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# Role of Irrigation Schedule and plant Spacing on Seed Yield and Oil Percentage of Sunflower Grown in Gezira Scheme, Sudan

*[1]Eman R.A Elsheikh and [2]Bart Schultz*

[1]Agricultural Research Corporation, Forestry Research Centre,
Arid Zone Research Section, Khartoum-Sudan
[2]UNESCO-IHE Institute of Water Education,
Land and Water Development, Delft, The Netherlands

**Abstract:** Sunflower (*Helianthus annuus*) is an important oilseed. The main source of feed for dairy cows and feed for birds, Sunflower meal is one of the major protein sources in livestock feed, especially dairy cattle, chickens and even pigs and rabbits. The experiments were conducted at Gezira Research Station to study the effect of three irrigation intervals (10, 15 and 20 days) and two intra-row plant spacing (30 and 40 cm) on seed yield and seed oil content in winter season. The results revealed that the highest seed yield (3300 kg/ha) was obtained from 10 days irrigation interval with plant spacing of 40 cm while the lowest one (1890 kg/ha) was observed from 20 days irrigation interval in both plant spacing. The results also showed that the highest oil percentage (40%) was obtained when Sunflower was irrigated every 10 days under both plant spacing in two seasons, while the lowest oil content percentage (38%) was obtained with prolonging irrigation intervals to 20 days.

**Key words:** Hysun 33 · Deficit irrigation · Plant spacing · Seed yield

## INTRODUCTION

Sunflower (*Helianthus annuus*) is an important oilseed crop that can be successfully grown in most regions of Sudan. Sunflower grows best on loam, silty loam, and silty clay loam soils with good drainage and low salinity. Most dairy farmers may not know the value of Sunflower as feed for dairy cows and even chickens. The main source of feed for dairy cows and feed for birds, Sunflower meal is one of the major protein sources in livestock feed, especially dairy cattle, chickens and even pigs and rabbits. It has a high protein, fiber and oil content. Protein percentage is between 29- 30%. Commercially available Sunflower varieties contain oil percentage ranged between 39 - 49%. In past few years Sunflower seed was the third largest source of vegetable oil worldwide, following soybean and palm. Sunflower world production amounted 14% of seed oils and about 7% of the oilcake and meal produced from oilseeds. The oil accounts for 80% of the value of the Sunflower crop, as contrasted with soybean which derives most of its value from the meal. Sunflower oil is generally considered a healthy oil due to its properties viz, light color, high level of unsaturated fatty acids and lack of linolenic acid, bland flavor and high smoke points. Sunflower oil is the preferred and is the sole oil used. The price of Sunflower oil usually prohibits its widespread use in industry, but there are several applications that have been explored, Sunflower oil is used commonly in the manufacture of soaps, cosmetic and detergents.

The agronomical practices involved in Sunflower husbandry (genotype, row spacing, irrigation, fertilization) affect yield by developing crop growth and biomass. In addition, intra-row plant spacing, sowing dates, sowing methods and seed rates are the most important factors that have great impact on final seed yield in Gezira Scheme. Intra-row plant spacing may affect the utilization of light, water and nutrients. In most cases these factors confounded by their effects on growth development.

Gezira Scheme (GS) is the largest agricultural irrigated scheme in Sudan, which lies between the Blue Nile and White Nile Rivers (Figure 1). It was designed to

**Corresponding Author:** Eman R.A Elsheikh, Agricultural Research Corporation, Forestry Research Centre, Arid Zone Research Section, Khartoum-Sudan. E-mail: emanoob@yahoo.co.uk.

