

Effect of Sowing Date, Irrigation Intervals and Fertilizers on Safflower (*Carthamus tinctorius* L.) Yield

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Abstract: Despite the importance of safflower in the world, this crop has received only little research attention in Sudan. Therefore, a field experiment was conducted at the College of Agricultural Studies, Sudan University of Science and Technology in Khartoum, to study the effects of sowing date, irrigation intervals and different types of fertilizers on yield, yield components and pigment of safflower (*Carthamus tinctorius* L.) Geeza cultivar during 2010/11 and 2011/12 in split-split plot layout was used with four replications. The main plots were two sowing dates (S1) on 13th and (S2) on 28th November. Subplots were three irrigation intervals (7, 14 and 21 days) and sub-subplots were three fertilizer levels (urea 80 kg fed⁻¹, pellet granules 105 kg fed⁻¹ and farm yard manure 2000 kg fed⁻¹). Sowing date had significant effects on seed yield in the first season and on seed yield, dry weight and pigment yield in the second season ($p < 0.05$). Irrigation significantly affected seed yield and pigment ($p < 0.05$) and shoot dry weight in first and second season ($p < 0.01$), respectively. The interaction of sowing date and irrigation intervals had significant effects on seed yield in the first season and on pigment in the second season. There were no significant effects of fertilizers on all parameters, Correlations showed negative results between harvest index, shoot dry weight (-0.3), number of seeds / head (-0.04), between pigment and 1000-seed weigh (-0.08) and also between seed yield and seed / head (-0.004) in the first season. Moreover, there was a negative correlation between pigment yield kg ha⁻¹ and seed / head (-0.13) in season two. The highest seed yield of 2700 kg ha⁻¹ and 2300 kg ha⁻¹ were achieved from S1 and S2 in season one, respectively, as compared to 1600 kg ha⁻¹ and 1000 kg ha⁻¹ from S1 and S2 in season two, respectively. Decreased seed yield in season two was due to serious infection with *Orabanche crenata* which was the first record in Sudan.

Keywords Nitrogen sources, Safflower, Sowing date, Water intervals

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a highly branched, herbaceous, thistle-like annual plant varying in height from 30 to 150cm. It has a strong, somewhat thickened tap-root, and numerous thin laterals. The stem is stiff, solid, circular in section, thick at the base and tapering with height, smooth and glabrous. The plant has many branches, each terminating in a flower, and the extent of branching within a variety depends mainly on environment

The leaves are simple, usually dark green, sessile and glabrous, estipulate, deciduous, with short spines scattered along the margins, having acuminate tips and a pronounced midrib. The flower has no pappus, and florets are tubular, sessile, regular epigenous, and grow out through the apical opening of the involucre. The calyx is rudimentary. The ovary is unilocular, with a simple basal ovule, which is composed of two united carpels, and is inferior

The fruit is cypsela, glabrous, obovate with a flattened top, with four longitudinal ribs such that a cross-section of the seed has a rhombic shape. The pericarp is generally whitish, the pappus normally absent. The seed is dicotyledonous, oleaginous and exalbuminous (Weiss, 1971).

Safflower belongs to the family Compositae or Asteraceae. It's a multipurpose oilseed crop grown mainly for its high

quality edible oil and bird seed. Initially, safflower oil was used as a source of oil for the paint industry. Its edible oil is used for cooking, making margarine and salad oil (Pascual-Villalobos and Albuquerque, 1996). Safflower is also grown for its flowers which are used as cut flowers, coloring and flavoring foods, making dyes for the textile industry, livestock forage, vegetable, making herbal teas and medicinal purposes. In China, safflower is grown as a medicinal plant (Singh, 2007) for the treatment of cardiovascular diseases, male and female sterility, lowering blood cholesterol, release of retained placenta and still birth, induction of labour in expectant women, delayed, heavy and painful various types of rheumatism (sciatica, thorax, arthritis), respiratory diseases (whooping cough, chronic bronchitis), gastritis. In addition to their medicinal uses, safflower flowers are also highly nutritious. In order to determine nutrientiveness and suitability of safflower flowers of Indian cultivars for human consumption, flowers of non-spiny variety and non-spiny hybrid developed in India were analyzed for biochemical composition. The flowers of both the cultivars were found suitable for human consumption and were highly nutritive (Singh, and. Nimbkar. 2007).

