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Effect of Sowing Date and Preceding Crop, on Growth and Productivity of the Sunflower Hybrid Sirena, under Varying Nitrogen Fertilization Levels

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SUNFLOWER is an important oil crop that has received great attention by the Egyptian agricultural sector in the early nineties, when a boom in oil extraction from the crop was observed. Since then and for more than two decades now, sunflower for oil purpose was neglected, hybrids are no longer on the market and confectionery sunflower became more profitable for Egyptian farmers. Recently, the registration of the single hybrid Sirena and its promotion based on contract basis with farmers, may present a new comeback to oil sunflower in Egypt. The aim of this study was to evaluate effect of sowing date (April vs. August) and preceding crop (maize vs. sunflower) in a double cropping system, under varying nitrogen fertilization levels (36, 72, 108 and 144kg N/ha), on growth and productivity of the newly introduced sunflower hybrid Sirena. Results from the two-year experiments, indicated that April sowing, at a prevailing average temperature of 20-24^{o}C later rising to about 28^{o}C at harvest time, was suitable to secure maximum seed yield of 4.39ton/ha. In a double cropping system, where sowing was performed in August, the hybrid yielded an average of 3.4 ton/ha, whether preceded by maize or sunflower. Seed oil percentage amounted to an average of 42.8% and was affected by the year, rather than sowing date or preceding crop. Effects of the nitrogen fertilization rates were masked by the soil available nitrogen, however, based on the regression analysis and equations for estimating the nitrogen requirements based on the hybrid seed yield, 72-108kg N/ha were necessary to achieve the maximum seed yield while sustaining an oil percentage above the 42%.

Keywords: Head rot, *Helianthus annuus*, Oil percent, *Sclerotinia*, Stem rot, Yield.

Introduction

Egypt's deficiency in vegetable oils has soared to 95%, with a record import of 2.5 million metric tons in 2018, 18.5% of which was contributed by sunflower (USDA, 2020). The Egyptian Ministry of Agriculture and Land Reclamation (MALR, 2017) proposed growing canola (*Brassica napus* L.) and sunflower (*Helianthus annuus* L.) in newly reclaimed areas to rectify the deficiency in vegetable oil production. The two crops were selected for their tolerance to salinity levels that characterize the majority of the new areas under development, in addition to their low water requirements compared to traditional crops. Besides its tolerance to salinity, sunflower is a short duration crop that can fit well in the crop rotation in the Nile Delta and its Valley as a single or double crop in the summer season. The crop fits well in areas where rice growing is being restricted due to water shortage and growing cotton is not favored because of its high production costs and unreliable marketing. As opposed to canola, sunflower is not new to Egyptian agriculture. The production area of sunflower seeds for oil production in Egypt exceeded the 10,000ha in the time period between 1988 and 2007, reaching its peak (30,000ha) in 1993. The increase in production area was linked to the construction of the oil extraction factory located in El-Fayoum governorate, and the dramatic reduction in area that followed was linked to the termination of the factory's extraction activities. Hybrids grown

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during that period included Euroflor, Vidoc, Hysun and Pioneer, with yields exceeding 3.5ton/ha and an average oil percent amounting to 40%, as reported by Allam et al. (2003). These hybrids are currently out of the Egyptian market and the open pollinated cultivars Sakha 53 and Giza 102 are the ones available with yields not exceeding 2.4ton/ha under best conditions and an average oil percent of 38% according to Abd El Mohsen (2012) and Hafiz et al. (2014). The most recent data indicated that only 7000 ha were grown in 2018 (FAO, 2020). This drop in production area is a clear manifestation of the lack of a profitable market for farmers to sell their produce. The recommendations of the Ministry of Agriculture and Land Reclamation (MALR, 2015) for the cultivars Sakha 53 and Giza 102 are the least among the summer crops, mainly due to the low nitrogen requirements (72kg N/ha), cultivation and pesticide costs. The proposed sowing dates extend from as early as March and up to June in Middle and Lower Egypt, in addition, two sprays of micronutrients and two honey bee hives/ha are usually recommended to ensure seed setting and good yield.

The registration of a single-cross hybrid by the name of "MS Sirena" and the promotion of that hybrid by a new oil extraction facility in Borg El-Arab region in Alexandria, on contract basis with farmers, could lead to a successful return of sunflower to the Egyptian crop rotation. The hybrid was described as a mid-late hybrid that flowers after 60-64 days from sowing and matures after 120-125 days. It was also designated as highly tolerant to stress conditions, with a plant height of 150-160cm and an oil content of 44-48%, according to MAY Seed Company (http://www.may.com.tr/en/product/sirena). Research on this hybrid under Turkish irrigated conditions in South East Anatolian indicated seed yield of 2.6ton/ha and oil percent of 37% (Karaaslan et al., 2010), while in Eastern Anatolia seed yield ranged from 2.9 to 3.3ton/ha and oil percent of 43-48%, according to the year of cultivation (Ozturk et al., 2017). In Sudan, Amin El Sir et al. (2017) reported that the hybrid "Sirena" is being produced from its parental lines on a large scale and research on the hybrid have indicated yields of 2.8ton/ha. Data on the hybrid in Egypt, however, is lacking and farmers are reluctant to grow the hybrid.

