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RESPONSE OF SUNFLOWER TO DIFFERENT CROPPING PATTERNS AND N FERTILIZER RATES

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ABSTRACT: *Sunflower response to four cropping systems and 30 (N_1), 45 (N_2) and 60 (N_3) kg N/fed. were studied at Agriculture Research Station, Alexandria University, Egypt, during 2013 and 2014 summer seasons. Cropping systems were sunflower relay-cropping into (Sun_1) or double cropping with faba bean (Sun_2), in addition to sunflower double cropping following fodder (Sun_3) and silage (Sun_4) maize crops. Responses of head and 100-seed weights, as well as seed yield/ fed and harvest index (HI) to cropping systems, were significant over the two seasons. The highest values of those traits were obtained from relay-cropped sunflower to faba bean (Sun_1), however, the lowest values resulted from sunflower sowing after silage maize (Sun_4), that was previously relay-cropped into faba bean. Differences in seed yield and HI, for the combined treatments, were significant, as indicated by crop systems*N levels interaction in both seasons. The highest values of the two traits were obtained from (Sun_1) at 45 kg N /fed, whereas, the least values resulted from (Sun_4) at 15 kg N/fed. increasing the nitrogen level from 30 to 60 kg/ fed led to significant increases in plant height, head seed weight, seed yield/ fed and harvest index in both seasons. Response of head –seed and 100-seed weight, in addition to seed yield /fed. of sunflower, as N level was applied up to 45 kg N/fed. to nitrogen fertilization, was linear. Sunflower relay-cropping and growing of short season crops should be applied to enable farmers to plant more than two crops per year.*

***Key words**: Sunflower, Cropping systems, Nitrogen fertilizer, Seed yield.*

INTRODUCTION

Sunflower, that ranks second to soybean among the world's oil crops, is receiving increasing attention in Egypt as a source of vegetable oil and a way to reduce oil imports.

To reach land potential yield, multiple cropping through land , time and space dimensions represents a major procedure for increasing land use, provided, there should be an appropriate crop sequence combinations coupled with a suitable crop allocation within each sequence (Nawar *et al*., 2009). Intensive crop sequence means saving time enough for growing more than two crops per year (Khalil *et al*., 2011). Relay-cropping of sunflower into faba bean or into early maturing fodder maize will save time through elimination of turn over period between two successive crops and associate with triple, or more, sequential cropping.

The inclusion of faba bean, as a leguminous crop, with other non-legumes increases soil fertility due to N_2-fixation and producing roots, able to add organic matter and scavenge nutrients from lower soil depths (Nawar, 2004 and Khalil *et al.,* 2011). Responses of a crop to its allocation in crop sequence were reported in different studies. EL-Sodany and Abou-Elela (2012), Shaalan *et al.* (2014) and Ibrahim *et al.* (2015) found in divergent studies, that legumes improved soil quality, by increasing soil content from organic matter and added that crop sequences different in root depths were able to restore water and nutrients not accessed by their preceding crops. Khalil *et al.* (2004)

indicated that sunflower yield and its attributes (head and 100-seed weights) tended to be higher, following legumes than non-legumes.

Nitrogen is one of the most yield-limiting nutrients for crop production and must be applied to plants for growth (Fageria, 2009). In intensive cropping systems , agricultural production has increased the use of N fertilizer to produce and sustain high crop yields (Nawar, 2004, Khalil *et al*., 2011 and Ibrahim *et al*., 2015). In addition to the effect of nitrogen on the number of leaves/ plant, nitrogen, also, influences leaf area generation and photosynthesis capacity as well (Khalil, 2003). The increase in N uptake, as N level increased, led to greater size of vegetative shoot system, hence, larger photoassimilates production and translocation into seeds and individual seed weight (Nawar, 2004). Different studies showed that sunflower plant height (Khalil, 2003), seed weight/ head and seed index (Gewefiel, 1997) as well as seed and straw yields (Khalil, 2003).increased with increase N level .