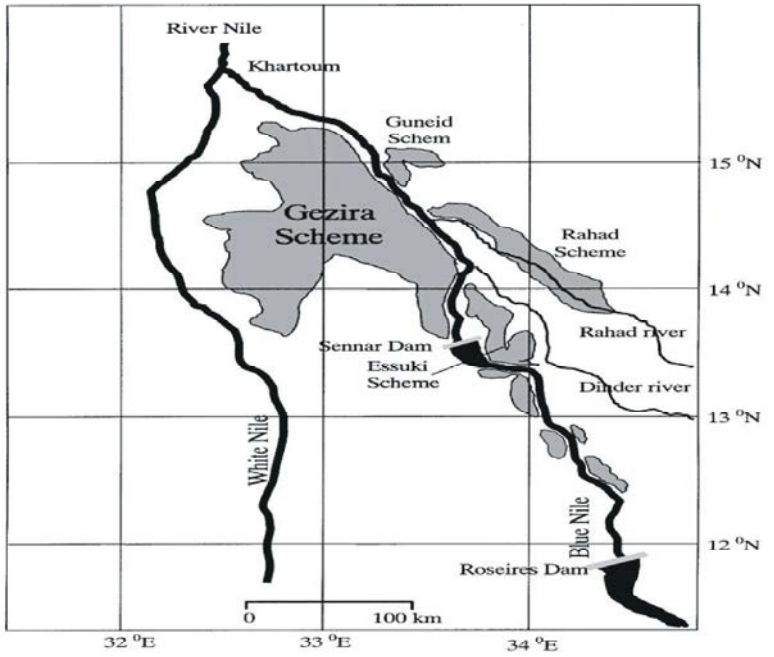


Fig. 1: Location of Gezira Scheme (Adapted from [1])

be irrigated by gravity from Sennar Dam on the Blue Nile, about 110 km south of WadMedani. GS has 47% of the total area under irrigated agriculture, produce 50% of domestic crop output [7]. Gezira Scheme is located between Latitude 14° 22 to 14° 25 N and Longitude 33° 29 to 33° 30 E in Gezira State in central Sudan. GRS lies under the responsibility of Agricultural Research Corporation (ARC) which is responsible for most of the research on agricultural problems in the Sudan. The Gezira area has three climatic zones, semi-desert in the north, dry in the centre and semi-dry in the south [2]. The Gezira clay soil lies within the dry zone. The maximum temperature ranges from 34°C in January to 41 - 42°C in April and May, while the minimum temperature range from 14°C in Jan to 25°C in June. The objective of this study was to evaluate the effect of three irrigation intervals of 10, 15 and 20 days and two plant spacing of 30 and 40 cm on seed yield and oil content.

Table 1: Analysis of soil chemical and physical properties of the experimental field

| Depth cm | 0 - 30 | 30 - 60 | 60 - 90 |
|---|---|---|---|
| Clay (%) | 58 | 60 | 54 |
| Silt (%) | 25 | 28 | 31 |
| Sand fine (%) | 13 | 9 | 7 |
| Sand coarse (%) | 4 | 3 | 3 |
| BD (g/cm$^3$) | 1.60 | 1.52 | 1.78 |
| FC (%) | 38.2 | 45.9 | 41.9 |
| PWP (%) | 20.7 | 24.9 | 22.8 |
| OM (%) | 0.34 | 0.31 | 0.13 |
| pH | 7.9 | 8.1 | 8.0 |
| Hydraulic conductivity (cm/hr) | 2.23 | 2.61 | 0.22 |
| $CaCO_{3\%}$ | 5.2 | 4.8 | 5.0 |
| ECE (dS/m) | 0.66 | 0.68 | Na |
| ESP | 9 | 15 | 14 |
| CEC cmol./kgsoil | 46 | 45 | 37 |
| Av.P mg/kg soil | 3.2 | 2.4 | 2.8 |
| N% | 0.050 | 0.045 | 0.040 |

Source: Land and Water Research Centre Laboratory 2012. Note na: not available.

## MATERIALS AND METHODS

The experiment was designed as a split plot experiment, with three replications, each sub plot was 10 m of length and 5 m of width (total area was 50 m$^2$) with 6 rows. The experimental treatment was three irrigation intervals 10, 15 and 20 days designated as W1, W2, W3 and two intra-row plant spacing 30 and 40 cm specified as S1 and S2. Seeds of sunflower variety Hysun 33 (Hybrid) was used. The crop was sown in the third week of November, 2012 and in the first week of December, 2013 in the first and second season respectively. The total number of plots was 18. Three seeds were sown per hill and then thinned to one plant two weeks in the first season and three weeks in the second season after emergence; all other agronomic practices were kept uniform for all the treatments. The amount of water

Applied for each treatment was measured during the two growing seasons by using current meter. Weeds were controlled manually three times during the two growing seasons. Harvest was done manually during the second week of March in the first winter season 2012/2013 and during the end of March in the second season 2013/2014. Fertilizers in form of Urea were added during the experiment as required to maintain soil fertility. Statistical analysis was done by using Statistix 9 computer software program. The difference of means was identified by standard error at ($P \leq 0.05$) level according to Tukey's HSD. Table 1 shows the chemical and physical properties analysis of the experimental field.