Sowing date and nitrogen fertilization are the two main factors that have been shown to affect sunflower productivity and oil content. Delayed sowing has been shown to negatively impact sunflower growth characters, seed yield and oil content (Abd El Mohsen, 2012; Hamza & Safina, 2015; Ozturk et al., 2017). According to the results of Alonso-Ayuso et al. (2016) maize growing leads to a reduction in soil inorganic nitrogen along the entire soil profile (being more pronounced in the range between 0-60cm), while sunflower grown after maize depleted layers between 40-100cm. While, Massignam et al. (2009) noted that sunflower's seed yield was not responsive to nitrogen supply as in case of maize, and it partitions most of its nitrogen to the stem, most literature suggested that 80-100kg N/ha was more than adequate to achieve maximum yield of the tested sunflower hybrids (Montemurro et al., 2007; De Giorgio et al., 2008). The increase in nitrogen fertilization, in general, had positive impact on sunflower growth and seed yield, but showed negative effects on oil % (Hafiz et al., 2014; Kandil et al., 2017).

The aim of this study was to evaluate effect of sowing date and preceding crop, on growth and productivity of the sunflower hybrid Sirena, under varying nitrogen fertilization levels.

Materials and Methods

The research presented here was conducted at the Abbis Experimental Research Station, Faculty of Agriculture, Alexandria University, over the two summer seasons of 2017 and 2018. The soil at the experimental site was classified as highly capable, *Vertic Torrifluvents* soil, according to USDA (2014). The soil organic matter content was 1.5-2.5%, as determined by the Walkley-Black chromic acid wet oxidation method (Nelson & Sommers, 1982) and pH of 8.6, that was measured in 1:2.5/ soil: water suspension according to McLean (1982). Available macro-elements concentration were N= 200 ppm determined according to Keeney & Nelson (1982), P= 9.6 ppm, according to Olsen & Sommers (1982) and K= 320 ppm, according to Knudsen et al. (1982), at a soil depth of 30cm. The sunflower single-cross hybrid "MS Sirena" from MAY Seed Company, Turkey, was studied in two different experiments that were laid out in a randomized complete block design with three replications. Each experimental plot was made up of five ridges 3 x 0.7m, bordered with two guarding ridges. Monthly temperature, humidity and precipitation averages for the location are presented in Table 1.

TABLE 1. Average temperature, relative humidity and precipitation in Alexandria during the 2017 and 2018 growing seasons

2017	Average temp. (°C)	Relative humidity (%)	Rain fall (mm)	2018	Average temp. (°C)	Relative humidity (%)	Rain fall (mm)
April	19.58	57.54	0.00	**April**	20.78	64.16	0.00
May	23.20	57.57	0.00	**May**	24.25	64.75	0.00
June	26.06	60.00	0.00	**June**	26.51	63.47	0.00
July	28.41	59.52	0.00	**July**	27.93	68.32	0.00
Aug.	28.01	60.70	0.00	**Aug.**	28.33	66.43	0.00
Sep.	26.71	57.09	0.00	**Sep.**	27.35	64.82	0.00
Oct.	23.56	54.87	0.00	**Oct.**	24.50	62.22	0.00
Nov.	18.99	59.40	0.00	**Nov.**	20.08	70.34	0.00
Average	24.31	58.34	0.00	**Average**	24.97	65.56	0.00

The first experiment studied the effect of early summer (20th April) and late summer (10th August) sowing dates, under three levels of nitrogen fertilization namely; 36, 72 and 108kg N/ha, (in the form of NH_4NO_3), split in two equal doses (applied after 15 and 40 days from sowing), on growth and productivity of Sirena. To allow for better regression estimates of nitrogen level on sunflower productivity, a fourth level of nitrogen was included in the second growing season, namely; 144kg N/ha. Prior to sowing, the soil was ploughed twice and phosphorous (P_2O_5) was incorporated in the soil at the rate of 36kg/ha with the second ploughing. After ridging, a single seed of Sirena, was sown per hill, at a distance of 25cm between hills bringing the plant density to 57,000 plants/ha. Stomp was applied as a post planting, pre-emergent herbicide for weed control at the rate of 3.0L/ha and hand hoeing was performed once after 30 days from sowing. Potassium was applied at the rate of 58kg/ha (K_2O), along with the second dose of the nitrogen fertilizer. Two foliar applications of "Mega green" at the rate of 1L/ha, (11% N, 8% P_2O_5, 6% K_2O, 0.3% Zn, 0.3% Fe, 0.2% Mn, 0.5% Mg, 1% Ca, 1.3% SO_3, 0.2% B and 0.02% Mo) were applied 38 and 50 days from sowing.