Despite the many uses of safflower, it has remained a minor crop. Therefore, it is essential for the scientific community to carry out research on this crop and popularize it as a commercial crop for development of pharmaceuticals, edible oil, paint and varnishes industry, dye extraction (carthamin), source of α -tocopherol, livestock feed, vegetable and cut flower. The crop can be grown successfully in arid and sunny regions. Application of nitrogen was found to increase yield and improve growth (Ahmed et al. 1985, Zaman and Das, 1990). Crop response to nitrogen has generally been more pronounced than to other fertilizers, and it would appear that nutrient affects not only the total yield of seed but also seed composition (Hoag, 1960). Nitrogen compounds are important in plant chemical compounds such as protein, nucleic acid, chlorophyll and enzymes structure. It has an important role in the tissues structure of plants (Herdrich, 2001)

Therefore, the determination of the most suitable dose of nitrogen fertilizer will increase the seed yield of safflower. In Sudan the plant is cultivated on small scale throughout Nile valley and Northern state where it is known as ghurtum or usfar for both its oil and dye. There was no major commercial planting prior to World War II, and any marketing and exporting of seed. After War it was introduced into Gezira rotations, but with little success. (Nur, 1967). It was grown well on pump schemes between Wad Madani and Sennar. Gurtum is winter crop. Therefore it is adapted to moderate temperatures to achieve high percentage of oil (Kidder 1997).

Organic fertilizer in various forms and at various stages of decomposition was used in soil in tons /ha for improvement of the crop productivity (Lasaridi and Stettiford, 1999).

Safflower response to different irrigation regimes plays an important role in safflower seed yield. Suitable irrigation regime increases seed yield primarily through its effect on the number of heads per plant and the increase is greater in secondary branches maintaining of soil moisture at an adequate level produce more grain and oil yield in safflower (Omid, A.H2010a)

Sowing date has an expressing influence and determining the appropriate sowing date is one of the most critical factors for optimizing safflower productivity (Yau, 2007, Ghanbari, 2011 Yarnia. Samanci and Ozkaynak Samanci, 2003) studied the effects of three planting dates on seed yield, oil content and fatty acid composition of three safflower cultivars in a Mediterranean region and reported that seed yield, oil content, palmitic acid, stearic acid and oleic acid contents decreased while linoleic acid content increased with delay in planting date.

The main objectives of this study are:

- 1- To determine the optimum sowing date of safflower.
- 2- To evaluate the effect of irrigation intervals on the yield.
- 3- To study the impact of fertilizers on safflower.

MATERIALS AND METHODS

The experiment was carried out during the period from November to April (2010/11 and 2011-/12) at the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat (latitude $1^{\circ}5:10'N$, longitude $3^{\circ}2: 32'E$). The climate of the location is described as tropical semi arid with only three months of rain fall during July, August and September. Maximum temperature is above $40^{\circ}C$ in summer and minimum is around $20^{\circ}C$ in winter season. The relative humidity ranges between 14 -27% during dry season and 31-51% during wet season. The soil is a typical clay soil characterized by a deep cracking, moderately alkaline and low permeability, nitrogen content and PH ranging between 7,5 - 8 (Addelhafeez, 2001). The experiment was carried out as split-split plot based on randomized complete block design (RCBD) with four replication where 18 treatments including two sowing dates (S1) 13th November and (S2) 28th November, three irrigation intervals (7, 14 and 21 days) and three types of fertilizers (Urea 80 kg/fed, Viz pellet granules of organic fertilizers 105 kg /fed and Farm yard manure 2000 kg/fed) in sub-sub plot. Plot size was $3 \times 4 m^2$. Each plot consisted of five rows 70cm apart, holes in row 30cm and three seeds were planted. Yield and

Table1. F values of statistical analysis of some yield components for the two seasons