## RESULTS AND DISCUSSION

The number of filled seeds per head is an important parameter to evaluate the seed yield of Sunflower, because it is considered as a direct factor. Results showed significant differences in the number of filled seeds per head among irrigation treatments and intra-row plant spacing (Table 2). The highest seed yield was obtained from increased number of irrigation due to increase available soil moisture in the root zone [16] and [9]. A reduction in seed yield under irrigation 20 days interval was variable owing to confounding with other environmental factors such as water stress. Seed yield was determined under different irrigation intervals to assess the effect of water stress during the different growth stages on final seed yield. There was a direct relationship between number of irrigation water supplies and seed yield [19]. Table 2 demonstrates the results of statistical analysis and interaction of different irrigation regimes with two plant spacing on seed yield and number of filled seed for the two growing seasons. The irrigation interval of 10 days and intra-row plant spacing of 40 cm had the highest number of filled seeds. Overall full irrigation increased the number of seeds per head by 11% and 24% compared to the 15 and 20 days interval. Moreover, results concluded that the number of filled seeds increased linearly with each increase in irrigation frequency. The highest seed yield (3300 kg/ha) was recorded from 10 days irrigation interval with plant spacing of 40 cm while the lowest one ( 1890 kg/ha) was observed from 20 days irrigation interval in both plant spacing.

The results showed that water deficit at flowering stage needs to be avoided while at seed formation it is somewhat acceptable [10]. Water stress at different crop development stages can affect final seed yield and oil content [14]. It was found that soil water stress during slow elongation, rapid elongation, flowering and ripening stages significantly decreased oil content [18]. The increase in yield was mainly due to increase in number of seeds/head and not to seed weight. Sunflower showed slightly less performance under irrigation every 15 days compared to other treatments. However, according to previous studies initial growth stage is the most important for adequate water than to later irrigations [6, 4, 13]. However, irrigation deficit at late growth stages of Sunflower has less effect on yield than at the early growth stages [12]. It is noteworthy that in Gezira Scheme farmers use irrigation scheduling for other crops to irrigate Sunflower. The results showed that, water stress significantly ($P \leq 0.05$) decreased seed yield and number of filled seed.

Table 3 displays the means of the oil and protein content obtained from different treatments. No significant differences were detected between the three irrigation treatments and the two plant spacing and their interactions. The results did not show any significant effect of irrigation levels on oil content of Sunflower while an increase in protein content was observed under mild water deficit of 15 days irrigation interval [17, 11 and 3]. The results indicated that water stress significantly decreased yield and its components but oil content did not change significantly [15] [5]. The highest oil percentage (40%) was recorded when Sunflower was irrigated every 10 days under both plant spacing in two seasons, while the lowest oil content (38%) was recorded with prolonged irrigation intervals of 20 days. The comparison results between the two seasons in oil percentage (%), which indicated that there were no significant differences between the two seasons. The oil percentage is an important parameter of Sunflower quality, which may be affected by deficit irrigation. Sunflower seeds contain good quality oil amounted 37 - 42% as well as high amounts of protein (14.8%). Previously, studies reported that the percentage of oil content of Sunflower slightly decreased when the crop was exposed to water stress at flowering stage [8]. Significantly, there were no differences observed in oil content among different irrigation treatments. Oil content increased with increasing the amount of irrigation. Results from two seasons clearly showed that there were no significant differences in protein content among all treatments.

Table 2: Effect of irrigation interval, intra-row plant spacing and their interactions on seeds number and total seed yield (kg/ha) for two winter seasons

| Number of filled seeds | | | | | | | Total seed yield (kg/ha) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2012/2013 | | | | | | |
| Treatment | W1 | W2 | W3 | Means | SE± | CV% | W1 | W2 | W3 | Mean | SE± | CV% |
| S1 | 955b | 1000b | 663b | 874 | 36.0 | 11.21 | 3230b | 3120a | 1890a | 2750 | 59.5 | 6.47 |
| S2 | 1150a | 1080a | 865a | 1030 | | | 3300a | 2910b | 1890b | 2700 | | |
| Mean | 1050 | 1040 | 764 | | | | 3270 | 3010 | 1888.5 | | | |
| SE | 24.8 | | | | | | 107 | | | | | |
| CV% | 6.30 | | | | | | 9.52 | | | | | |
| | | | | | | 2013/2014 | | | | | | |
| S1 | 1180a | 1120b | 1001a | 1100 | 26.3 | 7.01 | 3210b | 2860b | 1830a | 2670 | 56.4 | 6.36 |
| S2 | 1270b | 1240a | 960b | 1150 | | | 3290a | 3050a | 1590b | 2710 | | |
| Mean | 1220 | 1180 | 980 | | | | 3250 | 2950 | 1711 | | | |
| SE± | 38.9 | | | | | | 143 | | | | | |
| CV% | 8.47 | | | | | | 13.2 | | | | | |

