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Effect of Plant Density and Nitrogen Fertilizer Splitting on the Production of Sunflower

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Abstract:

A field experiment was carried out at the Agronomy Department Farm, Faculty of Agriculture, Assiut University during 2017 and 2018 seasons to study the effect of plant density and nitrogen fertilizer splitting on the production of sunflower. The experiment was laid out in Randomized Complete Block Design (RCBD) in split- plot arrangement with four replications. Plant density (46666, 28000, 20000 plants/fed.) were assigned in main plots and three treatments of nitrogen fertilizer splitting (2 and 3 doses) were arranged in sub-plots. The obtained results showed that plant height, seed weight per plant, seed yield (kg fed^{-1}), oil percentage (%) and oil yield (kg fed^{-1}) were affected significantly by plant density in both seasons. Plant density 20000 plants /fed gave the highest mean values of seed yield fed^{-1} (2669.14 and 2569.59 kg /fed.) and oil yield fed^{-1} (990.47 and 915.21 kg/fed, in the first and second seasons, respectively). Additionally, Splitting nitrogen fertilizer into three doses (N1) gave the highest mean values for mention traits in both seasons. There was significant interaction between plant density and splitting nitrogen fertilizer on all the studied traits in the both seasons, except plant height. Plant density 20000 plants /fed when received nitrogen fertilizer at three doses (N1) gave the highest mean values of seed yield fed. (2833.33 and 2728.58 kg/fed.) in the both seasons.

***Keywords**: Sunflower, nitrogen fertilizer splitting, plant density.*

Introduction

Among the oil crops, sunflower is one of the important oilseeds that subsidizes substantially to edible oil production in the world. Its seeds contain (40-52%) of oil, no cholesterol and high non-saturated fatty acids content that ranged between 85-90%. In addition, the oil contains variable amounts of vitamins K, E, D and A. The by-products of seed (seed cake) is a rich source of proteins (35%) and carbohydrates (18-20%) for animals and poultry feed. (Ibrahim, 2012).

The cultivated area of sunflower seeds in Egypt during 2019 season was about 8,000 hectare with the total production of 19,000 metric ton (USDA, 2019).

Nitrogen occupies an important place among the nutrients because of its vital role in physiological and biochemical purposes of plant. Therefore, it is one of the most required nutrients by sunflower plants. The most important role of nitrogen in the plant is its presence in the structure of protein and nucleic acids, which are the most important building and information substances of every cell. In addition, nitrogen is also found in chlorophyll that enables the plant to transfer of energy from sunlight by photosynthesis. Thus, nitrogen supply to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed, moreover, it influence cell size, leaf area and photosynthetic activity. (Namvar *et al*., 2012). It is therefore, important to use a suitable application technique such as split N fertilizer that can help to promote uptake of nitrogen, thus enhance N fertilizer efficiency and minimize N losses.

Plant density is one of the main agronomic practices that affect sunflower productivity. In case of sunflower suitable spacing, make available sufficient interception of light and absorption of water and nutrients from the soil due to the proper spatial distribution of roots and results in higher yield. Yield losses due to suboptimal population or overcrowding can be minimized by maintaining the optimum plant spacing. Increased plant population may compensate for the reduced yield of individual plant in non-tillering/ non-branched crop (Dhillon and Sharma, 2017).

The objective of this work was to work the effect of plant density and nitrogen fertilizer splitting on the production of sunflower.

Materials and Methods

A experiment was carried out during 2017 and 2018 seasons at the Agronomy Department Experimental Farm, Agriculture Faculty, Assiut University, in order to study the effect of plant population and nitrogen fertilizer splitting on the production of sunflower.