The second experiment, represented the double cropping pattern of sunflower, and studied the effect of the preceding crop (either maize or sunflower) on the late summer sown sunflower (August 10th) under conditions mentioned in the previous experiment. Seeds were sown on the opposite side of the previously established ridge after removing the preceding crop, in hills, without ploughing (zero tillage). The preceding (sunflower or maize) was grown in the early summer sowing date (20th April). Phosphorous was broadcast in the plots during the first irrigation after sowing; potassium, nitrogen and micronutrients were applied as indicated in the first experiment. Maize was grown and fertilized according to the standard agricultural processes of maize hybrids.

In both experiments the crop was irrigated with about 6000m^3/ha, using furrow irrigation method and split on five irrigations delivered at sowing and 15, 30, 58 and 70 days after sowing. At maturity, when the back of the head changed to the yellow color and bracts turned brown (95 days after sowing), five guarded plants were harvested from each plot and were studied for the following traits: plant height in cm (measured from soil surface to base of the head), stem diameter in cm (measured at half the plant height) and head diameter in cm. At the same time, the percentage of plants infested with stem rot and head rot were determined on plot basis. When heads were fully dried in storage, seeds were manually threshed and left to dry before 100 seed weight (g) and seed yield adjusted to ton/ha were measured at 10% moisture basis. Oil percentage (% dry matter) was determined in seed samples using Soxhlet extractor according to AOAC (1980). Statistical analyses (ANOVA and regression analysis) were analyzed using the SAS 9.3 package (SAS, 2007). Regression analysis for the nitrogen levels on yield and oil content was performed over data from the two experiments, while ANOVA was performed for each year separately and a combined analysis over the two years of study was undertaken due to the homogeneity of the error variance according to Winer (1971). Significance was declared at $P \leq 0.05$, and the least significant difference ($L.S.D_{0.05}$) was employed for comparison of means.

Results and Discussion

Because of the homogeneity of error variance between the two seasons in both experiments was insignificant, according to Winer (1971), only the combined analysis for the two seasons for each experiment were presented in this study.

Sowing date effect

The combined analysis for the two growing seasons (Table 2), indicated significant effects for the year on the 100 seed weight, oil percentage and percentage of heads infested with rot/plot. The interaction between the year and the sowing date significantly affected the 100 seed weight, oil percentage and percentage of heads infested with rot/plot, while the interaction between the nitrogen level and either the year or the sowing date and the three-way interactions were all insignificant for all studied traits (Table 2). Regarding the 100 seed weight, significantly higher seed weight was observed in the early sowing of 2018 (7.93g) compared to that of 2017 (6.52g) as opposed to the insignificant differences observed for the two years when it came to the late sowing date (5.51 and 5.89g, respectively) (Fig. 1). Oil percentage on the other hand, showed significant increase in the late sowing date compared to the early sowing of the 2017 season, but insignificant variation in oil percentage was detected between the two sowing dates in 2018 (Fig. 1). These results are not in full agreement with those of Hamza & Safina (2015), who reported a reduction in oil percentage from 38.5 to 37%, due to delay in sowing date.

Sowing date significantly affected plant height, stem diameter, head diameter, the 100 seed weight, seed and oil yield/ha and the percentage of plants infested with stem rot/plot and head rot/plot, but had no significant effects on oil percentage (Table 2). The delay in sowing date had a negative impact on production of the hybrid, where seed yield was reduced from 4.39 to 3.38ton/ha and oil yield was also reduced from 1.87 to 1.45ton/ha (Table 3). The reduction in seed and oil yield could be attributed to the reduction in both head diameter and 100 seed weight (Table 3). These results are in general agreement with Andrade (1995) who reported that a delay of the sowing date significantly reduced grain yield of sunflower due to a decrease in the number of seeds/m^2 and in seed weight. Similarly, Abd El Mohsen (2012), observed that seed yield of the cultivars Sakha 53, Giza 102 and the hybrid Pioneer 63M02 was reduced from 2.32, 1.96 and 1.89ton/ha when sown on the 1st of May to 1.58, 1.23 and 1.14 t/ha when sown on the 1st of July, respectively. Moreover, Hamza & Safina (2015) indicated that the delay in sowing from March (where maximum seed yield and oil yield were obtained) to August, resulted in average reduction in seed yield for the two cultivars Sakha 53 and Giza 102 from 2.49ton/ha to 1.90ton/ha, respectively.

