Water stress in four Sunflower (*Helianthus annuus* L.) cultivars. 2. Effect of different Irrigation intervals on yield and yield Components

الإجهاد المائي في أربعة أصناف من زهرة الشمس (*Helianthus annuus* L.) 2. تأثير فترات الري المختلفة على المحصول و مكوناته

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الخلاصة

أجريت هذه التجربة خلال موسمين متتالين (2004/2003 و 2005/2004) وذلك لدراسة تأثير فترات مختلفة من الري (10 ، 15، 20 يومًا) على الإنتاجية ومكوناتها لأربعة أصناف من نبات زهرة الشمس.

توصلت النتائج إلى أن الري كل 10 أيام أدى إلى زيادة معنوية في وزن الألف حبة. بينما أدى الري كل 15 يوم إلى زيادة معنوية في إنتاجية الحبوب، إنتاجية الزيت، نسبة الزيت في الحبوب ووزن الحبوب في القرص بالمقارنة مع باقي المعاملات.

أوضحت النتائج بأن الصنف هايسن – 33 والصنف هنغاريان – (أ) تفوقا معنويًا على باقي الأصناف في إنتاجية الحبوب، إنتاجية الزيت، وزن الحبوب في القرص، عدد الحبوب في القرص، قطر القرص، ووزن الألف حبة. بينما تفوق معنويًا كلٌّ من الصنف روديو وبرودوفيك على باقي الأصناف في نسبة الزيت في الحبوب. أظهرت النتائج أن الفعل المتبادل بين الري كل 15 يومًا والصنف برودوفيك أدى إلى زيادة معنوية في نسبة

الزيت في الحبوب. بينما أدى الفعل المتبادل بين الري كل 15 يومًا والصنف هايسن-33 إلى زيادة معنوية في كل من إنتاجية الحبوب، إنتاجية الزيت ووزن الحبوب في القرص. ومن ناحية ثانية أدى الفعل المتبادل بين الري كل 10 أيام والصنف هايسن-33 إلى زيادة معنوية في عدد الحبوب في القرص. أما التعامل بين الصنف هنغاريان-(أ) والري كلَّ 20 يومًا فقد أدى إلى زيادة معنوية في وزن الألف حبة.

كما أشارت النتائج إلى أن فترات الري والاختلافات بين الأصناف والتفاعل بينهما لم يكن له أي تأثير معنوي على صفات محصول التبن في الفدان، دليل المحصول ودليل الحصاد. وذلك لأن موسم الشتاء، وبخاصة عندما تكون درجة الحرارة منخفضة، من المتوقع ألا يكون هنالك فرق بين الري كلَّ 10 و 20 يوم.

ABSTRACT

Two field experiments on sunflower (*Helianthus annuus* L.) were carried out at the demonstration Farm, Faculty of Agriculture, Omdurman Islamic University, during the 2003-2004 and 2004-2005 seasons. Plants were grown on sandy clay loam soil, to investigate the effect of different irrigation intervals on yield and yield components.

The results revealed that irrigation every 10 days caused a significant increase of the 1000- seed weight, whereas, the fortnightly irrigation increased significantly seed yield, oil yield, oil percentage in seed, seed weight per head and seed number per head compared with other treatments.

The results showed that *Hysun-33* and *Hungarian-A cultivars* surpassed the other cultivars significantly in seed yield, oil yield, seed weight per head, seed number per head, head diameter and 1000–seed weight. However, *Rodeio* and *Peredovik* cultivars surpassed the other cultivars significantly in oil percentage per seed.

The interaction between irrigation every 15 days and Peredovik cultivar increased significantly the oil percentage in seed. On the other hand, the interaction between irrigation every 15 days and Hysun-33 *cultivar* increased significantly seed yield, oil yield and seed weight per head. However, the interaction between irrigation

every 10 days and Hysun-33 increased seed number per head significantly, whereas, irrigation of Hungarian –A every 20 days increased significantly of 1000–seed weight.

There was no significant effect for the irrigation intervals, varietals differences and the interaction between them on straw yield, crop index and harvest index. Irrigation interval as expectedly will not have a significant effect in winter, especially if temperature is low.

