Asian J Agri & Biol. 2018;6(3):357-366.

AJAB

Original Research Article

Splitting of nitrogen application through growth stages in various sunflower cultivars to improve their vegetative growth and seed yield

Hanaa Khudhaier Mohammed Ali Al-haidary
Department of Field Crops, College of Agricultural Engineering Sciences, University of Baghdad, Karrada District, Al-Jadiriya, Baghdad, Iraq

Received:
November 17, 2017
Accepted:
May 15, 2018
Published:
September 30, 2018

**Corresponding author email:*
hanaa.khuder@coagri.uobaghdad.edu.iq

Abstract

A field experiment was carried out in spring seasons of 2012 and 2013 to increase the efficiency of nitrogen application in spite of that no splitting nitrogen has practiced for the studied cultivars. Five splitting treatments (T1, T2, T3, T4, and T5) of nitrogen application were studied in three sunflower cultivars (Shumos, Akmar, and Zehrat Al-Iraq). The results showed that Shumos cultivar, T4 treatment of nitrogen application and their interaction gave the highest seed yield (6.3 and 6.43), (5.78 and 6) and (6.62 and 6.9 ton ha^{-1}), respectively, on both seasons. The highest significant correlation value belonged to the correlation between seed yield and leaf area (0.85 and 0.87) for both seasons. It can be concluded that splitting of nitrogen fertilizer during growth stages is effective to increase the efficiency of nitrogen application and lead to increase seed yield. Also, leaf area could be a selection criterion to improve seed yield.

Keywords: *Helianthus annuus* L., Nitrogen, Sunflower, Vegetative growth, Seed yield

Introduction

Helianthus annuus L. is one of the important oil crops because of the high quantity and quality of its oilseed content. Oil crops are considered as soil exhausted and any weakness of fertilization management lead to a decline in yield (Ali et al., 2007). Khan et al. (2006) indicated that shortage of soil nutrients content such as nitrogen in the root zone maybe causes a big weakness in the vegetative growth and lead to decline seed yield. Vegetative and reproductive growth stages of sunflower were described by Schneiter and Miller (1981) which differ in their nutrients requirement. That is asks to use certain nitrogen application during specific growth stages in which their effects were clear on seed yield components. On another hand, that practice is considered an important method for decrease risk of lodging which is resulted in high levels of nitrogen. The optimum use of nitrogen by the plant with minimized losses by volatility, leaching, and fixation was got a lot of considerations. The nitrogen improved root growth and increased leave area, time of lasting green, net of photosynthesis and some of the yield components (Tsialtas and Maslaris, 2008; Rafiq et al., 2010). Ozer et al. (2004) mentioned that nitrogen maybe contributes in growth and development both of roots and vegetative parts through improving the relation between source-sink and elongation of the vegetative part, high CO_2 metabolism caused increased photosynthesis plant parts (Tonev, 2006). Mazher et al. (2006) and Awais et al. (2013) considered nitrogen is a key of functions for each amino acids, cellulose, chlorophyll, proteins, quinines, oxins, and organizing of enzymes actions which in turn are transformed as a products of photosynthesis activity as starch contents in leave's cell wall and then are converted to the seed. Yasin et al. (2013) noticed an increase in seed number per disc of sunflower to 1267 and weigh of 1000 seed to 68.65 g, biological yield to 11166.6 kg ha^{-1}, seed yield to 3360 kg ha^{-1} and harvest index to 30.09%. Yu et al. (2002) and Khan et al. (2006) reported that adding nitrogen at the flowering stage and seed set contributes in development of the pollen tube and fertilization and formation of the flowers set and seed filling period through raising of carbohydrate metabolism and making balance between the net of photosynthesis and respiration. AL-Ahbabi and Al-Gebore (2015) noticed increase percentage of fertility and total seed yield of sunflower when nitrogen was added at the beginning of the flower disc formation. Shehzad and Maqsood (2015) noticed that splitting of nitrogen application through growth stages effected on growth, yield component, seed yield and quality of fatty acids (citric, palmitic, oleic and linolenic) of sunflower, also they noticed that splitting of nitrogen (at emergence, 50% of the flowering and 50% of maturity stages) gave the highest number of seed per disc and seed yield in comparison with adding all the amount of nitrogen. AL-Ahbabi and Al-Gebore (2015) found significant differences among cultivars in seed yield; the Isaki-1 cultivar gave the highest seed yield (3.96 ton ha^{-1}) due to the increase in disc diameter and conversion efficiency metabolites of the photosynthesis from the source to the sink and the increase of harvest index. The aim was to investigate the effect of the splitting of nitrogen application through growth stages of sunflower on growth, yield and yield components of three cultivars in spite of that no splitting nitrogen has practiced for these cultivars. Also, calculation the correlation between traits to determine the trait(s) that could be related with seed yield to use as a selection criterion to improve seed yield.