Means followed by the same letters within the same column are not significantly different at ($P \leq 0.05$) level according to Tukey's HSD

Table 3: Effect of irrigation interval, intra-row plant spacing and their interactions on oil seed yield and protein percentage (%) at two growing winter seasons

| Oil seed (%) | | | | | | Protein (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | S1 | S2 | Mean | SE± | CV% | S1 | S2 | Means | SE± | CV% |
| | | | | | 2011/2012 | | | | | |
| W1 | 40a | 40a | 40 | 0.84 | 5.28 | 14a | 14a | 14 | 0.48 | 7.80 |
| W2 | 38a | 40a | 39 | | | 13a | 14a | 14 | | |
| W3 | 38a | 38a | 38 | | | 13a | 13a | 14 | | |
| Mean | 38 | 39 | | | | 13.3 | 13.6 | | | |
| SE± | 0.73 | | | | | 0.57 | | | | |
| CV% | 5.65 | | | | | 11.3 | | | | |
| | | | | | 2012/2013 | | | | | |
| W1 | 40a | 40a | 40 | 0.82 | 5.20 | 14a | 15a | 15 | 0.35 | 7.30 |
| W2 | 38a | 38a | 38 | | | 14a | 15a | 15 | | |
| W3 | 39a | 38a | 38 | | | 14a | 14a | 14 | | |
| Mean | 38.9 | 38.8 | | | | 14.1 | 15 | | | |
| SE± | 0.70 | | | | | 0.40 | | | | |
| CV% | 5.42 | | | | | 6.83 | | | | |

Means followed by the same letters within the same column are not significantly different at ($P \leq 0.05$) level according to Tukey's HSD

Table 4: Number of irrigations and amount of water applied for each treatment and yield reduction for two winter seasons 2012/2013 and 2013/2014

| Irrigation/ Plant spacing treatment | Irrigation water applied ($m^3$/ha) | Water saving (%) | Number of irrigation | Average per irrigation | Seed yield (kg/ha) | Seed yield reduction (%) |
|---|---|---|---|---|---|---|
| | | | 2012/2013 | | | |
| W1S1 | 9120 | - | 9 | 1010 | 3230 | 3 |
| W1S2 | 9220 | - | 9 | 1030 | 3300 | 0 |
| W2S1 | 6330 | 31 | 6 | 1060 | 3120 | 6 |
| W2S2 | 6380 | 31 | 6 | 1060 | 2910 | 12 |
| W3S1 | 6300 | 32 | 6 | 1080 | 1890 | 43 |
| W3S2 | 6470 | 30 | 6 | 1080 | 1890 | 43 |
| | | | 2013/2014 | | | |
| W1S1 | 9780 | - | 10 | 978 | 3210 | 2 |
| W1S2 | 9730 | - | 10 | 973 | 3290 | 0 |
| W2S1 | 6600 | 36 | 6 | 1100 | 2860 | 13 |
| W2S2 | 6500 | 36 | 6 | 1080 | 3050 | 9 |
| W3S1 | 5730 | 41 | 5 | 1146 | 1830 | 43 |
| W3S2 | 5670 | 42 | 5 | 1134 | 1590 | 48 |

Seasonal water applied and reductions in seed yield due to different amounts of irrigation water are presented in (Table 4). The irrigation treatment was started after third irrigation when plants completed the establishment period. Thus, the reduction in seed yield was higher in treatment W3 by 43-48% as compared to full irrigation treatment. Whereas, the reduction in seed yield in treatment W2 (mild stress) was somewhat lesser 6-13% owing to the sufficient water availability during the sensitive stages. Treatments which were stressed during the critical growth stages had a higher seed yield reduction compared to full irrigated treatments. The percentage of water savings under different irrigation treatments that had not significantly different in seed yield compared to full irrigation treatment that was 31% to 36% in the first and second season respectively.

## CONCLUSION

The results revealed that the differences between 10 days and 15 days irrigation in seed yield were not significantly different, thus, shifting irrigation interval to 15 days when there is a shortage in water supplies during the growing season is recommended. Higher oil percentage was obtained from 10 days intervals. However, the highest and lowest values of oil percentage were recorded at 40%, 39% and 38% and 40%, 38% and 38% for the different irrigation intervals of 10, 15 and 20 days. For the first and second seasons respectively.

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