Divergent two field studies of EL-Nakhlawy (1993) and Khalil (2003) revealed significant linear increases in sunflower seed yield as N level increased.

This investigation was carried out to study the beneficial effect of relay and sequential cropping of short duration crops, as a time saving factor for multiple cropping, under different N levels, on sunflower, growth and productivity.

MATERIALS AND METHHODS

A two year filed study was carried out during 2013 and 2014 summer seasons at Alexandria Agricultural Research Station, Alexandria University, Egypt. This investigation was laid out to study the effect of four cropping systems on sunflower (Sakha, 53 cv) supplied with 3 N levels. The cropping systems are presented in Table (1) as a four sunflower different sequences.

In Sun_1 and Sun_2, sunflower was sown as a relay-crop into or as a sequential crop , following faba bean, respectively, however, in Sun_3 and Sun_4, sunflower was relay-cropped, respectively, into fodder (55 days) and silage maize crop (75 days) which were grown sequentially after faba bean.

Nitrogen levels (i.e. N_1 (= 30), N_2 (= 45) and N_3 (= 60 KgN) were supplied to sunflower, as ammonium nitrogen (33.5%), in two equal doses, at the first and second irrigations.

A split plot design with three replicates was used where the main and sub-plots were, respectively, assigned to cropping systems and N levels in both seasons. Each sub-plot comprised seven ridges (each 12.6 m^2 in area = 3.0 m long $\times$ 0.6 m wide).

Table (1): **Sunflower crop sequences in both experiments.**

Cropping system	**Successive crops**
Sun_1	fa-sunflower (relay crop).
Sun_2	fa-sunflower (sequential crop).
Sun_3	fa-fodm-sunflower (relay crop).
Sun_4	fa-Sim-sunflower (relay crop).

Where ,Sun = Sunflower ,Sim = silage maize ,fodm = fodder maize and Fa= Faba bean

Faba bean (Giza 843 cv.) was sown on the upper and one side of ridges in hills (2 plants/ hill), spaced at 20 cm apart on November 15^{th} and 20^{th} during the two successive seasons. Relay-cropping of sunflower, fodder and silage maize crops (each house- hold maize seeds) was applied on March 15^{th} and 20^{th} in the first and second seasons, respectively. Meanwhile, sunflower followed fodder and silage crops, respectively, on May 15^{th} and June 15^{th}, in the first season with a delay in sowing of five days for these double crops in the second season. Sunflower, as well as maize fodder crops , were relay-cropped at the last irrigation of faba bean on the second side of faba bean ridge. Other cultural practices were applied, according to recommendations.

At sunflower harvesting, the plants of inner five ridges were random taken from each experimental unit. Characters recorded for sunflower were plant height (cm), number of leaves/ plant, head diameter (cm), head seed weight (g), 100-seed weight (g), seed yield (kg/ fed) and harvest index (HI). Economic evaluation, in terms of cereal units (CUs), was proposed by Brockhaus (1962) to express the agronomic gain from sunflower, based on its seed yield (the maize product), considering that each 100 kg seeds of sunflower seeds equals 1.5 cereal units. In addition, monetary net return/ kg N (pound) was estimated, as an economical parameter for sunflower seed yield (Net return) = Prices of sun flower yield – costs of agricultural practices. / N rate (kg). Analysis of data was conducted, according to Gomez and Gomez (1984), using SAS ver. 9.1.3 (2007). Means were compared, using the least significant difference (LSD) value at $p \leq 0.05$.

RESULTS AND DISCUSSION

1- Effect of preceding crops on growth traits of sunflower:

The effects of preceding crops on head diameter and 100-seed weight were significant and insignificant in both seasons (Tables 2, 3 and 4). The two traits were influenced by the time proximity of faba bean to sunflower, where the more it was, the greater estimates were obtained. Sunflower relay-cropping into faba bean (Sun_1) was statistically equal to its double cropping after faba bean, compared to the other preceding crops (Sun_3 and Sun_4). The data revealed insignificant differences among Sun_1, Sun_2 and Sun_3, which were significantly greater than Sun_4 in head diameter. Those observations hold fairly true during the two seasons. Faba bean, as a legume, is known to increase soil fertility, i.e. soil N and organic matter (Ghosh *et al*., 2007 and Rajaii and Dah-Mardeh, 2015) to improve soil physical properties (EL-Sodany and Abou-Elela, 2010 and Jannoura *et al*., 2014) and, consequently, to enhance the growth of succeeding crops.