Material and Methods

A factorial field experiment was carried out at College of Agricultural Engineering Sciences, University of Baghdad during 2012 and 2013 spring seasons. Three cultivars of sunflower (Shumos, Akmar, and Zehrat Al-Iraq) and five treatments (T1, T2, T3, T4 and T5) of splitting of nitrogen application (150 kg ha^{-1}) through growth stages were investigated (Table 1). Experimental field soil was plowed and divided into 45 experimental units. Area of each experimental unit was 8.4 m^2 with 3 m width and included 4 furrows. One meter distance was left between each experimental unit to prevent fertilizers and water leakage. The seed were planted on furrows with a distance of 70 cm between the furrows and 25 cm between plants. The plant's density was 57142 plants ha^{-1}. Tri superphosphate (46% P_20_5) was added with 80 kg ha^{-1} before planting during processes of soil preparation. Hand sowing was done in 14th and 10th of March of 2012 and 2013 by planting 3 seed per hole at depth 5 cm then thinning to one plant per hole after formation two of real leaves. Hand weeding, irrigation, and harvesting were done according to the recommendations. Some of the physical and chemical properties of the experiment's soil were recorded in 2012 and 2013 seasons (Table 2).

The following traits were studied on ten plants that selected randomly from the medium lines; plant height (cm), leaf width (cm), number of leaves per plant, leaf area (m^2) was calculated according to Elsahookie and Eldabas (1982), disc diameter (cm), fertility ratio (%), number of seed per disc, weight of 1000 seed (g), seed yield (ton ha^{-1}).

Statistical analysis

A randomized complete block design in split plot arrangement with three replications was applied. Sunflower cultivars were placed as main plots and nitrogen application as subplots. The data were analyzed by Genstat program, version 4.0. The means were compared by the test of least significant difference at 0.05 level of probability (LSD5%) and the correlation coefficient (r) was calculated between studied traits (Steel et al., 1997).

Results

Plant height (cm)

The results of table 3 showed that Shumos cultivar had a significant performance. It gave the highest plant height (203.4 and 212.4 cm) during both seasons. T4 had a significant superiority in plant height in the second season (179.3 cm) without differing significantly with T1, T3, and T5. The highest response of plant height was belonged to the interaction of Shumos×T4 (210.3 and 222.3 cm) during both seasons without differing significantly with the interactions of Shumos×T1 or Shumos×T5, while the less response was obtained by the Akmar×T2 during both seasons.

Leaf width (cm)

The Shumos cultivar gave the highest leaf width (19.2 and 21.4 cm) during both seasons (Table 4). T4 had a significant superiority in leaf width (18.4 and 20.1 cm) without differing significantly with T1 during both seasons. The highest response of leaf width was belonged to the interaction of Shumos×T4 (20.1 and 23 cm) during both seasons, without differing significantly with the interactions of Shumos×T1 during both seasons or with Shumos×T2 and Shumos×T3 during the first season (Table 4).

Number of leaves per plant

As a response to the effect of cultivars; the highest leaves number per plant which surpassed others significantly was related with Shumos cultivar (18.9 and 19.8) during both seasons (Table 5). The response of leaves number per plant to the effect of the splitting of nitrogen application was significant, and the highest average which surpassed others significantly was related with the treatment of T4 (16.1 and 17.4) during both seasons, but it didn't differ significantly with T1 during the first season (Table 5). The interaction treatment of Shumos×T4 surpassed others significantly when gave the highest leaves number per plant (20.8 and 22.2) during both seasons, without differing significantly with the interaction treatment of Shumos×T3 during the first season (Table 5).