0. INTRODUCTION

The productivity of sunflower is greatly influenced not only by variety, but also by environmental conditions, temperature, irrigation regime and soil fertility. A strong relationship was found between oil quality and temperature during the period from flowering to harvest. Low night temperature gave high linoleic acid content, whereas high temperature, on the contrary, produced an increase in oleic acid content (Harris 1978: 12-3-1212; Canvin 1965: 63-69).

In Sudan, sunflower is relatively a new crop in terms of production, breeding programmes, irrigation treatments and crop management. It can be grown on a wide range of soils, varying in texture from sand to clay (Heiser 1976), where good drainage is more important than basic fertility. In general, Weiss (1983) found that soils with high sand content produced higher yields than more clay soils in the same area and under similar husbandry practices (Weiss 1983:402).

Sunflower grows well on soils with a range of pH 6.5 to 8.0 neutral to moderately alkaline, and not on acidic and poor drained soils, which increase susceptibility to fungal disease and lodging (Weiss 1983).

In Sudan, Skoric (1983) and Hassan (1987:55-64) suggested that central clay plains are best suited for sunflower growth, while Mahmoud (1987) found

that it grows well on heavy cracking vertisols, which are rich in potassium and phosphorous, and that sandy soils indicate problems of crop establishment.

The response of sunflower varieties to water supply regime is considered to be an important factor affecting yield. Many investigators studied the effect of irrigation treatment on yield and its components of sunflower plant. They found that the maximum seed yield, and therefore total oil yield, was produced by the maximum availability of water in the roots zone (Pal and Yadav 1974: 157-61). However, Robinson (1978) found that in a sand loam soil, with permanent wilting percentage of 8.6%, sunflower germinated 73% at 8% soil moisture and 89% at 9% soil moisture.

In Sudan, Khalifa (1989:213) observed higher germinability of sunflower under dry farming than under irrigated system. In Egypt, Talha (1976) mentioned that irrigation at 15 days interval produced the highest seed yield. Soil water stress has been shown to decrease sunflower yield. Taha and Osman (1975) reported that a significant decrease in yield, 100 – seed weight and oil content occurred when soil moisture stress was imposed during the elongation and flowering stage. Hang and Evans (Hang and Evans 1985:588-592) found out that moisture stress caused early maturity and decreased seed yield.

Lazim (1984) mentioned that yield and yield components were highly affected by water stress, having found that some growth stages were more sensitive than others. Twenty days, before and after flowering, were discovered to be highly sensitive to water stress (Robelin 1967; Rolier:1975).

The greatest yield reduction was obtained by Stegman and Lemet (1981) when stress was imposed in the bud-last anthesis stage and least in sowing-bud period. El- Naim (1992) found that water stress occurring at any growth stage reduced seed yield.

Sionit et al. (1973), Karami (1977:15-17) and Lazim (1984) reported that, under water stress, plants produced smaller heads. These results confirmed the findings of Human (1990:231-241) and (Chiaranda and Andria 1994: 35-63) to the same effect.

More and Palmer (1976:101-104) and Yegappan (1982:69-75) found decrease in head diameter when plants were stressed at flowering, while Flenent (1994:96-105) found reduction in head weight when plants were stressed at maturity. Teama and Mahmoud (1994:21-25) mentioned that water stress, before flowering, gave the greatest reduction of head diameter as contrasted with that at flowering and /or maturity stage.

Sionit et al. (1973) noticed that as the soil water stress potential decreased, the number of seeds produced also decreased. Goyre (1978: 129-134) mentioned that yield was more highly correlated with the number of seeds per head than with seed weight, and that the primary effect of water stress around anthesis was on seed set per head. Kahan and Hussain (1996) found that different soil moisture depletions and fertilizer level had significant effect on the number of achene per head.