Sources	Season1			Season2		
	Seed yield	Pigment yield	1000 seed weight	Seed yield	Pigment yield	1000seed weight
Rep	1.38	0,54	0.30	0.73	0.13	0.67
Sowing	10.03**	0.29	0.26	5.64*	3.64*	0.20
Sowing*rep	0.44	1.68	0.74	0.59	0.65	1.21
Water	4.35*	3.51*	0.62	0.78	0.44	0.99
Sowing*water	5.39**	2.76	1.21	1.71	3.66*	0.88
Sowing*water*rep	2.34*	0.35	0.82	2.70*	1.95	0.69
Fertilizers	0.99	0.24	0.68	0.46	0.07	1.84
Sowing* Fertilizers	6.16**	0.98	0.54	0.88	0.76	0.12
Fertilizers *water	0.51	0.56	0.97	1.88	0.47	0.95
Sowing*water* Fertilizers	0.94	1.84	1.04	0.43	0.23	0.11
CV	21.04	29.31	36.06	45.00	27.00	37.00

*, ** Significance at $P < 0.05$ and $P < 0.01$, respectively

Table 2 .Mean temperature and relative humidity during growing seasons.

Months	Mean temperature	Relative humidity
November2010	30.05	29
December 2010	24.8	30
January 2011	21.55	29
February 2011	25.9	21
March 2011	26.85	18
April 2011	30.5	14
November 2011	24.7	25
December 2011	24.5	33
January 2012	21.8	29
February 2012	26.45	26
March 2012	26.55	19
April 2012	29.85	17

its components (seed number/head,1000-seed weight , total dry shoot, harvest index and pigment weight)were measured. Randomly samples were taken from the middle rows of the plot. After data collection different statistical analysis including ANOVA, correlation were done using Microsoft excel .SAS, MSTAT and Sigma plot software.