Leaf area (m^2)

The significant response of leaf area to the cultivars effect gave the highest average that correlated with the cultivar of Shumos (0.447 and 0.529 m^2) during both seasons (Table 6). As a response to the effect of the splitting of nitrogen application; the highest leaf area which surpassed others significantly was correlated with the treatment of T4 (0.373 and 0.419 m^2) during both seasons (Table 6). The cultivars responded significantly to the splitting of nitrogen application and the interaction treatment of Shumos×T4 surpassed others to give the highest average (0.543 and 0.633 m^2), while the lowest response was obtained by the Akmar×T3 during both seasons (Table 6).

Disc diameter (cm)

The results of table 7 showed that Shumos cultivar had a significant performance. It gave the highest disc diameter (16.7 and 17.9 cm) during both seasons. T4 had a significant superiority in disc diameter (15.6 and 17 cm) during both seasons, without differing significantly with T1 during the first season (Table 7). The highest response of disc diameter was belonged to the interaction treatment of Shumos×T4 (18.3 and 19.5 cm) during both seasons, without differing significantly with Shumos×T1 or Shumos×T2, or Shumos×T3 during the first season (Table 7).

Fertility ratio (%)

The cultivar of Zehrat Al-Iraq gave the highest fertility ratio (91 and 92 %) without differing significantly with the cultivar of Shumos during both seasons (Table 8). The treatment of T4 had superiority in fertility ratio (90 and 93 %) during both seasons, without differing significantly with T1, T3, and T5 during the first season (Table 8). The highest response of fertility ratio was belonged to the interaction treatment of Shumos×T4 (96%) without differing significantly with the Shumos×T4 or Zehrat Al-Iraq×T4 or Zehrat Al-Iraq×T1 or Zehrat Al-Iraq×T5 during the second season, while the results were not significant during the first season (Table 8).

Number of seed per disc

As a response to the effect of cultivars; the highest seed number per disc which surpassed others significantly was related with Zehrat Al-Iraq cultivar (1281 and 1329) on both seasons (Table 9). The response of disc seed number to the splitting of nitrogen application was significant, and the highest average which surpassed others significantly was related with the treatment of T4 (1182 and 1251) on both seasons (Table 9). The interaction treatment of Zehrat Al-Iraq×T4 surpassed others significantly when gave the highest seed number per disc (1469 and 1532) on both seasons (Table 9).

Weight of 1000 seed (g)

The weight of 1000 seed was responded to the cultivars effect and gave the highest average that correlated with the cultivar of Shumos (99 and 101.27 g) which surpassed others significantly on both seasons (Table 10). As a response to the effect of the splitting of nitrogen application; the highest weight of 1000 seed which surpassed others significantly was correlated with the treatment of T4 (79 and 82.44 g) on both seasons (Table 10). The cultivars responded significantly to the splitting of nitrogen application and the interaction treatment of Shumos×T4 surpassed other and gave the highest average (111.33 and 111.24 g) on both seasons (Table 10).

Seed yield (ton ha^{-1})

The results of table 11 showed that Shumos cultivar gave the highest seed yield (6.3 and 6.43 ton ha^{-1}) which surpassed others significantly during both seasons. The treatment of T4 had a significant superiority with seed yield (5.78 and 6 ton ha^{-1}) in comparison to others during both seasons (Table 11). The highest response of the seed yield was belonged to the interaction treatment of Shumos×T4 (6.62 and 6.9 ton ha^{-1}) that surpassed others significantly, while the lowest response was obtained by the Akmar×T3 on both seasons (Table 11).

Correlation between studied traits

There was a significant positive correlation between the most studied traits on both seasons. The seed yield was correlated positively and significantly with all studied traits on both seasons, except the number of seed per disc during the second season (Table 12) and the highest correlation coefficient value attained among seed yield with leaf area (0.85 and 0.87) on both seasons.

The weight of 1000 seed was correlated positively and significantly with all studied traits during both seasons, except the fertility ratio and number of seed per disc (Table 12) and the highest correlation coefficient value attained among weight of 1000 seed with plant height (0.81 and 0.82) on both seasons.

The number of seed per disc didn't give stable correlation relationships with traits of vegetative and reproductive growth on both seasons (Table 12).

