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Response of Sunflower (*Helianthus Annuus* L) to Plant Spacing

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Abstract

Agriculture is an important sector of Sudan economy and is the backbone of growth, poverty reduction, and sustainable development. Sunflower has become an important crop for both farmers and consumers in Sudan, fits well in the local cropping system and is considered the most important cash crop of the country. The experiment was conducted in the Experimental Farm, University of Kassala (New Halfa) of Sudan, to investigate the influence of cultivars and planting Spacing on plant growth and yield of Sunflower (*Helianthus annuus* L). It consisted of two cultivars (pannar-735 and Damazin-1) and three plant spacing's (10 cm, 20 cm and 30 cm). Treatments were arranged in a factorial randomized complete block design (RCBD), in three replications. The results revealed, the cultivar, pannar- 735, early flowering, significantly highest hundred seed weight, seeds number per disc, seed yield (g/plant) and final yield (3.00 ton/ha). The Intra-row spacing of 30 cm had a thicker stem diameter, a highest number of seeds per head, 100-seed weight, seed yield per plant and final seed yield (3.34 ton/ha). The study revealed that the sunflower hybrid pannar-735 and plant spacing 30 cm apart is the best for New Halfa Eastern of Sudan.

Keywords: crop density, seed filling, oilseeds, Sudan

1. Introduction

Sunflower (*Helianthus annuus* L.) belongs to the family Compositae. It is widely grown in the United State of America and Australia. The origin of the sunflower is United States of America. It was first used in Europe as an ornamental and as an oilseed crop in Europe and Russia. Russian cultivars had impact on the development of sunflower as a commercial crop in Europe. The sunflower is considered as the second oilseed crop, after soybean, in world production (El Naim & Ahmed, 2010). It is adapted to a widely range of temperate (not sensitive to day length). It's grown in rotation with sorghum, millet, peanut and maize. The literature on this crop and topic has been reviewed by several workers. The most prominent among them are El Naim and Ahmed (2010), Viorel *et al* (2015), Yasaswini *et al* (2020), Philippe *et al* (2021) and Xiaoyu *et al*, (2022). Sudan one of the countries in which the climatic and soil properties are suitable for production of sunflower. The central clay plain of Sudan proved to be appropriate area for growing sunflower under irrigation or rain fall. It has been produced on clay soils that have good structure and in high in nutrients (Dalal & Mayer,1986).

The sunflower oil can be used as a salad and cooking oil or in making margarine. Also it has been used as a source of commercial fiber, and the seeds are used in medicine as diuretic and in treating certain disorder of the respiratory track. The seeds cake makes a high quality cattle and poultry feed because of its high protein content. El Naim and Ahmed (2010) reported that sunflower oil is healthier than most other food oils on the market. Sunflower oil is a premium oil for of its high of unsaturated fatty acids and for presence of linoleic acid.

The environmental condition in the Sudan is favorable for commercial production of seed oil crops, sesame, groundnut and sunflower (Saad *et al*, 2022). The experimentation of sunflower in Sudan started as early as the 1950s, concern with it is production started late mainly under rainfall crop. The cultivated area of land about 293 thousand feddans concentrated in the rain-fed area with an average yield of 100 kg/feddan.

Recently, high yielding hybrids were introduced and grown under irrigation (Ahmed & El Naim, 1993). The exclusion of castor crop from the Gash delta, sunflower was suggested with other cash crops for the Gash delta in Eastern Sudan. We speculate to have a good chance of adaptation in the flood irrigation for of its well–branched tap root system, tolerance to drought and a wide ecological adaptation.

The row crop equipment should dictate row spacing used in preparing land. Solid seeded sunflower is feasible. Adequate plant population is an important for highest yields (Viorel *et al*, 2015). Sunflower will compensate for differences in plant populations and density through adjustments in head size. Higher plant populations are planted for oil type than for confection type cultivar. Plant populations for oilseed cultivars grown under dry land might be between (14,000 - 18,000) plants per feddan for yield potential (El Naim & Ahmed, 2010).

The objective of this study is to evaluate the influence of cultivars and spacing on growth and yield of sunflower in New Halfa (Khashm Elgirba) Eastern of Sudan.