TABLE 2. ANOVA for sunflower traits combined over the two growing seasons 2017 and 2018, as affected sunflower traits as affected by sowing date (SD) and nitrogen level (N)

Source of variance	d.f	Plant height	Stem diameter	Head diameter	100 seed weight	Oil %	Seed yield/ ha	Oil yield/ ha	% Stem rot/ plot	% Head rot/ plot
Year (Y)	1	5467.99	0.002	0.51	7.25**	105.85**	0.40	0.12	67.27	112.39**
Replicate (Rep.)	2	271.31	0.132	1.47	0.03	1.79	0.017	0.22	16.34	1.95
Y x Rep.	2	690.43	0.026	0.42	0.04	0.49	0.54	0.01	4.08	1.93
Sowing date (SD)	1	17247.35**	2.80**	62.61**	20.98**	0.36	9.05**	1.54**	77.52*	8.5**
Nitrogen level (N)	2	10.46	0.032	2.46	0.01	1.02	0.052	0.01	17.52**	1.41
Y x SD	1	171.28	0.15	1.27	2.34**	9.12**	0.058	0.0001	5.83	17.13*
Y x N	2	16.14	0.02	1.57	0.04	0.29	0.76	0.04	10.1	1.44
N x SD	2	9.67	0.018	3.59	0.41	0.44	0.31	0.12	1.48	0.05
Y x N x SD	2	30.58	0.013	1.12	0.02	1.02	0.081	0.1	0.28	0.06
Error b	20	174.04	0.05	2.2	0.04	0.95	0.81	0.15	4.82	0.75

*Significant at 0.05 and **Significant at 0.01 levels of probability, otherwise not significant.

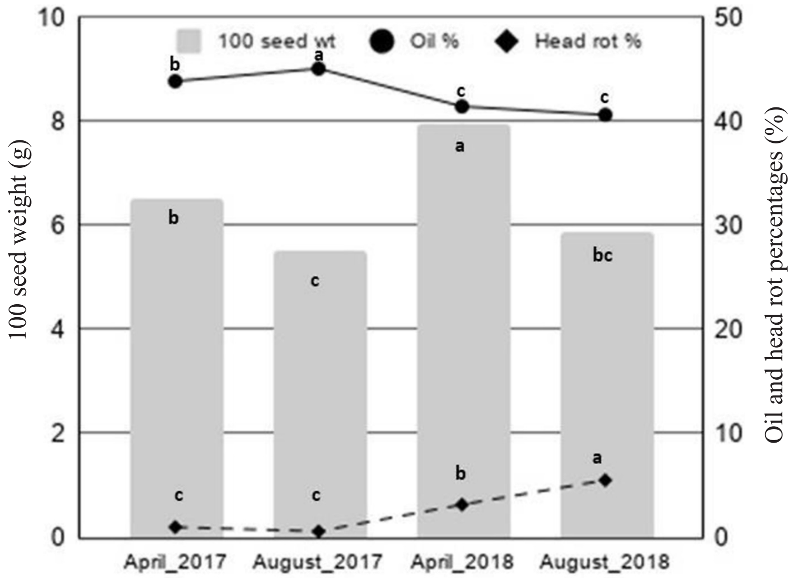

Fig. 1. 100 seed weight, oil percentage and head rot percentage as influenced by sowing date for the two years of study [Within sowing dates, years and traits (100 seed weight, oil and head rot percentage). The means followed by different letters are significantly different according to L.S.D. at P<0.05]

TABLE 3. Mean values of sunflower traits as affected by the sowing date (SD) and nitrogen levels (N), for the 2017 and 2018 years of study

Treatment	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	100 seed weight	Oil %	Seed yield (ton/ha)	Oil yield (ton/ha)	% Stem rot/ plot	% Head rot/ plot
				Year					
2017	180.5a	1.94a	18.20a	6.01b	44.23a	3.86a	1.72a	2.82a	0.83b
2018	155.85a	1.95a	17.96a	6.91a	41.0b	3.91a	1.6a	5.55a	4.36a
				Sowing date (SD)					
20th April	190.06a	2.23a	19.40a	7.23a	42.61a	4.39a	1.87a	2.72b	2.11b
10th August	146.28b	1.67b	16.68b	5.70b	42.81a	3.38b	1.45b	5.66a	3.08a
				Nitrogen level (N)					
36kg/ha	168.34a	1.89a	17.57a	6.46a	43.02a	3.86a	1.63a	2.80b	2.85a
72kg/ha	169.01a	2.00a	18.41a	6.44a	42.44a	3.96a	1.67a	4.97a	2.74a
108kg/ha	167.17a	1.94a	18.28a	6.48a	42.67a	3.82a	1.68a	4.80a	2.21a

Means followed by the same letter within the same column are insignificantly different at 0.05 level of probability.

The reduction in seed yield due to delayed sowing under irrigated conditions is most probably related to the variation in temperature with the progression of the growing season, rather than soil moisture condition as observed in other studies (Flagella et al., 2002; Barros et al., 2004). Aguirrezabal et al. (2003) suggested that yield components are affected by variations in environmental conditions during seed filling. A cooler temperature during plant establishment (~20^{o}C) followed by an increase in temperature up to (~28^{o}C) at maturity (April sowing) was shown to result in higher yields than when Sirena was exposed to higher temperature during plant establishment (~28^{o}C) shifting to cooler temperature (~19^{o}C) during maturity (Table 1). When current data was compared to that of Ozturk et al. (2017), lower temperatures in Turkey appear to have negative effects on Sirena yield. In that study, in Turkey and under irrigated conditions too, April sowing of Sirena (the optimum sowing date), with an average temperature of 13.8°C during the growth season, seed yield of only 2.87 and 3.03ton/ha and oil percentage of 48.1 and 42.8% for the two growing seasons under study were recorded, respectively. The increase in seed yield of 52.96% and 44.88% for Sirena under Egyptian conditions, coupled with a reduction of 11.41% and zero % reduction in oil percentage, respectively, when compared to the two cooler seasons under Turkish conditions, verifies the effect of temperature mainly on seed yield of the hybrid. It is worth mentioning that, in both sowing dates, budding of Sirena occurred exactly 60 days from seed sowing while harvesting was performed at 95 days from sowing, indicating fixed periods of vegetative stage, budding, seed setting and physiological maturity for the two studied sowing dates.