Table 1. The mechanical and chemical properties of the experimental site

Properties	2017	2018
Mechanical analysis		
Sand%	27.00	27.80
Silt%	23.00	22.20
Clay%	50.00	50.00
Soil type	Clay	Clay
Chemical analysis		
PH	7.63	7.85
Organic matter%	1.80	1.70
Total nitrogen%	0.09	0.08

The experiment was laid out in Randomized Complete Block Design (RCBD) in split-plot arrangement with four replications. Plant density (46666, 28000, 20000 plants/fed.) were assigned in main plots and three treatments of nitrogen fertilizer splitting (2 and 3 doses) were arranged in sub-plots. Each subplot area was 10.5 m² (3.5 m long × 3.0 m width), there were five ridges in each plot 60 cm apart, with three plant densities (46666, 28000 and 200000 plants /fed.) in which were obtained by planting at hill spacing of 15, 25 and 35 cm, respectively. There recommended dose (30 kg N/ fed.) in the form of Urea 46% divided into three treatments of nitrogen fertilizer splitting (2 and 3 doses).

Table 2. The treatments of splitting nitrogen application (30 kg N/ fed.) in the two growing seasons

Nitrogen treatments	3 weeks after sowing	5 weeks after sowing	7 weeks after sowing
N1	10 kg	10 kg	10 kg
N2	20 kg	10 kg	-
N3	-	10 kg	20 kg

Sunflower seeds Sakaha-53 cultivar was sown on 6 June and 11 June, during first and second seasons, respectively. The proceeding crop was wheat in both seasons. All other cultural practices that recommended for sunflower crop were done in the both seasons.

Recording data

Seed yield and its attributes:

1- **Plant height (cm):** It was determined from the soil surface to the top of the plant at harvest as the average of ten guarded plants sample.
2- **Seed yield /plant (gm):** Average seed weight was obtained from a ten guarded plants sample per plot.
3- **Seed yield (kg fed-^{1}):** Heads of two bagged inner ridges of each plot were harvested and left two weeks until fully air dried and seeds were manually separated then weighed and transferred into kg fed-^{1}.
4- **Oil percentage:** Soxalet apparatus using Peteoleum ether (BP 40-60°C) as solvent according to the Official Method (A.O.A.C, 1995) estimated it.
5- **Oil yield/feddan:** It was estimated by:

Oil yield = Seed yield fed. × Seed oil percentage.

Statistical analysis:

All collected data were analyzed with analysis of variance (ANOVA) Procedures using the CoStat (Version 6.303, CoHort, USA, 1998-2004). Differences between means were compared by revised least significant difference (RLSD) at 5% level of significant (Gomez and Gomez 1984).

Results and Discussion

1- Plant height (cm):

The Data in Table 3 reveal that the plant density had a significant effect on plant height in the both seasons. Plant height increased by increasing plant density. Plant population of 20000 plants/fed. recorded the shortest plants in the both season (150.92 and 147.58 cm), while plant population of 46666 plants /fed., gave the tallest plants in both seasons (180.17 and 178.08 cm). These results may due to that plants in case of high population density increase in plant height as a result of competition among plants for light and this will tend to increase elongation of such plants. These results are in agreement with those reported by Bassal (2003), Namvar *et al.* (2012) and Hafiz *et al.* (2014).

In addition, the presented data in Table 3 show that splitting nitrogen fertilizer had a significant influence on plant height in both seasons. Splitting nitrogen fertilizer into three doses (N1) increase plant height as compared to other splitting treatments, where (N1) gave the highest mean values in both seasons (170.17

and 166.08 cm, respectively). The increase in plant height may be attributed to the optimum utilization of nitrogen by its split application at different stages. This leads to enhance meristematic activity of plants, which are responsible for cell division and elongation, thus increase of plant height. Vijayakumar *et al.* (2003), Khanzada *et al.* (2016) and Kubar *et al.* (2017) obtained similar results.

Here too, the interaction between plant density and splitting of nitrogen was non- significant in the both seasons.

Table 3. Effect of plant density, splitting N application and their interaction on plant height (cm).

Season	2017				2018			
Plant density (plants/ fed.) (D)	N Splitting (N)			Mean	N Splitting (N)			Mean
	N1	N2	N3		N1	N2	N3	
46666	183.00	179.50	178.00	180.17	181.75	177.00	175.50	178.08
28000	175.25	169.25	167.75	169.75	166.25	162.5	157.75	162.42
20000	156.00	151.50	146.00	150.92	150.25	147.75	144.75	147.58
Mean	170.17	166.75	163.92	---	166.08	162.42	159.33	---
F test and R.LSD 0.05	**F test**		**R.LSD 0.05**		**F test**		**R.LSD 0.05**	
D	**		3.00		**		3.77	
N	*		3.62		**		3.99	
D×N	n.s		---		n.s		---	

Where *and ** mean significantly and highly significantly at 5% level of significant.
n.s: Non- significant differences.