2. Materials and Methods

The experiment was conducted for two consecutive cropping seasons (2010/2011 and 2011/2012), in the Experimental Farm, Faculty of the Agriculture and Natural Resources at New Halfa, which is located between longitude 35° – 37' - 35° – 37' E, longitude 15° 18' - 15° 21' N, and altitude (450 meters) above sea level. The soil belongs to Khashm Elgirba series, which is a part of the central clay plain of Sudan. This type of soil occupies 75% of the total area under cultivation of New Halfa Agriculture Scheme. The soil is alkaline in reaction with pH value (2:5, soil: water) of 8.3, it is heavy textured soil with clay content 65%. This high clay content has a great negative impact on the preparation of crop production, soil survey staff (1999).

The land prepared as follows, ploughing using disc plough, harrowing, levelling and ridging to 75 cm a part, for both seasons, the experiments were laid out in factorial design, arranged in a complete randomized block design (RCBD) in three replicates. The area of the experiment was prepared into small plots, which consisted of six ridges 4-5 m wide and 6 m long, irrigation was applied consistently at 12-14 days, during both seasons, weeding was carried out manually, fertilizer was applied at the rate of 2 N (85 kg N/ha), 30 days after sowing.

Seeds of the hybrid (pannar-7351) was obtained from Agricultural Bank Sennar state and the cultivar Damazin-1, was obtained from Agricultural Research Corporation Wad Medani. Spacing was, within row 10 cm, 20 cm and 30 cm apart. Four seeds were planted in each hole. After two weeks from sowing, the seedlings were thinned to one plant.

Parameters Studied: Taken ten plants at random from each experimental unit to measure the following attributes.

-Diameter of disc.

-Number of seeds per disc.

-Empty seed (filling) %.

-Plant seed yield

-100-seed weight (g) was determined by counting 100-seeds at random from each plot unit three times and weighed by using a sensitive balance.

-The final seed yield (Kg ha^{-1}) was calculated as follows:

$$\text{Seed yield (kg/ha)} = \frac{\text{Seed weight (Kg/plot)} \times 10000}{\text{Harvested plot area (m2)}}$$

2.1 Statistical Analysis

Data were statistically analyzed using STAR (Statistical Tool for Agricultural Research) software version 2.0.1. The Means were tested using Duncan's Multiple Range Test (DMART) at the Alpha level of 0.05 (5% level of significance) (Gomez & Gomez, 1984).

3. Results and Discussion

Table 1 show effects of spacing and cultivar on head diameter (cm). Increased plant spacing increased the head diameter of the sunflower. This might be due to an increased growth parameter attributes in this treatment.

El Naim and Ahmed (2010) found that increasing in plant densities led to decreased head diameter. The smaller head size of closer intra plant spacing might be due to the competition of plants for moisture, nutrients and light. The wider intra plant spacing led to increased number of seeds per head (Table 3). This is for it had a better disc size. This in line with results of Lazim (1985) and El Naim and Ahmed (2010^{b}) who reported that, the plants competition reduced the seed number and disc size of the sunflower crop. The wider intra plant spacing had a higher seeds per head. Similar results were found by Steer et al (1985), Majid and Schneiter (1987) and El Naim and Ahmed (2010). This was due to a big heads at wider spacing. The two cultivars were significant ($P < 0.01$) in disc diameter among the three intra-spacing's, the interaction of spacing × variety was no significant. There is significant differences in disc diameter, 100-seed weight (Table 5) and yield (kg/ha) Table (6), but were not significantly different in seeds number/head, empty seeds%, and seeds weight (g) Table 4, during 2010/ 2011 season, while during 2011/ 2012 season recorded highly significant differences in disc diameter (cm), seeds number/ head and 100-seeds weight (g), whereas there significant differences in empty seeds%, plant seed weight (g) and yield (kg/ha). These observation were similar in line with Samo (2009). The cultivar Damazin-1 (open-pollinated) gave the higher days to 50% flowering compared with the Pannar-7351 hybrid in this experiment, this was probably attributed to the fact that open-pollinated cultivar was more tolerant and genotypes seem to be the most important factor limiting growth of this crop (Cannor & Hall, 1997).

Table 1. Means head (disc) diameter (cm) for Sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

	2010/2011				**2011/2012**			
Treatment	S1	S2	S3	mean	S1	S2	S3	mean
Pannar- 7351	1.53 c	2.28 b	2.63 a	2.15	1.32 c	1.90a	2.45b	1.89
Damazin-1	1.57 c	2.11 b	2.37 ab	2.02	1.25 c	1.76 b	2.33 a	1.78
Mean	1.55	2.20	2.50		1.29	1.83	2.39	
SE+	0.03							
C.V%	7.72							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test). CV% – coefficient of variation percentage; SE – standard error.