Data, also, declared the significant response of head seed weight to the preceding crops. The greatest mean value of this trait was obtained from Sun_1 (in which sunflower was relay-cropped into faba bean), however, the lowest one was associated with sunflower sequential cropping after silage maize (Sun_4). On the other hand, there were insignificant differences between (Sun_3) and (Sun_4) but significantly lower and greater than Sun_1 and Sun_4, respectively, regarding values of head-seed yield. These results might be attributed to the more availability of soil N, with respect to (Sun_1) and (Sun_2), leading to higher N uptake (Fageria, 2009), which enhanced photoassimilates production and translocation into seeds (Przedonowek *et al*., 2004, Anderson, 2005 and Olowe and Adebime, 2009). Meanwhile, the negative results after silage maize might be due to the soil-low supply with organic N and / or greater N uptake from soil by the proceeding silage maize. Head seed weight, as an average of the two seasons for sunflower, grown in Sun_4, Sun_3 and Sun_2 treatments, were 71.4, 95.9 and 97.9%, respectively, of the Sun_1 head seed weight.

Table (2): Means of plant height ,head diameter and weight of Seeds /Head as influenced by nitrogen levels, and cropping system and their interaction during 2013 and 2014 seasons .

Factor	Plant height (cm)		Head diameter (cm)		Weight of Seeds /Head(g)	
	2013	2014	2013	2014	2013	2014
	Cropping system					
$Sun_1(S_1)$	154.55_a	154.22_a	9.68_a	9.83_a	35.06_a	34.03_b
Sun_2 (S_2)	153.22_a	153.67_a	9.44_a	9.63_a	34.13_b	35.63_a
Sun_3 (S_3)	151.89_a	153.77_a	9.39_a	9.56_a	33.74_b	34.54_b
$Sun_4(S_4)$	150.00_a	153.83_a	8.58_b	8.37_b	29.16_c	34.07_b
	Nitrogen levels					
N_1	147.67_c	151.58_c	9.00_a	9.00_a	31.92_b	32.23_b
N_2	153.08_b	153.83_b	9.26_a	9.36_a	33.03_a	33.89_a
N_3	156.50_a	156.08_a	9.58_a	9.69_a	33.13_a	34.06_a
	Cropping system *Nitrogen levels					
S_1 * N_1	148.66_{fg}	152.00_{def}	9.33_c	9.40_{de}	33.66_d	34.26_{de}
S_1 * N_2	155.33_{bc}	154.00_{bcd}	9.70_b	9.86_b	35.23_{bc}	35.83_b
S_1 * N_3	159.66_a	156.66_a	10.00_a	10.23_a	36.30_a	36.80_a
S_2 * N_1	148.00_{gh}	151.00_f	9.16_d	9.26_e	33.10_e	33.23_f
S_2 * N_2	154.00_{cd}	154.00_{bcd}	9.40_c	9.63_c	34.00_d	34.43_d
S_2* N_3	157.66_{ab}	156.00_{ab}	9.76_b	10.00_b	35.30_b	35.96_b
S_3 * N_1	148.00_{gh}	151.66_{ef}	9.13_d	9.23_e	32.66_f	33.00_f
S_3 * N_2	152.33_{de}	153.66_{cde}	9.36_c	9.56_{cd}	33.66_d	34.00_e
S_3 * N_3	155.33_{bc}	156.00_{ab}	9.66_b	9.86_b	34.90_c	35.20_c
S_4 * N_1	146.00_h	151.66_{ef}	8.30_g	8.06_h	28.23_i	28.43_i
S_4 * N_2	150.66_{ef}	153.66_{cde}	8.56_f	8.36_g	29.20_h	29.30_h
S_4 * N_3	153.33_{cd}	155.66_{abc}	8.86_e	8.66_f	30.03_g	30.26_g
$LSD_{0.05}$	2.47	2.27	0.104	0.172	0.356	0.426

(1) Means followed by the same letter(s) are not significant, but different letters are significant at 0.05 level.