2- Seed weight /plant (g):

Data presented in Table 4 show that there was significant increase in seed weight per plant with decreasing plant density in the both seasons. Plant density of 20000 plants/fed. produced the highest mean values of seed weight per plant in both seasons (69.98 and 67.45 g, in the two respectively seasons), when compared with the higher density studied 46666 plants /fed. (44.97 and 41.98 g) in the both seasons. This may be due to the plants grown under lower population have more availability of different growth factors such as nutrients, light and moisture around each plant as compared to higher population and thus reduced competition between plants. These results are in agreement with those reported by Osman and Awed (2010) and Hafiz *et al.* (2014).

On the other hand, the demonstrated data in Table 4 state that the splitting nitrogen fertilizer had a significant influence on seed weight per plant in the first season only. Splitting nitrogen fertilizer into three doses (N1) gave the maximum mean values of seed weight per plant (59.55 and 56.16 g, the first and second seasons, respectively). These results may be due to the increase of yield components such as head diameter, seed index and number of seeds per head. The previous results are in accordance with those obtained by Khanzada *et al.* (2016) and Kubar *et al.* (2017).

In addition, the exhibited data in Table 4 decline that the interaction between plant density and splitting nitrogen fertilizer had a significant influence on seed weight per plant in the both seasons, where the highest mean values of seed weight per plant (74.38 and 71.63 g in the two respective seasons) were obtained from plant density of 20000 plants /fed. when received nitrogen fertilizer at three splits (N1).

Table 4. Effect of plant density, splitting N application and their interaction on seed weight/plant (gm).

Season	2017				2018			
Plant density (plants/fed.) (D)	N Splitting (N)			Mean	N Splitting (N)			Mean
	N1	N2	N3		N1	N2	N3	
46666	49.13	45.91	39.87	44.97	37.94	40.27	47.72	41.98
28000	55.14	59.39	58.54	57.69	58.91	57.13	53.40	56.48
20000	74.38	70.50	65.07	69.98	71.63	68.73	62.01	67.45
Mean	59.55	58.60	54.49	---	56.16	55.38	54.38	---
F test and R.LSD 0.05	**F test**		**R.LSD 0.05**		**F test**		**R.LSD 0.05**	
D	**		2.21		**		3.29	
N	*		3.78		n.s		---	
D×N	*		4.14		**		3.98	

Where *and ** mean significantly and highly significantly at 5% level of significant.
n.s: Non- significant differences.

3- Seed yield (kg /fed.):

The demonstrated data in Table 5 exposed that seed yield was significantly affected by plant density in both seasons. Seed yield increased by decreasing plant density to 20000 plants /fed., where the highest mean values of seed yield (2669.14 and 2569.59 kg/fed. during the first and second seasons, respectively) were detected from plant density of 20000 plants /fed., on the other hand, plant density of 46666 plants fed., gave the lowest mean values of seed yield during the two growing seasons (1720.48 and 1599.17 kg fed., respectively). This may be due to the superiority of low density regarding seed yield/ plant. These results are in confirmatory with those obtained by Abd El-Satar *et al.* (2017) and Emam & Awed (2017).

Moreover, the splitting nitrogen fertilizer affected significantly on seed yield in first season, data exhibited in Table 5 show that splitting the recommended doses of nitrogen (30 kg/fed.) into three doses (N1) increased seed yield as compared with other splitting treatments in this respect and gained 2268.48 and 2139.30 in the first and second seasons, respectively. This may be due to that nitrogen enhanced vegetative growth of plants such as the increase in plant height, stem diameter and dry matter accumulated, which in turn increased yield components such as seed index, number of seeds /head and seed weight /plant, thus increased seed yield /fed. Munir *et al.* (2007), Bonair *et al.* (2013) and Al- Haidari (2018) obtained similar findings in this respect.