El-Mahadi (1990) mentioned that irrigation intervals had no significant difference on 1000 seed weight, whereas he (*op. cit*.), and Ravishankar (1990:408-410) observed reduction in 100-seed weight especially under water stress (41-71 days after sowing). However, Chiarandra and D. Andria et al (1994) found significant yield losses related to reductions in 1000-seed weight caused by less amount of water. That is, while the work of Khan and Hussain (1996) showed the adverse effect of deficit soil moisture on 100-seed weight, and that of Andrich et al. (1996:285-291) found that all cultivars tested were affected by water shortage, whereas those with higher mean achene weight seemed to be more drought resistant. In addition Flenent (1994:96-105), found

that at maturity seed weight was significantly reduced after stress. Osman and Talha (1975) noted that the weight of produced seeds, 100-seed weight, and the yield of oil were increased as the irrigation amount and frequencies increased. On the other hand, Karami (1977:15-17) found that increasing the irrigation intervals reduced seed yield, 100-seed weight, harvest index and seed oil content. Similar results were found by El–Hinnawy et al (1981), Deshmukh and Srivastava (1982:396-933). The results obtained by Rawson and Turner (1982) and Serieys (1982) showed that seed production increased according to the increase in the number of irrigations supplied.

In the work of Ravishankar (1990:215-218), average seed yield was reduced especially under early stress (41-71 days) from sowing. Mozoffari (1997:1037-1039) found that the seed yield was highly sensitive to water stress, while Flenent (1997:306-312) reported no significant differences in seed yield between the control and that stressed from start of heading to when the head measured 5 cm, whereas the yield was reduced then the stress imposed at the growth stage but by varying percentage.

Teama and Mahmound (1994) reported that the seed per plant ratio was reduced when plants were stressed during flowering, and that the seed yield per area ratio was decreased mostly when water stress was imposed during the vegetative, flowering and maturity stages. Radringuez (1996:418-410) reported that seed yield was not strongly affected by soil water deficit at the flowering and seed filling stages. However El–Naggar (1991:80-82) gave higher yields by irrigation treatments, the best being with irrigation every 14 days.

Prunty (1983:745-749) and Rawson and Turner (1983:437-448) found that seed and oil yields, 1000- seed weight and percentage of oil in the seed of sunflower, increased significantly when irrigation rates were increased. Several investigators concluded that yield and growth of sunflower varied between

cultivars. Tomoroga and Simota (1974:569-757) concluded that the varieties varied in both seed and oil yields.

Human (1990:231-241), on the one hand, reported that moderate and severe water stress during budding significantly reduced oil yield. Teama and Mahmoud (1994), on the other hand, found that the greatest reduction in oil percentage was obtained when water stress was imposed during the maturity stage, while Nandhagobal (1996:152-154) stated that skipping irrigation at the flowering stage gave the lowest seed oil content.

Sunflower, generally, is characterized by having low harvest index (HI), compared to other crops (Donald and Humblin 1977:361-405; Thompson and Fenton 1979:570-574; English 1979:149-164). Teama and Mahmoud (1994) found that HI, on the one hand, was low in well watered plants as well as when they were stressed from the point when the heads measured 5 cm to maturity. and that, on the other hand, it was high when the plants were stressed from the start of heading to when the heads measured 5cm, as well as when the plants were stressed from the start of heading to prematurity.

1. MATERIALS AND METHODS

Two field experiments on sunflower (*Helianthus annuns* L.) were carried out at the demonstration farm, Faculty of Agriculture, Omdurman Islamic University, during the seasons 2003/2004 and 2004/2005 to investigate the response of some sunflower cultivars to irrigation interval treatments .The soil was generally sandy clay loam, non-saline and non-sodic, pH (7.8). The experiment design was split– plot in four replicates. The treatment was a combination of four sunflower cultivars (Peredovik, Rodieo, Hysun -33 and Hungarian–A) and three irrigation intervals (every 10, 15 and 20 days). The sunflower seeds, obtained from Medani Research Station, were sown in the first week of November for two seasons. The plot area was 21 m^2. Each plot included

5 ridges, 70 cm apart, and each ridge was 6 m in length. The irrigation treatment pattern was applied 20 days after sowing.

For the seasons, analysis of variance was performed, and means were compared, using Least Significant Difference (LSD; Gomez and Gomez 1984).

2. RESULTS AND DISCUSSION

The results presented in **Table 1** revealed that the seed yield, oil yield, oil percentage, seed weight per head and seed number per head increased significantly, when plants were irrigated every 15 days, as compared with 10 or 20 days irrigation intervals.