Table (3): Means of biological yield ,100-seed weight and seed yield as influenced by nitrogen levels, and cropping system and their interaction during 2013 and 2014 seasons .

Factor	Biological yield (kg/fed)		100-seed weight (g)		Seed yield (kg/fed)	
	2013	2014	2013	2014	2013	2014
	Cropping system					
$Sun_1(S_1)$	1991.4a	2022.4a	7.77_a	7.91_a	1200_a	1122.3_c
Sun_2 (S_2)	1930.9b	1965.1a	7.53_{ab}	$7.62a_b$	1166_b	1184.4_a
Sun_3 (S_3)	1897.7b	1839.4ab	7.45_b	$7.55a_b$	1146_c	1168.3_b
$Sun_4(S_4)$	1638.9c	1598.7b	6.97_c	7.10_b	979.4_d	963.3_d
	Nitrogen levels					
N_1	1799.2c	1817.7a	7.16_c	7.23_b	1083.63_b	1095.75_b
N_2	1857.9b	1890.5a	7.42_b	7.59_a	1123.43_a	1133.53_a
N_3	1935.6a	1861.1a	7.72_a	7.82_a	1162.62_a	1172.72_a
	Cropping system *Nitrogen levels					
S_1 * N_1	1906.8	1931.13	7.43_d	7.56_{de}	1146.66_{de}	1163.33_e
S_1 * N_2	2008.07	2044.57	7.80_{bc}	7.96_b	1213.33_b	1231.66_b
S_1 * N_3	2059.4	2091.6	8.10_a	8.20_a	1240.00_a	1260.00_a
S_2 * N_1	1864.9	1903.5	7.26_e	7.36_f	1123.33_f	1146.66_f
S_2 * N_2	1908.2	1959.3	7.50_d	7.63_{cd}	1158.33_d	1178.33_d
S_2* N_3	2019.5	2032.6	7.83_b	7.86_b	1216.66_b	1228.33_b
S_3 * N_1	1839.8	1875.8	7.20_e	7.26_{fg}	1108.33_g	1130.00_g
S_3 * N_2	1891.3	1967.2	7.43_d	7.60_d	1143.33_e	1165.00_{de}
S_3 * N_3	1961.9	1675.2	7.73_c	7.80_{bc}	1186.66_c	1210.00_c
S_4 * N_1	1585.3	1560.2	6.73_g	6.73_h	955.00_j	940.00_j
S_4 * N_2	1624.03	1590.8	6.96_f	7.16_g	978.33_i	958.33_i
S_4 * N_3	1701.6	1645.0	7.20_e	7.40_{ef}	1005.00_h	991.66_h
$LSD_{0.05}$	- (2)	-	0.089	0.199	12.23	14.31

(1) Means followed by the same letter(s) are not significant, but different letters are significant at 0.05 level.
(2) The ignored L.S.D. indicates that (S×N) interaction was not significant.

Table (4): Means of harvest index, cereal units and nitrogen use efficiency as influenced by nitrogen levels, and cropping system and their interaction during 2013 and 2014 seasons .