The fertility ratio was correlated positively and significantly with all studied traits during both seasons, except disc diameter and weight of 1000 seed (Table 12) and the highest correlation coefficient value attained among fertility ratio with leaf area (0.70 and 0.64) on both seasons.

The disc diameter was correlated positively and significantly with all studied traits during both seasons, except number of seed per disc and fertility ratio (Table 12).

The leaf area was correlated positively and significantly with all studied traits during both seasons, except the number of seed per disc during the second season (Table 12) and the highest correlation coefficient values attained among leaf area with number of leaves per plant (0.95 and 0.96), leaf width (0.94 and 0.91), and seed yield (0.84 and 0.85), respectively, on both seasons.

The number of leaves per plant was correlated positively and significantly with all studied traits during both seasons, except the number of seed per disc during the second season (Table 12).

The leaf width was correlated positively and significantly with all studied traits during both seasons, except the number of seed per disc on the second season (Table 12).

Table 1. The treatments (T1, T2, T3, T4 and T5) of splitting of nitrogen application (150 kg ha^{-1}) through growth stages

Growth stages	T1	T2	T3	T4	T5
Two leaves	One-half (1/2)	One-half		One-third (1/3)	
Four leaves			One-half		One-third
Six leaves	One-half			One-third	
50% of the flower buds appearance		One-half	One-half	One-third	One-third
Complete flowering					One -third

Table 2. Some of the physical and chemical properties of the experiment's soil.

Soil components	Season of 2012	Season of 2013
Silt (g*kg^{-1} soil)	520.2	541.8
Clay (g*kg^{-1} soil)	349.2	333.7
Sand (g*kg^{-1} soil)	130.5	124.5
Soil texture	Silty clay loam	Silty clay loam
Soil pH	8.3	8.6
Nitrogen (mg*kg^{-1} soil)	33	41
Available phosphorus (mg*kg^{-1} soil)	49	47
Available potassium (mg*kg^{-1} soil)	38	31
Organic matter (%)	8.4	8.9
Ec (dS*m^{-1})	3.2	3.7

Table 3. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on plant height (cm) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	209.1 216.6	193.4 195.4	196.5 207.3	210.3 222.3	207.7 220.5	203.4 212.4
Akmar	140.3 146.6	135.3 137.0	160.4 164.8	142.4 145.0	138.7 143.3	143.4 147.3
Zehrat Al-Iraq	154.8 162.5	164.1 172.7	150.0 155.4	163.1 170.8	155.4 163.7	157.5 165.0
Average	168.1 175.2	164.2 168.4	168.9 175.8	171.9 179.3	167.3 175.8	
LSD5%	Cultivars		Treatments		Interaction	
	9.9 6.9		ns 6.6		14.6 11.3	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively, [ns]Not significant at $P<0.05$

Table 4. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on leaf width (cm) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	20 22.2	18.7 20.7	18.8 20.9	20.1 23	18.5 20.1	19.2 21.4
Akmar	13.8 15.7	13.6 14.8	13.4 17.7	16.5 17.6	15.3 15.3	14.5 16.2
Zehrat Al-Iraq	18.8 20.2	15.9 16.7	17.9 19	18.7 19.8	14.9 15.4	17.3 18.2
Average	17.6 19.4	16.1 17.2	16.7 19.2	18.4 20.1	16.3 17	
LSD5%	Cultivars		Treatments		Interaction	
	0.5 0.5		1 0.8		1.5 1.3	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 5. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on number of leaves per plant during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	19.3 19.9	16.2 17	19.7 21	20.8 22.2	17.9 19.1	18.9 19.8
Akmar	11.6 12.8	10.2 11.5	10.2 11.3	11.4 12.6	11 12.2	10.9 12.1
Zehrat Al-Iraq	16.1 17.4	16 16.5	14.2 15.6	16.2 17.4	14.1 15.2	15.3 16.4
Average	15.7 16.7	14.1 15	14.7 16	16.1 17.4	14.3 15.5	
LSD5%	Cultivars		Treatments		Interaction	
	0.9 0.7		0.7 0.5		1.3 0.9	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 6. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on leaf area (m^2) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	0.473 0.520	0.367 0.460	0.453 0.540	0.543 0.633	0.397 0.493	0.447 0.529
Akmar	0.143 0.173	0.127 0.157	0.120 0.150	0.207 0.227	0.160 0.173	0.151 0.176
Zehrat Al-Iraq	0.370 0.400	0.263 0.283	0.320 0.350	0.370 0.397	0.207 0.240	0.306 0.334
Average	0.329 0.364	0.252 0.300	0.298 0.347	0.373 0.419	0.254 0.302	
LSD5%	Cultivars		Treatments		Interaction	
	0.021 0.023		0.029 0.027		0.047 0.045	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 7. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on disc diameter (cm) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	16.8 18.1	16.8 17.7	17.2 18.2	18.3 19.5	14.4 15.8	16.7 17.9
Akmar	15.6 16.5	13.1 14.3	12.2 13.3	14.5 16.2	13.4 14.2	13.7 14.9
Zehrat Al-Iraq	12.6 12.9	13.1 13.9	13.6 14.3	14.0 15.2	13.2 13.9	13.3 14
Average	15 15.8	14.3 15.3	14.3 15.2	15.6 17	13.7 14.6	
LSD5%	Cultivars		Treatments		Interaction	
	0.3 0.6		1 0.8		1.6 1.3	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively

Table 8. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on fertility ratio (%) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	92 95	84 84	91 92	93 96	90 92	90 92
Akmar	82 84	79 82	84 87	85 89	83 86	83 85
Zehrat Al-Iraq	92 94	84 85	92 93	93 95	92 94	91 92
Average	89 91	82 84	89 91	90 93	88 91	
LSD5%	Cultivars		Treatments		Interaction	
	2 1		2 1		ns 2	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively, ^{ns}Not significant at $P<0.05$

Table 9. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on number of seed per disc during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	1113 1127	1028 1045	1022 1067	1120 1150	1128 1164	1082 1111
Akmar	940 993	891 1010	877 1037	958 1072	833 998	900 1022
Zehrat Al-Iraq	1297 1345	1257 1285	1132 1149	1469 1532	1250 1336	1281 1329
Average	1117 1155	1059 1113	1010 1084	1182 1251	1070 1166	
LSD5%	Cultivars		Treatments		Interaction	
	71 68		45 48		89 90	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 10. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on weight of 1000 seed (g) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	99.67 102.33	89.67 94.67	89.33 92.33	111.33 111.24	105 105.67	99 101.27
Akmar	67 70	72.33 74.33	61 64	67.67 71.67	67.67 70	67.13 70
Zehrat Al-Iraq	55 59.33	57 61	57.67 60.33	58 64.33	55.33 63.67	56.6 61.73
Average	73.89 77.22	73 76.67	69.33 72.22	79 82.44	76 79.78	
LSD5%	Cultivars		Treatments		Interaction	
	2.18 3.64		2.71 2.41		4.47 4.65	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 11. Effect of the treatments of the splitting of nitrogen application, sunflower cultivars and their interaction on seed yield (ton ha^{-1}) during 2012 and 2013 spring seasons

Sunflower cultivars	Treatments of the splitting of nitrogen application					Average
	T1	T2	T3	T4	T5	
Shumos	6.43 6.47	6.13 6.2	6.1 6.17	6.62 6.9	6.23 6.39	6.3 6.43
Akmar	4.54 4.67	4.64 4.8	3.55 3.94	5.02 5.2	4.78 4.96	4.51 4.72
Zehrat Al-Iraq	5.1 5.6	4.77 4.99	4.35 4.53	5.69 5.89	5.1 5.28	4.99 5.26
Average	5.35 5.58	5.18 5.33	4.67 4.88	5.78 6	5.35 5.54	
LSD5%	Cultivars		Treatments		Interaction	
	0.19 0.23		0.2 0.19		0.33 0.34	

The upper and lower averages represented 2012 and 2013 spring seasons, respectively.