Here too, the obtained data in Table 5 reveal that the interaction between plant density and splitting nitrogen fertilizer had a significant influence on seed yield in both seasons. The highest mean values of seed yield (2833.33 and 2728.58 g, in the first and second seasons, respectively) were obtained from plant density of 20000 plants/fed., when received nitrogen fertilizer at three splits (N1).

Table 5. Effect of plant density, splitting N application and their interaction on seed yield /fed. (Kg).

Season	2017				2018			
Plant density (plants/ fed.)	N Splitting (N)			Mean	N Splitting (N)			Mean
	N1	N2	N3		N1	N2	N3	
46666	1871.62	1770.87	1518.95	1720.48	1445.34	1534.00	1818.19	1599.18
28000	2100.48	2226.57	2239.53	2188.86	2244.00	2176.48	2034.38	2151.62
20000	2833.33	2695.15	2478.95	2669.14	2728.58	2619.00	2363.00	2569.59
Mean	2268.48	2230.86	2079.14	---	2139.30	2109.52	2071.56	---
F test and R.LSD0.05	**F test**		**R.LSD 0.05**		**F test**		**R.LSD 0.05**	
D	**		80.22		**		125.50	
N	*		139.27		n.s		----	
D×N	*		150.24		**		153.41	

Where *and ** mean significantly and highly significantly at 5% level of significant.
n.s: Non- significant differences.

4- Oil percentage (%):

Data in Table 6 show that the plant density had a significant influence on oil percentage in the both seasons. Oil percentage increased by increasing plant density from 20000 to 46666 plants /fed., where the highest mean values of oil percentage (40.04% and 38.95% in first and second seasons, respectively) were registered from plant density of 46666 plants/fed. While, plant density of 20000 plants/fed. gave the lowest mean values in both seasons (37.04% and 36.32% in the first and second, respectively). This may be due to that plants grown under lower density have more availability of the environmental factors and less competition and consequently increase plant ability to build up metabolites. These results are in line with those obtained by Ali *et al.* (2012), Hafiz *et al.* (2014) and Abd El- Satar *et al.* (2017).

As for, the illustrated data in Table 6 show that the splitting nitrogen fertilizer had a significant effect on oil percentage in both seasons. The highest mean values of oil percentage (39.28 and 39.20%, respectively) in the both seasons respectively were obtained when nitrogen fertilizer was divided into three doses (N1). This is may be due to that nitrogen supply in the plants stimulate the formation of amino acids and consequently the accumulation of protein in the expense of oil. These results are in agreement with those reported by Abdyl-Razak *et al.* (2014).

Here too, the obtained data in Table 6 reveal that the interaction between plant density and splitting nitrogen fertilizer had a significant influence on oil percentage in both seasons. The highest mean values of oil percentage (41.48 and 41.16% in first and second seasons, respectively) were obtained from plant density 46666 plants/fed. when received nitrogen fertilizer at three splits (N1).

Table 6. Effect of plant density, splitting N application and their interaction on oil percentage (%).

Season	2017				2018			
Plant density (plants/fed.) (D)	N Splitting (N)			Mean	N Splitting (N)			Mean
	N1	N2	N3		N1	N2	N3	
46666	41.48	40.36	38.29	40.04	41.16	38.95	36.48	38.87
28000	38.09	39.24	38.51	38.61	39.00	37.18	38.93	38.37
20000	38.28	37.47	35.36	37.04	37.42	37.78	33.76	36.32
Mean	39.28	39.02	37.39	---	39.20	37.97	36.39	---
F test and R.LSD 0.05	**F test**		**R.LSD 0.05**		**F test**		**R.LSD 0.05**	
D	*		1.72		**		1.27	
N	**		0.87		**		1.49	
D×N	*		0.99		*		1.58	

Where *and ** mean significantly and highly significantly at 5% level of significant.