Factor	H.I %		Cereal units (CUs)		nitrogen use efficiency (LE/kgN)	
	2013	2014	2013	2014	2013	2014
	Cropping system					
$Sun_1(S_1)$	32.96_a	33.82_a	17.95a	18.2a	28.57a	26.80c
Sun_2 (S_2)	32.38_{ab}	32.89_b	17.49b	17.77b	27.82b	29.05a
Sun_3 (S_3)	31.96_b	32.66_b	17.19c	17.47b	27.38c	28.28b
$Sun_4(S_4)$	28.22_c	28.67_c	14.69d	14.45c	23.44d	27.90b
	Nitrogen patterns					
N_1	30.51_b	31.18_b	16.22c	16.39c	36.11a	36.5a
N_2	31.39_a	31.95_a	16.85b	17.00b	24.93b	25.19b
N_3	32.22_a	32.88_a	17.44a	17.53a	19.36c	19.54c
	Cropping system *Nitrogen patterns					
S_1 * N_1	32.10 $_{cd}$	32.90 $_d$	17.05 ef	17.45 e	38.22 a	38.77 a
S_1 * N_2	32.83 $_b$	33.93 $_b$	18.18 b	18.48 ab	26.82 e	27.37 e
S_1 * N_3	33.93 $_a$	34.63 $_a$	18.62 a	18.67 a	20.66 i	21.00 g
S_2 * N_1	31.56 $_d$	32.03 $_e$	16.85 f	17.20 f	37.44 b	38.22 b
S_2 * N_2	32.56 $_{bc}$	32.66 $_d$	17.37 d	17.68 d	25.74 f	26.16 f
S_2* N_3	33.00 $_b$	33.96 $_b$	18.25 b	18.42 b	20.28 j	20.47 h
S_3 * N_1	30.90 $_e$	31.83 $_e$	16.62 g	16.78 g	36.94 c	37.66 c
S_3 * N_2	32.06 $_{cd}$	32.66 $_d$	17.15 e	17.47 e	25.41 g	25.89 f
S_3 * N_3	32.90 $_b$	33.46 $_c$	17.80 c	18.15 c	19.78 k	20.17 h
S_4 * N_1	27.50 $_h$	27.96 $_h$	14.32 j	14.1 j	31.83 d	31.33 d
S_4 * N_2	28.10 $_g$	28.56 $_g$	14.67 i	14.37 i	21.74 h	21.29 g
S_4 * N_3	29.06 $_f$	29.46 $_f$	15.08 h	14.89 h	16.75 l	16.52 i
$LSD_{0.05}$	0.582	0.404	0.21	0.20	0.328	0.302

(1) Means followed by the same letter(s) are not significant, but different letters are significant at 0.05 level.

The statistical analysis of seed yield/ fed. indicated significant differences among the four preceding crops. Data behaved similar over the two seasons. Results on seed yield/ fed, also, revealed that the highest seed yield of sunflower was obtained when the crop was relay-cropped into faba bean, whereas, it was inferior when sunflower was preceded by silage maize. These results might be attributed to the production of vigorous plants with a wide foliage in Sun_1, compared to Sun_4treatment.That increased light uptake and photoassimilates production and translocation,these increasing number of seeds and individual seed weight with the final increase in seed yield/ fed (Khalil, 2003 and Khalil *et al*., 2004). Sinclair and Gardner (1998) attributed yield increases of a crop to increases in harvest index or to biological yield increase. As observed, the yield inferiority of (Sun_4), compared to (Sun_1) treatment, might be due to lower proximity in time of sunflower to faba bean that was coupled with greater resources depletion by silage maize before their access to sunflower (Khalil, 2003). Relay-cropping of sunflower into faba bean plants gave yield increase of 220.6, 54.0 and 34.0 kg, in the first season, and 255.0, 49.7 and 33.9 kg, , respectively, compared to Sun_4, Sun_3 and Sun_2 treatments.

Concerning, HI, as shown from data, this trait followed the same course of change with seed yield/ fed over the two seasons. Data obviously showed that the more the time proximity between sunflower and, the higher the yield obtained. Direct arrival of fixed N (in Sun_1) by faba bean to sunflower increased N uptake that was associated with increasing the other growth nutrients (Fageria, 2009) which was reflected in the enhancement of dry matter translocation into the economic part (seeds) and increase HI (Gardner *et al*., 1985 and Sinclair and Gardner, 1998).