Early sowing also played a key role in reducing the percentage of plants infested with stem rot (51.94%) and head rot (31.49%) compared to the late sowing of August. Similar results were reported by Clark et al. (1993) who proposed three reasons for variation in infestation rate due sowing date, namely; fluctuation in soil moisture and temperature could stimulate sclerote germination, rapid growth of roots gives more chance of encountering a germinating sclerotium and finally the production of soft root tissues that are susceptible to infection due to faster growth rates under higher soil and air temperatures.

Preceding crop effect

The combined analysis for the two growing seasons (Table 4), indicated significant effects for the year on stem diameter, 100 seed weight, oil percentage and percentage of heads infested with rot/plot. It could be observed that the percentage of heads infested with head rot/plot, were higher in the second season compared to the first season. Most importantly, however, the percentage of plants infested with either stem or head rot were insignificantly different, whether the August-sowing was preceded with maize or sunflower and ranged from 2.7-3.5% for stem rot and was exactly 2.4% for head rot (Table5), suggesting no major outbreak of the pests due to the double cropping of sunflower under the studied conditions that included zero tillage and sowing on the other side of the ridge. According to NSAC (2015), management of sclerotinia is not an easy task due to the wide host range of the pest, and sunflower should be rotated in the same field every 3-4 years to help decrease inoculum load in the soil, and rotation to maize and small cereals is recommended.

The effect of the interaction between the year and the preceding crop was shown to be significant only for stem diameter and 100 seed weight. Significantly higher stem diameter was observed following maize in 2017 but was similarly as high following sunflower in 2018, while the least value was recorded following maize in 2018 as seen in Fig. 2. In addition, significantly higher 100 seed weight was observed when sunflower was preceded by sunflower in 2018 compared to insignificant differences between the preceding crops in 2017, or maize in 2018 (Fig. 2). Furthermore, results have indicated that no significant effects for the preceding crop on August sown sunflower, whether that crop was maize or sunflower, on plant height, head diameter, seed yield, oil percentage or oil yield (Table 4). Because maize has higher nitrogen demands and is more responsive to nitrogen supply than sunflower (Massignam et al., 2009), reduction in sunflower production preceded by maize in the double cropping pattern was a concern. However, under the conditions presented here, sunflower was never in shortage of nitrogen even under the least dose of 36kg/ha. This could be explained by the fact that the generally known deep root system of sunflower utilized nitrogen in deeper layers than maize, which is in line with the results of Alonso-Ayuso et al. (2016), who reported that when sunflower was preceded by maize, it depleted nitrogen left behind from maize in layers between 40-100cm. On the other hand, in the double cropping pattern where sunflower preceded sunflower, the deep soil layers rich in nitrogen and the additional mineral fertilization employed compensated any apparent nitrogen depleted by the first sunflower crop. These results suggest that, in the double cropping pattern presented here, it is possible to grow maize or sunflower in April (optimum sowing date), achieving maximum yield from either crop, without negative effects on seed and oil yield or seed oil percentage for the later August-sown sunflower. The advantage of including sunflower either as a double crop, or simply including it in the crop rotation every three to four years has the capability of benefiting from the nitrogen that escapes the roots of other crops in the rotation that otherwise would have simply been leached.

TABLE 4. ANOVA for sunflower traits combined over the two growing seasons 2017 and 2018, as affected sunflower traits as affected by the preceding crop (PC) and nitrogen level (N)

Source of variance	d.f	Plant height	Stem diameter	Head diameter	100 seed weight	Oil %	Seed yield/ha	Oil yield/ ha	% Stem rot/ plot	% Head rot/ plot
Year (Y)	1	3703.74	0.12*	3.38	1.35*	177.11**	0.12	0.08	5.7	110.18**
Replicate (Rep.)	2	556.07	0.10	7.63	1.77	4.02	1.56	0.33	12.17	0.47
Y x Rep.	2	466.88	0.004	1.54	0.04	1.69	0.06	0.11	12.41	0.47
Preceding crop (PC)	1	80.25	0.10	1.59	2.07*	1.27	0.81	0.15	6.02	0.02
Nitrogen level (N)	2	39.96	0.032	2.84	0.49	2.8	0.12	0.04	3.29	0.51
Y x PC	1	92.0	0.24*	6.57	2.44**	7.1	0.29	0.09	11.15	0.02
Y x N	2	16.8	0.02	0.69	0.07	2.26	0.52	0.07	2.23	0.51
N x PC	2	3.33	0.02	1.62	0.67	5.19	1.27	0.2	0.17	2.88
Y x N x PC	2	2.94	0.003	0.54	0.03	0.28	0.23	0.06	3.41	2.88
Error b	20	58.7	0.037	1.7	0.46	2.06	0.81	0.15	7.0	3.64

*Significant at 0.05 and **Significant at 0.01 levels of probability, otherwise not significant.