Fortnightly irrigation is a suitable system to save the maximum water availability in the root zone without marked reduction in seed yield. In this regard, Talha (1976:49-56) reported that irrigation, at 15 days intervals, produced the highest seed yield. Furthermore, El Naggar (1991) mentioned that irrigation treatments gave higher yield, and were best, when irrigated every 14 days.

Also, the reduction in these characters by increasing the period between irrigations may be due to the harmful effect of water stress during heading and early following stage. In the, work of Teama and Mahmoud (1994:29–37), Khan and Hussain (1996), Flenent (1994:96-105), Mozoffari et al. (1997), Teama and Mahmoud (1994) and Nand Hagobal et al. (1996),.yield and its components were highly sensitive to water stress which caused the greatest reduction in these characters especially in seed yield, oil yield and oil percentage. Results of Yegappan et al. (1982) indicated that water stress also appears to reduce the supply of vascular tissue to all seed positions. This may help to explain why these characters were reduced. These results were in agreement with those of Pal and Yadav (1984), Osman and Talha (1975: 211-218), Karami (1977:15-17), EL-Hinnawy (1981:10), Deshmukh and

Srivastava (1982), Rawson and Turner (1983) and Kandil (1984), who found that increasing irrigation intervals reduced seed yield and percentage of oil in the seed.

Characters	Irrigation intervals			L.S.D at 5% level
	10 days	15 days	20 days	
Seed yield (kg) / fed	3170	3390	3179	98.15
Oil yield (kg) / fed	866	973	828	28.66
Oil percentage (%)	29	31	27	0.3
Seed weight / head (gm)	140.05	147	141	4.19
Seed number / head	1457	1568	1553	31.87
Weight of 1000-seed (gm)	86	84	82	1.57
Straw yield (kg) / fed	7376	8012	6898	N.S
Crop Index	0.28	0.31	0.32	N.S
Harvest index	0.42	0.46	0.48	N.S
Head diameter cm)	25	26	26	N.S

Table 1: Effect of irrigation intervals on yield and yield component of sunflower (Average of 2004 and 2005 growing seasons).

As shown in **Table 1** the weight of 1000-seed was increased significantly when sunflower plants were irrigated every 10 days. These results confirmed the findings of Osman and Talha (1975), Rawson and Turner (1982), Prunty (1983) and Serieys (1982), who noticed that 100-seed weight of sunflower increased significantly when irrigation rates were increased. There was no

significant effect of the irrigation intervals on straw yield, head diameter, Crop Index and Harvest Index (**Table 1**).

The data presented in **Table 2** indicate that Hysun-33 and Hungarian-A cultivars exceeded the other cultivars significantly in seed yield, oil yield, seed weight per head, seed number per head, head diameter, and 1000–seed weight. However, Rodeo and Peredovik cultivars surpassed the other cultivars significantly in oil percentage per seed.

The varietal differences were significant for all characters, seed yield, seed weight per head, oil content and oil yield (Tomoroga and Simota 1974: 569-574).

The superiority of these characters in one cultivar may be due to the fact that nectar flows varied between cultivars, as did the weight of sugar per flower and attraction of honeybee (Ilie 1980:418-423). Kandil (1984), also, suggested that these differences might be due to their genetical constituents. The number of disc florets in head of the cultivated sunflower which varies with gene type (Palmer and Steer 1985:1-12).

There was no significant varietal differences in straw yield, crop index and harvest index as shown in **Table 2**. On the other hand, there is no difference between Hysun-33 and Hungarin-A, or any noticeable between Rodeo and Peredovik.

On the one hand, the results in **Table 3a, b** revealed that the interaction between irrigation every 15 days and Hysun-33 cultivar increased seed yield, oil yield and seed weight per head significantly. On the other hand, the interaction effect between irrigation every 15 days and Peredovik cultivar increased significantly the oil percentage in seed. In addition, the interaction effect to irrigation every 10 days and Hysun-33 cultivar increased seed number per head

significantly. However, the interaction between irrigation every 20 days and Hungarian-A cultivar, significantly increased the weight of 1000-seed.