Table 12. Correlation coefficient value (r) between studied traits under the effect of the splitting of nitrogen application, sunflower cultivars and their interaction during 2012 and 2013 spring seasons

Traits studied	Seed yield	Weight of 1000 seed	Number of seed per disc	Fertility ratio	Disc diameter	Leaf area	Number of leaves per plant	Leaf width
Plant height	0.76* 0.78*	0.81* 0.82*	0.21 0.10	0.47* 0.51*	0.60* 0.63*	0.80* 0.88*	0.84* 0.87*	0.67* 0.79*
Leaf width	0.78* 0.74*	0.53* 0.65*	0.46* 0.18	0.65* 0.60*	0.52* 0.60*	0.94* 0.91*	0.83* 0.83*	
Number of leaves per plant	0.84* 0.85*	0.63* 0.66*	0.51* 0.33	0.68* 0.68*	0.62* 0.60*	0.95* 0.96*		
Leaf area	0.85* 0.87*	0.64* 0.73*	0.47* 0.22	0.70* 0.64*	0.63* 0.66*			
Disc diameter	0.68* 0.69*	0.74* 0.79*	-0.05 -0.27	0.23 0.22				
Fertility ratio	0.53* 0.55*	0.19 0.23	0.65* 0.56*					
Number of seed per disc	0.37* 0.23	-0.18 -0.28						
Weight of 1000 seed	0.76* 0.79*							

The upper and lower values represented 2012 and 2013 spring seasons, respectively, *Significant at $P<0.05$

Discussion

The Shumos cultivar had a superiority performance with all growth parameters for the two seasons in plant height, leaf width, number of plant leaves, leaf area, and disc diameter (Tables 3, 4, 5, 6, and 7). Also, Shumos cultivar surpassed other cultivars in fertility ratio, weight of 1000 seed and seed yield (Tables 8, 10, and 11). This may be attributed to the genetic nature of this cultivar and its high ability to tolerant the environmental conditions which led to the formation and compositing the growth of the plant parts, and increase photosynthesis activity then use its products in vegetative growth improvement and this represents the high efficiency of the photosynthesis of this cultivar which led to increasing the seed yield and yield components. This is agreed with Al-Ahbabi and Al-Gebore (2015).

The highest seed numbers per disc in Zehrat Al-Iraq cultivar didn't show the highest seed yield and weight of 1000 seed. This is maybe due to the cultivar trait and it's response to the nitrogen application or maybe due to the concept of compensation that occurs alternately between the number of formed seed and their weight. The more number of formed seed the more decrease in their weight and vice versa. This is confirmed by the results in tables 9 and 10, in addition to the results of simple correlation analysis, which showed an inverse relationship between these two traits (Table 12).

The treatment of T4 in which nitrogen was added at three stages that represented stages of vegetative growth and beginning of the reproduction stage was related to the superiority performance in plant height, leaf width, number of plant leaves, leaf area and disc diameter (Tables 3, 4, 5, 6, and 7). Also, T4 treatment influenced significantly in fertility ratio, number of seed per disc, weight of 1000 seed, and seed yield (Tables 8, 9, 10, and 11). That is maybe due to the optimum utilization of nitrogen by plant organs which is important during growth stages that considered important and critical stages in crop cycle. The nitrogen availability at these stages can reduce the competition between plant parts on the nutrients, especially nitrogen and that would reflect the growth efficiency increase (Killi, 2004). These results are in agreement with Moghaddasi and Mohammed (2011). Also, Nitrogen availability during these stages can increase the photosynthesis rate, producing the higher crop surface area, period elongation of stay green leaf, and then seed yield increase (Khan et al., 2006; Tsialtas and Maslaris, 2008; Rafiq et al., 2010; Shehzad and Maqsood, 2015).

The vegetative and reproductive growth responded to the interaction between cultivars and the splitting of nitrogen application. The superiority was belonged to

the interaction treatment of Shumos×T4 during both seasons. This is in agreement with Schneiter and Miller (1981) who mentioned that nitrogen is an important nutrient and must be added according to the growth stages of the plant.
According to the analysis of variance and simple correlation for both seasons: the positive response in leaf area maybe belonged to the previous positive response in plant height, leaf width and number of leaves per plant (Tables 3, 4, 5, 6, and 12); the positive response in disc diameter maybe belonged to the previous positive response in leaf area (Tables 6, 7, and 12); the positive response in fertility ratio maybe belonged to the previous positive response in the leaf area followed by the number of leaves per plant and leaf width (Tables 4, 5, 6, and 12); the positive response in weight of 1000 seed maybe belonged to the previous positive response in plant height, disc diameter, and leaf area (Tables 3, 6, 7, and 12). It seems that weight of 1000 seed as one of the yield components is more important than number of seed per disc according to the analysis of variance and simple correlation for both seasons (Tables 9, 10, 11, and 12), in which mean; the increase in seed yield was belonged to the increase in weight of 100 seed. The highest correlation coefficient value between seed yield and leaf area on both seasons (Table 12) indicates the effectiveness of metabolism in leaves which supported by the important theory of source-sink. This is in agreement with Ozer et al. (2004) and Tonev (2006).