TABLE 5. Means values of sunflower traits as affected by the preceding crop (PC) and nitrogen level (N), for the 2017 and 2018 years of study

Treatment	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	100 seed weight	Oil %	Seed yield (ton/ha)	Oil yield (ton/ ha)	% Stem rot/ plot	% Head rot/plot
Year									
2017	156.43a	1.73a	17.07a	5.51b	45.03a	3.43a	1.5a	2.66a	0.63b
2018	136.14a	1.61b	16.46b	5.89a	40.59b	3.31a	1.4a	3.45a	4.12a
Preceding crop (PC)									
Sunflower	147.78a	1.72a	16.97a	5.94a	43.0a	3.53a	1.51a	3.47a	2.40a
Maize	144.79a	1.62a	16.55a	5.46b	42.6a	3.24a	1.38a	2.65a	2.35a
Nitrogen level (N)									
36kg/ha	146.78a	1.61a	16.50a	5.58a	43.33a	3.46a	1.50a	2.81a	2.57a
72kg/ha	147.81a	1.69a	15.47a	5.59a	42.37a	3.26a	1.39a	2.70a	2.16a
108kg/ha	144.26a	1.71a	17.33a	5.93a	42.74a	3.43a	1.46a	3.66a	2.40a

Means followed by the same letter within the same column are insignificantly different at 0.05 level of probability.

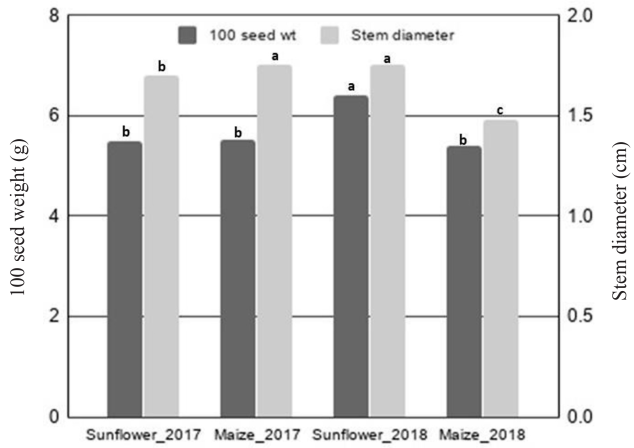

Fig. 2. 100 seed weight and stem diameter as influenced by preceding crop for the two years of study [Within preceding crop, years and traits (100 seed weight and stem diameter). The means followed by different letters are significantly different according to L.S.D. at P<0.05]

Nitrogen level effect

Except for the effect on the percentage of stem rot/plot in the sowing date experiment, nitrogen levels had insignificant effects on any of the studied traits (Table 2). Similarly, insignificant effects were observed for the preceding crop experiment for all traits (Table 4). The two-way and three-way interactions were also shown to be insignificant in both experiments (Tables 2 and 4). Regression analysis for the four studied nitrogen levels indicated an R^2= 0.913 for seed yield/ha and R^2= 0.765 for oil percentage (Fig. 3). The nitrogen rate of 72kg N/ha resulted in maximum yield and at the same time considerably high oil percentage, with reduction in values for both traits when nitrogen level reached 144kg N/ha (Fig. 3).

The lack of response to nitrogen fertilization has its explanation in the nitrogen soil profile, where excess amounts of nitrogen (≥200 ppm) were already available even before the nitrogen fertilizer levels were applied, based on the soil samples collected before the experiments. Across sowing dates and preceding crops, the regression curve indicated that the dose of 72kg N/ha resulted in the maximum yield/ha (Fig. 3). Any further increase in application of nitrogen fertilizers was not translated into yield improvement. Furthermore, the highest dose of 144kg N/ha, applied in the second season in both experiments, indicated a tendency for reduction in yield (Fig. 3). These results are in agreement with the replicated trials at the northern New South Wales in Australia, according to Serafin & Belfield (2008). The research in Australia and the one presented here suggested that the starting soil nitrogen level at the growing location is essential to determine sunflower yield, and that excess amounts of nitrogen could even lead to reduction in yield. Similarly, a steady reduction in oil percentage was observed with the increase in nitrogen levels (Fig. 3) and this was also in agreement to the observations of Serafin & Belfield (2008).

