a	50.4 a	636.4 a	26.8 a	6.1 a
Urea	10.6 b	41.1 c	500.4 b	25.6 a	5.0 b
Mixed cropping	9.0 c	43.2 b	305.1 d	21.2 a	3.1 c
Control	8.9 c	42.4 bc	329.9 c	28.8 a	3.3 c
SE±	0.8	2.7	60.4	3.2	0.6
CV%	15.8	12.2	27.3	24.8	27.7

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

Table 4. Main effects of cultivar and nitrogen source on yield components and total yield of sunflower (summer season, (2012/13).

Treatments	Head diameter (cm)	1000-seed weight (g)	Number filled seed/head	o Empty seed (%)	Total yield (t/ha)
		Cultivar			
Hysun33	15.0 a	50.4 b	1120 a	15.5 b	11.2 a
Damazin-1	14.1 b	54.9 a	856.6 b	25.4 a	8.6 b
Nitrogen source					
Chicken manure	15.1 a	51.7 a	1104.6 a	19.1 a	11.0 a
Urea	15.0 a	54.2 a	954.3 a	24.6 a	9.5 a
Mixed cropping	14.4 a	53.3 a	967.1 a	18.3 a	9.7 a
Control	13.8 a	51.5a	927.8 a	19.9 a	9.3 a
SE+	0.68	3.7	85.5	3.1	0.9
CV%	9.4	14.0	17.3	30.6	17.3

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

The combined analysis of the three-way interaction between season x fertilizer x cultivar had a significant ($P<0.05$) effect on empty seed percentage in both seasons (Table 5). Although not significant, Hysun33 had lower empty seed percentage (21% and 16%) than Damazin-1(30% and 25%) during winter and summer seasons, respectively. Seasonality had a significant effect on percentage of empty seeds. It was observed that empty seed percentage in the summer season was lower than the winter season for both sunflower cultivars (Table 5).

Table 5. Interaction effects of season, cultivar and nitrogen source on empty seeds percentage (%) of sunflower in winter (2011/12) and summer (2012/13) seasons.

Treatments	Winter			Summer		
Nitrogen source	Hysun33	Damazin-1	Mean (Ns)	Hysun33	Damazin-1	Mean (Ns)
Chicken manure	21.5e	32.1a	26.8A	14.7f	23.6de	19.1A
Urea	26.4c	24.8cd	25.6A	15.7f	33.5a	24.6A
Mixed cropping	13.3f	28.9b	21.2A	15.6f	21.0e	18.3A
Control	24.4cd	33.1a	28.8A	16.1f	23.7de	19.9A
Mean (CV)	21.4A	29.7A		15.5A	25A	
Mean (S)		25.6A			20.5B	
C.V. %			27.37			

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

Table 6 shows the effect of the three-way interaction on total yield of sunflower. Total yield of the two cultivars was higher in the summer than in the winter season. This could be due to the larger LAI (Table 2), larger head diameter, higher number of filled seeds/head, heavier seeds (Table 4) and lower percentage of empty seeds (Table 6) during summer season. These results were inconsistent with those reported by Mohamed *et al.*(2005) who stated that the total yield of Hysun33 and Damazin-1 was higher in the winter than in the summer season.

Table 6. Interaction effects of season ,cultivar and nitrogen source on total yield (t/ha) of sunflower in winter (2011/12) and summer (2012/13) seasons.

Treatments	Winter			Summer		
Nitrogen source	Hysun33	Damazin-1	Mean (Ns)	Hysun33	Damazin-1	Mean (Ns)
Chicken manure	4.9a	7.4a	6.1A	12.6 a	9.5a	11.0 A
Urea	4.5a	5.5b	5.0B	10.8b	8.3b	9.5B
Mixed cropping	4.1ab	1.9 c	3.1C	10.7b	8.6b	9.7B
Control	3.8b	2.8 c	3.3C	10.7b	7.9 c	9.3B
Mean (CV)	4.3C	4.4C		11.2A	8.6B	
Mean (S)		4.4B			9.9A	
C.V. %			20.77			

Means followed by the same letter(s) in columns are not significantly different at 0.05 level of significance according to Duncan's Multiple Range Test.

CONCLUSIONS

Higher total yield of both sunflower cultivars Hysun33 (hybrid) and Damazin-1(open-pollinated) was obtained during the summer season. The higher seed yield was obtained by Hysun33 compared with Damazin-1. The highest seed yield of sunflower cultivars was obtained when chicken manure was applied at the rate of 5 t/ha.

RECOMMENDATION

To obtain high total yield of sunflower it was recommended that sowing of the two cultivars should be commenced during the summer season and chicken manure at the rate of 5 t/ha should be applied.

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تأثير الزراعة المختلطة باللوبيا الحلو ومصدر النتروجين على نمو وإنتاجية زهرة الشمس (*Helianthus annuus* L.)

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الخلاصة

أجريت هذه الدراسة خلال شتاء (12/2011) وصيف (13/2012) بهدف معرفة تأثير الصنف ومصادر النتروجين المختلفة على نمو وإنتاجية زهرة الشمس. تم استخدام تصميم القطاعات العشوائية الكاملة بأربعة مكررات. شملت التجربة 8 معاملات صنفين من زهرة الشمس، هايصن33 ودمازين-1 وثلاثة مصادر نتروجين، الزراعة المختلطة باللوبيا الحلو وسماد اليوريا وسماد الدواجن زائداً الشاهد. أظهرت النتائج فروقاً معنوية بين صنفي زهرة الشمس في طول النبات، وعدد الأيام لـ 50% إزهار، ووزن الألف بذرة، ونسبة البذور الفارغة في كلا الموسمين. تفوق الصنف هايصن33 في طول النبات، ووزن البذور على الصنف دمازين-1 كما كان متأخراً عنه في النضج وأقل منه في نسبة البذور الفارغة. كما أظهر الصنفان اختلافاً معنوياً في دليل مساحة الورقة، وقطر القرص، وعدد البذور المليئة بالقرص وإنتاجية البذور في موسم الصيف فقط. سماد الدواجن واليوريا كان لهما أثراً معنوياً على طول النبات وسمك الساق في كلا الموسمين. كما كان لهما أثراً معنوياً على دليل مساحة الورقة وعدد الأيام لـ50% إزهار وقطر القرص ووزن الألف بذرة وعدد البذور المليئة بالقرص وإنتاجية البذور في الموسم الشتوي فقط. أظهر سماد الدواجن تفوقاً معنوياً في طول النبات وقطر الساق في كلا الموسمين. كما كان متفوقاً على بقية المعاملات في دليل مساحة الورقة وقطر القرص وعدد البذور المليئة/النبات وإنتاجية البذور. أظهرت الزراعة المختلطة تأثيراً معنوياً على عدد الأيام إزهار ودليل مساحة الورقة ووزن الألف بذرة وقطر القرص وعدد البذور المليئة/القرص وإنتاجية لـ 50% البذور في الموسم الشتوي فقط. لم تظهر مصادر الاسمدة المختلفة أي تأثير معنوي على نسبة البذور الفارغة في كلا الموسمين. كان للتداخل بين الأسمدة والمواسم والأصناف تأثيراً معنوياً على نسبة البذور الفارغة وإنتاجية البذور. حقق الموسم الصيفي أعلى إنتاجية بذور مقارنة بالموسم الشتوي. للحصول على أعلى إنتاجية لبذور زهرة الشمس يوصى بزراعة هايصن33 و دمازين-1 في موسم الصيف مع إضافة 5 طن/هكتار من سماد الدواجن.