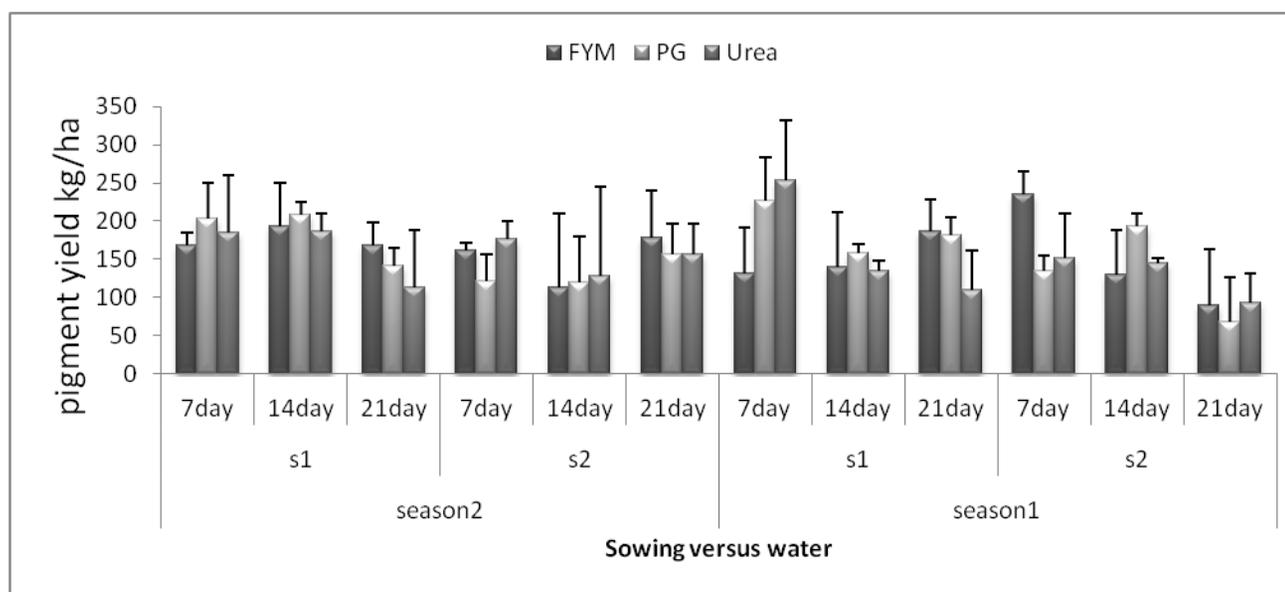
RESULTS AND DISCUSSION

The results of simple analysis of variance demonstrated that differences among treatments (main plots, sub plots and their interaction) were significant for the traits. Non significant replication effect for all traits demonstrated that the treatments arranged correctly in blocks (Table 1). Sowing date had significant effects on seed yield in the first season and on seed yield, dry weight and pigment yield in the second season ($p < 0.05$). The highest rates of seed yield and pigment yield were recorded by plant sown at the first sowing date (13th November). Decrease of seeds number/head and seed weight in delayed sowing dates can be attributed to unfavorable climatic conditions during flowering and seed filling stages. Decreasing of seeds number per head and seed weight due to planting date postponement have been shown by other authors (Cazzato, et,al 1997. Cholak,I ,1993. Dadashi, 2004, Tomar, 1995). These results are in agreement with those of (Yau (2007), who reported that in a semi-arid Mediterranean environment seed yield were higher by 59–169% in fall or early winter sowing than in late winter or early spring sowing. Irrigation significantly affected seed yield and pigment ($p < 0.05$) and shoot dry weight in first and second season ($p < 0.01$), respectively. The meteorological data recorded during the trial period in each growing season are given in Table 2.

Temperature was generally similar in both growing seasons. The interaction of sowing date and irrigation intervals had

Table 3 Spearman correlation between yield components in Season1 and season2

Sources	Season one						Season two					
	Seed/h	Dry w	seedy	HI	1000seed w	pigment	Seed/h	Dry w	seedy	HI	1000seed w	pigment
Seed/h	1.000						1.00000					
Dry w	0.096	1.000					0.31138	1.00000				
seedy	-0.0042	0.236	1.000				0.48351	0.66189	1.00000			
HI	-0.043	-0.362	0.666	1.000			0.22886	0.17899	0.62736	1.00000		
1000seed w	0.169	0.102	0.416	0.295	1.000		0.32980	0.17148	0.36932	0.32871	1.00000	
Pigment	0.3471	0.773	0.228	0.7015	-0.082	1.000	0.15775	0.67715	-0.1342	0.42129	0.19110	1.000

**Figure 1.** Safflower pigment yield as affected by sowing date (S1 and S2), water intervals (W1, W2 and W3 7, 14 and 21 days) and fertilizers

significant effects on seed yield in the first season and on pigment in the second season. There were no significant effects of fertilizers on all parameters, but farm yard manure had some influence on yield components at S2 in the two seasons (figure 1). Because it took much more time on the ground before sowing at S2 than S1.

Application of organic manures had significant influence on the plant height, (Gortappeh et al. 2000). In Iran they showed that increases in application rates of

nitrogen fertilizers and manure increased seed and biological yields, 100- seed weight, plant height, as well as oil percentage and yield. The highest seed and oil yields were obtained with 200 kg N/ha and with organic fertilizer of 30 t/ha (Keshta and El-Kholy, 1999) indicated that organic manure application increased the efficiency of both mineral nitrogen and bio fertilizers of nitrogen as well as organic matter percent. Therefore the. (Bocchi and Tano, 1994) stated that farmyard manure and other types of manures maintaining long-term soil productivity besides meeting timely requirement of nutrients. The results showed negative correlations between harvest index, shoot dry weight (-0.3), number of seeds per head (-0.04), between pigment and 1000-seed weigh (-0.08) and also between seed yield and seed per head (-0.004) in the first season as demonstrated in table 3. Moreover, there was a negative correlation between pigment yield kg ha⁻¹ and seed per head (-0.13) in season two. The higher seed yield of 2700 kg ha⁻¹ and 2300kg ha⁻¹ were achieved from S1 and S2 in season one respectively, as compared to 1600 kg ha⁻¹ and 1000 kg ha⁻¹ from S1 and S2 in season two, respectively .Decreased seed yield in season two was due to infection by *Orabanche crenata* which was the first record in Sudan.

The effects of sowing date on number of seeds/head and 1000-seed weight were significant. The highest rates of seeds number/ head and 1000-seed weight was recorded by the plants sown at the first sowing date (13th November) (Table 1). The lowest rates of yield components were obtained by safflower plants sown on 28th November.

CONCLUSION

According to the results of present study, in order to cultivate safflower as oil crop in conditions similar to the region of this experiment, it is recommended that safflower should be sown as soon as possible in the mid November. Delaying of safflower planting afterwards will result in late flowering due to day length shortage and consequently the reproductive phase of crop development and seed filling stage may coincide with winter low temperatures leading to expressing drop in crop yield and productivity.

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