Sunflower production guidelines by the Ministry of Agriculture in Egypt suggest a 72kg N/ha in the Nile Delta and Valley that is to be reduced to 54 kg/ha if sunflower was preceded by legumes or vegetable crops in the crop rotation (in the winter season). On the other hand, no nitrogen fertilization is recommended if preceded by tomatoes or potatoes, as each crop leaves a lush of nitrogen credit behind. In newly reclaimed areas, low in soil nitrogen holding capacity, a total of 108kg N/ha, however, is advised to be split on as many doses as possible. While our results have indicated that those recommendations seem to be generally valid, the hybrid Sirena showed a potential of 3.96 ton/ha compared to a yield potential of 2.4 ton/ha for the local cultivars Sakha 53, Giza 102 under the recommended 72 kg N/ha, however, the soil available nitrogen was not accounted for. To understand these observations, we point out that a better nitrogen fertilization recommendation depends on the seed yield goal and the amount of nitrogen already available in the soil, taking into consideration that deep roots of sunflower can scavenge nitrogen leached below the roots of many other crops especially cereal crops (NSAC, 2015) and that soil tests at a depth of 120 cm should be included in calculating the nitrogen requirements of sunflower (GRDC, 2017). A simple nitrogen budget could be calculated from the formula: N required for sunflower (ton/ha)= Target yield (ton/ha) x kg N removed by 1 ton of seeds x1.7, where the quantity of nitrogen removed by the seeds was estimated to be 26kg N, and the total amount of nitrogen needed to grow the crop is nearly 1.7 times that removed by the seed (GRDC, 2017). Based on this formula, to achieve a 2.4 ton/ha of seed yield only 106kg N/ha is required by the open pollinated local varieties, while for 3.96ton/ha, 176kg N/ha were required for Sirena, with an increase in nitrogen requirements of 69kg N/ha compared to the local varieties. This suggests that available soil nitrogen in this study obscured the true response of the new hybrid to the added nitrogen fertilization rate. Nevertheless, these observations clearly imply that the nitrogen fertilization rates must be revised for high yielding hybrids compared to the local open pollinated varieties. Because soil tests are not a common procedure in Egypt, it appears that in the Nile Delta and Valley and under any soil nitrogen level, a dose of 108kg N/ha is better suited for efficient hybrid production (Fig. 3). Soil tests on the other hand are essential for a more precise dose. For the hybrid Sirena to reach its expected yield potential in sandy soils, usually devoid of nitrogen, at least 176kg N/ha should be supplied.

Another important effect for increasing nitrogen fertilization observed here was the almost doubling in the percentage of plants infested with stem rot/plot from 2.8% when 36kg N/ha was applied to 4.8% when 108 kg N/ha was applied. It is plausible that high rates of nitrogen fertilization will cause a much denser canopy that in turn promotes the spread of the disease (NSAC, 2015). It is thus recommended to manage the nitrogen fertilization rates and to include sunflower in the crop rotation every 3-4 years to keep sclerotinia diseases under control.

During this experiment it could be noticed that after growing sunflower, soil became more friable than before the experiment. These observations were in full agreement with the results of Benitez et al. (2017) who reported that, in a rotation sequence where sunflower preceded maize, maize seedlings showed better germination responses, seedlings shoot biomass and plant nutrient content. It appears that this improvement in soil could be attributed to the branching roots of sunflower that penetrate deeper in the soil than many other crops, which helps restoring soil structure by breaking up compacted layers rendering soil more friable (Serafin & Belfield, 2008). Finally, it could be observed that the yields from the hybrid Sirena were achieved under natural insect populations, with no bee hives included, supporting the instructions of the producing company as the hybrid expresses high level of self-fertility.

Conclusion

It could thus be concluded that the high yields achieved here may be due to the genetic makeup of the hybrid Sirena as compared to the local open pollinated cultivars Sakha 53 and Giza 102 and even the old hybrid Pioneer 63M02, causing it to express yields that were 89.22, 123.98% and 132.28% higher, respectively, upon comparison with the values reported earlier by Abd El Mohsen (2012), for the early sowing date of May. Similarly, Sirena seed oil percentage was shown to be 14.48% higher than Sakha 53, 16.68% than Giza 102 and only 10.16% than the hybrid Pioneer 63M02. Oil percentage was affected by the year rather than sowing date or preceding crop, but a general tendency for reduction in oil percentage was observed with the increase in nitrogen fertilization level.

Due to its deep root system, sunflower is regarded as a nitrogen scavenger making it suitable for inclusion in the crop rotation in the Nile Delta and its Valley. It is expected to benefit from the nitrogen escaping below the reach of other summer crops like maize and at the same time restoring soil structure by breaking up compacted layers with its deep roots making the soil more friable, while ensuring good yields. With that being said, it's important to consider the nitrogen requirements of the hybrid based on its yield potential, being about 72-108 kg N/ha under conditions presented in this experiment. Early sowing under Egyptian conditions with prevailing average temperatures of 20-24°C during sowing and rising to about 28°C at harvest time are suitable to the hybrid Sirena to ensure maximum yield. Higher or lower temperatures during establishment appear to have negative effects on seed yield and to much lower extent on oil percentage.