Table 2. Means of days to 50% flowering for sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

Treatment	**2010/2011**				**2011/2012**			
	S1	**S2**	**S3**	**mean**	**S1**	**S2**	**S3**	**mean**
Pannar- 7351	63.00 d	61.33 e	60.00 f	61.44	59.00 d	58.00 e	56.00 f	56.00
Damazin-1	67.00 b	68.00 a	65.00 c	66.67	64.00 a	63.00 b	60.00 c	62.33
Mean	65.00	64.67	62.50		61.50	60.50	53.00	
SE+	0.22							
C.V%	0.74							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test)., CV% – coefficient of variation percentage; SE – standard error.

Table 3. Means seed number per head for Sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

	Spacing(cm) 2010/2011				**Spacing(cm) 2011/2012**			
	S1	**S2**	**S3**	**mean**	**S1**	**S2**	**S3**	**mean**
Pannar- 7351	27.71 a	11.68 d	15.78 c	16.72	23.75 a	9.92 c	13.85 b	15.84

Damazin-1	23.13 a	10.46 d	19.03 b	17.54	21.85 a	8.18 c	12.62 b	21.48
Mean	22.92	11.07	17.41		22.80	9.05	13.24	
SE+	1.01							
C.V%	7.30							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test)., CV% – coefficient of variation percentage; SE – standard error.

Table 4. Means seeds weight for Sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

	Spacing(cm) 2010/2011				**Spacing(cm) 2011/2012**			
	S1	S2	S3	mean	S1	S2	S3	mean
Pannar- 7351	19.13 c	39.91 b	80.13 a	46.39	19.00 d	45.12 c	78.60 a	47.57
Damazin-1	17.70 c	45.54 b	74.20 a	45.81	17.20 d	42.71 c	73.30 b	44.40
Mean	18.42	42.73	77.17		18.10	43.92	75.95	
SE+	4.6							
C.V%	10.2							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test)., CV% – coefficient of variation percentage; SE – standard error.

Table 5. Means 100-seeds weight (g) for Sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

	Spacing(cm) 2010/2011				**Spacing(cm) 2011/201**			
	S1	**S2**	**S3**	**mean**	**S1**	**S2**	**S3**	**mean**
Pannar- 7351	3.59 c	5.15 b	7.02 a	5.25	3.22 e	4.79 c	6.89 a	4.97
Damazin-1	3.25 c	4.78 b	6.75 a	4.93	2.98 e	4.17 d	6.28 b	4.48
Mean	3.42	4.97	6.89		3.10	4.48	6.59	
SE+	1,7							
C.V%	10.5							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test)., CV% – coefficient of variation percentage; SE – standard error.

Table 6. Means seed yield (kg/ha) of Sunflower cultivars at different spacing during (2010/2011 and 2011/2012) seasons at New Halfa area

	Spacing(cm) 2010/2011				**Spacing(cm) 2011/2012**			
	S1	**S2**	**S3**	**mean**	**S1**	**S2**	**S3**	**mean**
Pannar-7351	2544.02 d	3073.69 bc	3525.79 a	3047.83	2525.80 c	2977.92 b	3452.43 a	2985.38
Damazin-1	2353.75 d	3005.75 c	3264.76 b	2874.75	2354.62 c	2819.15 b	3227.94 a	2800.57
Mean	2448.89	3039.72	3395.28		2440.21	2898.54	3340.19	
SE+	24.31							
C.V%	10.70							

Note: Treatment was expressed as S1 –10cm, S2-20cm and S3-30cm spacing apart.

Similar letters in each column are not significantly different (P< 0.05; Duncan's test)., CV% – coefficient of variation percentage; SE – standard error.

4. Conclusion

The results revealed that sunflower hybrid pannar-735 and the intra-row spacing of 30 cm apart should be preferred of sunflower production in New Halfa (Khashm Elgirba series) Eastern of Sudan. Further research experiment could be carried in future to buttress this result.

Author Contributions

This research was undertaken by the collaborating authors. Authors: Babkir A Ibrahim, Entisar M. Eldey, Adam A. Ishag and Ahmed M. El Naim. Entisar and Babkir designed the study, wrote the protocol, interpreted the data and anchored the field study, Adam and El Naim gathered the data analysis. Both authors managed the literature searches and background studies and produced the initial draft. Both authors approved the final manuscript.

Competing Interests

No conflict of interest exists.

Ethics Approval

Not applicable.

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