Differences in cereal units (CUs), among the four cropping patterns, were significant, greater for sunflower ,as a relay-crop to faba bean (Sun_1), followed by Sun_2, Sun_3 and Sun_4,which ranked second, third and fourth to (Sun_1), respectively. These results might be attributed to the more availability of soil N, with respect to Sun_1 and Sun_2 (relay or sequential cropping to faba bean), leading to higher N and other growth nutrients uptake (Fageria, 2009) , which enhanced photoassimilates production and translocation into vegetative and reproductive parts (Zamski and Schaffer, 1996). The lowest value of CUs was obtained when sunflower was proceeded by silage maize, which resulted from greater N uptake by silage and lower N available for sunflower which was reflected in CUs reduction, as a result of HI decline (Khalil *et al*., 2004 and Shaalan *et al*., 2015).

2- Effect of nitrogen level on sunflower growth traits:

Responses of sunflower growth traits to N levels (Tables 2, 3 and 4) were significant, except for number of leaves/ plant and head diameter, in both seasons.

There were significant differences in plant height with N level, where the more the N level, the taller plants were produced during the two seasons. Higher N application increased the level of its uptake, leading to vigorous vegetative growth and, consequently, taller sunflower plants (Sinclair and Gardner, 1998).

Data showed that the increases in head seed yield and 100-seed weight, were significant at 45, but insignificant at 60 kg N/ fed, in both seasons. Compared to N_1, increases in 100-seed weight of N_2 and N_3 averaged 0.4 and 0.5 g, respectively. However, N_2 and N_3 were superior to N_1 in that trait by 1.62 and 1.76 g, as an average of both seasons, respectively.

Application of nitrogen up to 45 kg/ fed led to a significant increase in seed yield/ fed., while, the further increase of 60 kg/fed produced insignificant increase in that trait. Responses of sunflower seed yield to N_1, N_2 and N_3 were, 1083.3, 1123.43 and 1162.1 kg/ fed respectively, in the first season, corresponding to 1095.75, 1133.53 and 1172.72 kg/ fed. in the second season. Lesser N uptake during seed development and maturity, as a result of applying lower N levels, might reduce photoassimilates partitioning into the developing seeds, resulting in small or infertile seeds (Loubser and Humam, 1993). This might explain the reductions in 100-seed weight and seed weight/ head. These results were in agreement with those reported by several investigators, who indicated that increasing N level increased plant height, 100-seed weight, weight of seeds/ head and seed yield/ fed. (Gewefiel *et al*., 1997; Halvorson *et al*., 1999 and Khalil, 2003).

Harvest index behaved similar to seed yield/ fed, as influenced by N level, during the two successive seasons. Sunflower HI indices reached the highest and the lowest values at the N_3 and N_1 levels, respectively. Increasing N level increased leaf generation and expansion, in terms of LAI, that was associated with great light interception, N use efficiency and assimilates greater translocation to seeds of a head (compared to the non-economic parts), resulting in an increase of sunflower harvest index (Gardner *et al*., 1985 and Sinclir and Gardner, 1998).

Data showed that the effect of N levels on cereal units (CUs) was significant during the two seasons. The N_3 level produced the highest cereal units from sunflower, whereas, the least was obtained by the 30 kgN application. Lesser uptake of N and other growth resources, during seed development and maturity, as a result of applying lower N rates, might have reduced photoassimilates translocation into the developing seeds, resulting in a low production of seed and straw yields (Nawar, 2004 and Halvorson *et al*., 1999), hence a decrease in CUs.

The monetary net return, invested in one kilogram of applied N, was inversely related to N rates, where, the maximum and minimum responses of 36.11 and 19.36 Egyptian pounds, in the first season, compared to 36.5 and 19.54, in the second season, were produced from 30 and 60 kgN/ fed, respectively. Increasing N level might have increased production costs, which was not compensated for by a proportional increase in seed yield (Khalil, 2003).