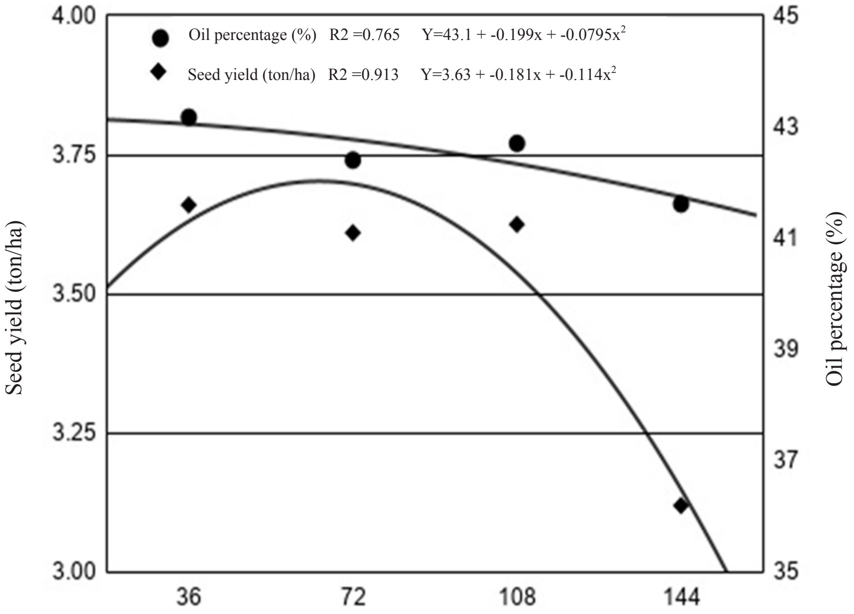

Fig. 3. Regression of seed yield and oil percentage on nitrogen fertilization dose for means of the two experiments for the two years of study

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تأثير ميعاد الزراعة و المحصول السابق على نمو و إنتاجية هجين دوار الشمس "سيرينا" تحت مستويات مختلفة من التسميد الأزوتى

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دوار الشمس الزيتى من المحاصيل التى لاقت إهتماماً كبيراً من القطاع الزراعى فى مصر فى بداية التسعينيات، حيث كان هناك طفرة فى إستخلاص الزيت من هذا المحصول. ولكن منذ ذلك الحين وعلى مر العقدين الماضيين قل الإهتمام بدوار الشمس الزيتى، فاختفت الهجن من الأسواق وصارت زراعة دوار الشمس بغرض إنتاج اللب للتسالى أكثر ربحاً للمزارع من دوار الشمس الزيتى. حديثاً تم تسجيل الهجين الفردى "سيرينا" فى مصر بهدف إستخلاص الزيت وجرى التسويق لزراعته على أساس نظام تعاقدى مع المزارعين مما يبشر بعودة زراعة دوار الشمس الزيتى فى مصر. وتهدف هذه الدراسة إلى تقييم أثر زراعة الهجين الجديد فى شهر أبريل مقارنة بالزراعة فى العروة المتأخرة فى شهر أغسطس وكذلك تقييم أثر المحصول السابق لدوار الشمس (إما ذرة شامية أو دوار شمس) فى حالة العروة المتأخرة وذلك تحت مستويات تسميد مختلفة (36 و 72 و 108 و 144 كجم نيتروجين/هكتار) وذلك على نمو و إنتاجية الهجين سيرينا.

وقد أوضحت نتائج عامى الدراسة أن الزراعة فى أبريل حيث متوسط درجة الحرارة يتراوح ما بين 20-24 درجة مئوية، ترتفع لاحقاً إلى 28 درجة مئوية عند الحصاد، قد أعطت أفضل إنتاجية وصلت إلى 4.39 طن/هكتار. أما فى حالة الزراعة فى العروة المتأخرة فى شهر أغسطس فإن إنتاجية الهجين إنخفضت إلى 3.4 طن/هكتار سواء كانت الأرض منزرعة بدوار الشمس أو الذرة الشامية فى العروة المبكرة. أما متوسط نسبة الزيت ببذور الهجين فكانت 42.8% و تأثرت الصفة بعام الزراعة أكثر من ميعاد الزراعة أو المحصول السابق. و بالنسبة لتأثير التسميد الأزوتى على الهجين، فقد أدت مستويات النيتروجين المرتفعة أصلاً بالتربة إلى حجب أثر مستويات النيتروجين المدروسة و لكن بقراءة معادلة الإرتداد و إستخدام المعادلات الخاصة بالتنبؤ بإحتياجات الأزوت لهجن دوار الشمس بناء على إنتاجيتها، فإن المعدل 72-108 كجم نيتروجين/هكتار كانت الأمثل للوصل لأعلى إنتاجية مع الإحتفاظ نسبة زيت أكثر من 42% فى بذور الهجين.