These differences between cultivars under different irrigation regimes may be due to the differences in their genotypes and resistance of Hungarian cultivar to drought or lack of irrigation more than other cultivars, which were more sensitive to lack of irrigation

It is clearly shown in the present investigation that the effect of the interaction between irrigation intervals and cultivars on straw yield, head diameter, crop index, and harvest index was not significant (**Table 3 a, b**). This is expected in winter, in particular, when temperature is low.

4. CONCLUSION

The results revealed that fortnightly irrigation significantly increased seed yield, oil yield, oil percentage, seed weight per head and seed number per head, as compared with other treatments, whereas irrigation every 10 days significantly increased 1000-weight.

Hysun-33 and Hungarian-A cultivars surpassed other cultivars significantly in seed yield, oil yield, and yield components, while Rodeo and Peredovik cultivars exceeded the others in oil percentage per seed.

The results showed that there was no significant effect for the irrigation intervals, varietals differences and the irrigation between them on straw yield, crop index and harvest index. As expected, irrigation intervals will not have a significant effect in winter, particularly when temperature is low.

Characters	VARIETY				L.S.D at 5% level
	Hysun-33	Hungarian-A	Rodeo	Peredovik	
Head diameter (cm)	0.29	0.29	0.22	0.22	1.3
Seed number / head	1806	1714	1309	1276	36.81
Seed weight / head (gm)	196	193	88	93	4.83
Weight of 1000-seed(gm)	104	106	63	64	1.81
Straw yield (kg) / fed	8758	8347	6670	6072	N.S
Oil yield (kg)/ fed	1094	1016.99	739.67	707.48	33.1
Oil percentage (%)	23.46	24.10	35.34	34.95	0.34
Seed yield (kg) / fed	4663.89	4221.00	2082.56	2019.33	113.33
Crop Index	0.36	0.31	0.26	0.27	N.S
Harvest index	0.57	0.45	0.38	0.39	N.S

Table 2: Varietal differences in yield and yield components of sunflower (Average of 2004 and 2005 growing seasons).

Characters	Varieties	Irrigation intervals		
		10 days	**15 days**	**20 days**
Seed number / head	***Hysun-33***	1985.00	1744.00	1691.00
	Hungarian-A	1570.00	1797.00	1774.00
	Rodeo	1127.00	1390.00	1409.00
	Peredovik	1145.00	1342.00	1340.00
L.S.D at 5 %		63.75		
Seed weight / head (gm)	***Hysun-33***	197.45	202.28	188.76
	Hungarian-A	182.74	197.15	200.58
	Rodeo	87.80	93.79	85.16
	Peredovik	92.20	97.31	91.19
L.S.D at 5 %		8.37		
Weight of 1000-seed (gm)	***Hysun-33***	107.77	107.71	97.28
	Hungarian-A	104.75	97.96	116.14
	Rodeo	68.67	65.46	55.75
	Peredovik	62.90	66.82	62.75
L.S.D at 5 %		3.13		
Seed yield / fed (kg)	***Hysun-33***	4729.00	4856.00	4406.00
	Hungarian-A	4055.00	4238.00	4369.00
	Rodeo	2032.00	2306.00	1908.00
	Peredovik	1866.00	2159.00	2032.00
L.S.D at 5 %		196.30		

Table 3a: Effect of interaction between irrigation intervals and varieties on yield and yield components of sunflower (Average of 2004 and 2005 growing seasons). Continued without interruption in 3b.

Characters	Varieties	Irrigation intervals		
		10 days	15 days	20 days
Oil yield / fed (kg)	***Hysun-33***	1103.52	1157.87	1022.31
	Hungarian-A	979.53	1048.92	1022.51
	Rodeo	746.84	872.74	559.45
	Peredovik	636.42	815.28	670.76
L.S.D at 5 %		57.32		
Oil percentage in seed	***Hysun-33***	23.34	23.86	23.20
	Hungarian-A	24.15	24.75	23.40
	Rodeo	36.75	36.84	31.42
	Peredovik	34.10	37.75	33.00
L.S.D at 5 %		0.60		

Table 3b: Effect of interaction between irrigation intervals and varieties on yield and yield components of sunflower (Average of 2004 and 2005 growing seasons). Continued without interruption from 3b.

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