The response equations of seed yield/head ,100-seed weight and seed yield to nitrogen fertilization levels indicated that these traits linearly increased as nitrogen fertilizer increased up to 45 kg N/fed. (Fig. 1). The coefficients of determination (r^2) indicated that 54.2 ,90 and 98 % in the first season, in addition to 81, 98 and 98 %, in the second season , of the total variation for these traits ,respectively ,were explained by the linear regression .That finding might indicate the possibility of increasing N level above 45 kg/fed. to obtain higher records of these characters.

3- Cropping systems × N levels interaction effect on sunflower traits:

The interaction effects on some growth traits of sunflower followed the general trend of the two studied factors in both seasons.

Increases in values of head-seed weight were positively associated with time proximity of sunflower to faba bean and increases in N level, as well. As a result, the $S_1 \times N_3$ and interactions $S_4 * N_1$ produced the highest and lowest values of 36.55 and 28.33 g, as an average of the two seasons, respectively. In addition, data in Table 2 , 3

Fig 1

and 4 indicated that cropping system and N levels first order interaction, significantly affected both seed yield/ fed. and harvest index over the two seasons. Decreases in these traits resulted from a delay in sunflower sowing date (from time of Sun_1 to that of Sun_4)by decreasing N level. Consequently, $S_1\times N_3$ interaction gave the highest values of yield and HI, corresponding to the minimum ones obtained from $S_4\times N_1$ interaction in the two successive seasons. Increases in yield, with $S_1\times N_3$ combination, were 285 and 320 kg/ fed in the two successive seasons, compared to S_4 and N_1 combined effect. On the other hand, the application of Sun_4,with N_1 level, led to a reduction in HI during the two seasons. Increasing N level, under the same cropping system, increased sunflower-harvest index, which reached the highest or lowest with $S_1\times N_3$ and $S_4\times N_1$interactions, respectively. Application of N_3 rate to a soil, higher in soil fertility (N status ,i.e. sun_1), probably allowed the increase in photoassimlates production and translocation into grains ,compared to the transfer into the vegetative parts (straw),resulting in the raise of sunflower harvest index (Shaalan *et al*.,2014 and Ibrahim *et al.*, 2015)

Cropping systems and N levels combined effect on a monetary net return obtained from one kilogram of applied N, was significant with the course of change over the two seasons. The 30 and 60 kg N/ fed produced the greatest and smallest values of that trait over the four preceding crops where returns attributed to the increase in seed yield did not compensate for the increased costs as N level increased. Differences in the economic use of one kilogram N, within any of N level, varied with preceding crops. When sunflower was relay-cropped into faba bean or sequentially followed it, there were increases in profits of lower N application where the more the soil was rich in organic matter, the lower response of sunflower to higher N levels.

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استجابة محصول دوار الشمس لنظم زراعية ومستويات من التسميد الآزوتى المختلفة

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الملخص العربى

تمت دراسة استجابة محصول زهرة دوار الشمس لأربعة من نظم الزراعة تحت تأثير مستويات مختلفة من التسميد النيتروجينى وهى (٣٠، ٤٥، ٦٠ كجم نيتروجين/ فدان)، وكانت نظم الزراعة كما يلى:

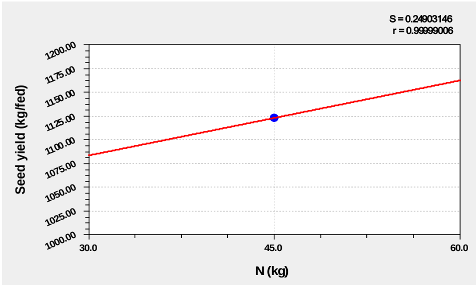
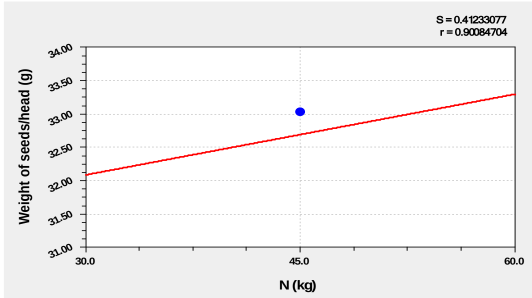
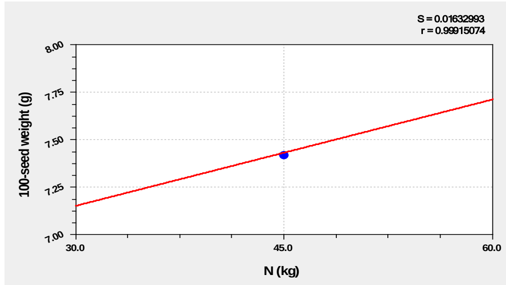
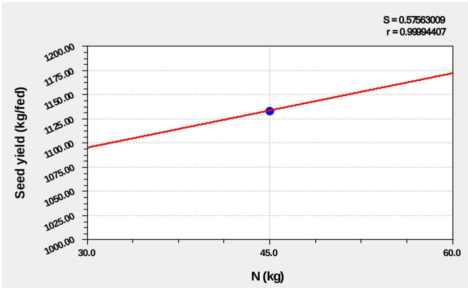
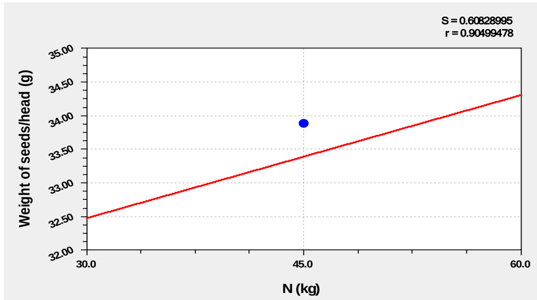
Sun_1 : زراعة دوار الشمس متكئاً على الفول البلدى، Sun_2 : زراعة دوار الشمس بعد الفول البلدى، Sun_3 : زراعة دوار الشمس بعد ذرة العلف (دراوة) الذى زرع بالتناوب على الفول البلدى، Sun_4 : زراعة دوار الشمس على الفول البلدى بعد السيلاج الذى زرع بالتناوب على الفول البلدى.

كانت استجابة صفات محصول بذور النبات، ووزن المائة بذرة، ومحصول الفدان وكذلك دليل الحصاد لنظم الزراعة استجابة معنوية. حيث تم الحصول على أعلى النظم لهذه الصفات عندما زرع دوار الشمس بالتناوب على الفول البلدى، بينما كانت أقل النظم لهذه الصفات عندما زرع دوار الشمس خلف ذرة السيلاج.

وكانت زيادة مستوى التسميد النيتروجينى حتى ٦٠ كجم/ فدان قد ادت إلى زيادة معنوية فى ارتفاع النبات ومحصول القرص بجانب الزيادة فى كل من محصول الفدان ودليل الحصاد.

وكانت استجابة كل من محصول القرص و وزن المائة بذرة ومحصول الفدان للتسميد النيتروجينى استجابة خطية و أوضحت البيانات أنه باستخدام التناوب المحصولى مع المحاصيل قصيرة العمر يمكن زراعة أكثر من محصولين فى العام الواحد.

Fig (1): Linear regression for each of seed yield, seed weight per head and 100-seed weight on N levels in 2013 and 2014 summer seasons.

Season	Seed yield (kg/ fed)	**Weight of seeds/head (g)**	**100-seed weight (g)**
2013	S = 0.261 r^2 = 0.98 $\hat{Y}$= 1044.19 + 2.634 X  	S = 0.807 r^2 = 0.542 $\hat{Y}$= 31.628 + 0.4143 X  	S = 0.126 r^2 = 0.90 $\hat{Y}$= 6.87 + 0.018 X 
2014	S= 0.575 r^2 = 0.98 $\hat{Y}$= 1057.03 + 2.56 X  	S = 0.608 r^2 = 0.81 $\hat{Y}$= 31.56 + 0.061 X  	S = 0.053 r^2 = 0.98 $\hat{Y}$= 6.96 + 0.0196 X