Conclusion

It is concluded that splitting of the nitrogen fertilizer through growth stages increases the efficiency of nitrogen application to reach the highest seed yield. Shumos cultivar is the most superior cultivar in seed yield and vegetative growth as response to splitting nitrogen application. The splitting nitrogen in treatment T4 is able to improve the seed yield and vegetative growth parameters for all the 3 cultivars and can be recommended for all these 3 cultivars. Also, it can depend on leaf area as selection criteria to improve seed yield of sunflower.

References

Al-Ahbabi HAA and Al-Gebore RKh, 2015. Response of two sunflower cultivars (*Helianthus annuus L.*) to different levels of nitrogen and time of application. Al-Furat J. Agric. Sci. 7(2): 145-158.

Ali A, Tanveer A, Nadeem MA, Tahir M and Hussain M, 2007. Effect of varying planting pattern on growth achene yield and oil contents of sunflower (*Helianthus annuus L.*). Pak. J. Agric. Sci. 44: 449-452.

Awais M, Wajid A, Ahmed A and Bakhsh A, 2013. Narrow plant spacing and nitrogen application enhance sunflower (*Helianthus annuus L.*) productivity. Pak. J. Agric. Sci. 50: 689-697.

Elsahookie MM and Eldabas EE, 1982. One leaf dimension to estimate leaf area in sunflower. J. Agron. Crop Sci. 151: 199-204.

Khan R, Gurmani AH and Zia MS, 2006. Effect of boron application on rice yield under wheat-rice system. Int. J. Agric. Biol. 8: 805-808.

Killi F, 2004. Influence of different nitrogen levels on productivity of oilseed and confection sunflower (*Helianthus annuus L.*) under varying plant populations. Int. J. Agric. Biol. 6: 594-598.

Mazher AAM, Zaghloul SM and Yassen AA, 2006. Impact of boron fertilizes on growth and chemical constituents of *taxodium distichum* growth under water regime. World J. Agric. Sci. 2: 412-420.

Moghaddasi Sh and Mohammed AMJ, 2011. Study of nitrogen fertilization times effects on new sunflower hybrids for grain and oil yields. Adv. Environ. Biol. 5(7): 1968-1975.

Ozer H, Polat T and Ozturk E, 2004. Response of irrigated sunflower hybrids to nitrogen fertilization, growth, yield and yield components. Plant Soil Environ. 50: 205-211.

Rafiq MA, Ali A, Malic MA and Hussain M, 2010. Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. Pak. J. Agric. Sci. 47: 201-208.

Schneiter, AA and Miller JF, 1981. Description of sunflower growth stages. Crop Sci. 21: 901-903.

Shehzad MA and Maqsood M, 2015. Integrated nitrogen and boron fertilization improve the productivity and oil quality of sunflower grown calcareous soil. Turk. J. Field Crops. 20(2): 213-220.

Steel RGD, Torri JH and Deekey DA, 1997. Principles and procedures of statistics: A biometrical approach, 3rd ed. McGraw Hill Book, Int. Co., New York, US.

Tonev TK, 2006. Agronomic characteristics of high yielding sunflower crop. Res. Common USB Branch Dobrech. 8: 162-173.

Tsialtas JT and Maslaris N, 2008. Evaluation of a leaf area prediction model proposed for sunflower. Photosynthetica. 46: 294-297.

Yasin M, Mahmood A, Ali A, Aziz M, Javaid MM, Iqbal Z and Tanveer A, 2013.Impact of varying planting patterns and fertilizer application strategies on autumn planted sunflower hybrid. Cercetari Agronomic in Moldova. XLVI(2): 154.

Yu Q, Halavacka A, Matoh T, Volkmanm D, Menze D and Baluska F, 2002. Short term B deprivation inhibits endocytosis of cell wall pectin's in meristem tic cells of maize and wheat root apices. Plant Physiol. 130:415-421.