5- Oil yield /fed.:

The recorded data in Table 7 reveal that oil yield was significantly affected by plant density in two growing seasons. Oil yield increased by decreasing plant density up to 20000 plants/fed., where the heaviest mean values of oil yield (990.47 and 915.21kg/fed. in first and second seasons, respectively) were obtained from plant density 20000 plants /fed., on the contrast, plant density 46666 plants/fed gave the lowest mean values of oil yield in the both season (691.77 and 619.25, respectively). This increase may be attributed to increase in seed yield/fed. These results are in the same trend with that reported by Salehi & Bahrani (2000), Radwan *et al.* (2013) and Mehdi (2019). Furthermore, the presented data in Table 7 confirm that the splitting nitrogen fertilizer had a significant influence on oil yield in the first season only. Splitting nitrogen fertilizer into three doses (N1) gave the maximum mean values of oil yield (887.30 and 813.79 kg/fed.). This due to the increase in seed yield per fed., regardless of the reduction in oil percentage. These results are in agreement with those reported by Osman & Awed (2010).

In addition, the obtained data in Table 7 reveal that the interaction between plant density and splitting nitrogen had a significant effect on oil yield in the two growing seasons. The highest mean values of oil yield (1084.73 kg/fed.) was noted from 20000 plants /fed., when received nitrogen fertilizer (N1) in the first season, while in the second season the highest mean values of oil yield (990.69 kg/fed.) was recorded from 20000 plants/fed. when received nitrogen fertilizer (N2).

Table 7. Effect of plant density, splitting N application and their interaction on oil yield /fad. (Kg).

Season	2017				2018			
Plant density (plants/fed.) (D)	N Splitting (N)			Mean	N Splitting (N)			Mean
	N1	N2	N3		N1	N2	N3	
46666	777.25	718.03	580.02	691.77	595.80	598.52	663.44	619.25
28000	799.90	869.36	863.68	844.31	875.29	809.16	791.59	825.35
20000	1084.73	1010.95	875.74	990.47	970.27	990.69	784.67	915.21
Mean	887.30	866.10	773.15	---	813.79	799.46	746.57	---
F test and R.LSD 0.05	**F test**		**R.LSD 0.05**		**F test**		**R.LSD 0.05**	
D	**		38.42		**		70.74	
N	**		87.88		n.s		---	
D×N	*		46.99		*		77.79	

Where *and ** mean significantly and highly significantly at 5% level of significant.
n.s: Non- significant differences.

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تأثير الكثافة النباتية وتجزئة السماد النيتروجيني على إنتاج محصول عباد الشمس

مروه رشدي فرويز، المهدي عبد المطلب طعيمة، جمال راجح النجار ومحمد ثروت سعيد
قسم المحاصيل – كلية زراعة – جامعة أسيوط

الملخص:

أجريت تجربة حقلية بمزرعة قسم المحاصيل، كلية الزراعة، جامعة أسيوط خلال موسمي ٢٠١٧ و٢٠١٨ وذلك لدراسة تأثير الكثافة النباتية وتجزئة السماد النيتروجيني على إنتاج محصول عباد الشمس. وقد استخدام تصميم القطاعات كاملة العشوائية بترتيب القطع المنشقة مرة واحدة في أربع مكررات حيث تم وضع الكثافة النباتية (٤٦٦٦٦، ٢٨٠٠٠،٢٠٠٠٠ نبات /فدان) في القطع الرئيسية بينما تم وضع تجزئة السماد النيتروجيني (٢و٣ مرات) في القطع المنشقة. اشارت النتائج الي ان الصفات التي تم دراستها وهي ارتفاع النبات، وزن البذور للنبات، محصول البذور للفدان، نسبة الزيت، محصول الزيت للفدان تأثرت معنويا باختلاف الكثافة النباتية لكلا الموسمين. حيث أعطت نباتات عباد الشمس التي زرعت بمعدل ٢٠٠٠٠ نبات/فدان اعلي متوسط لصفات محصول البذور للفدان (٢٦٦٩,١٤ و٢٥٦٩,٥٩ كجم للفدان للموسمين على التوالي) ومحصول الزيت للفدان (٩٩٠,٤٧ و٩١٥,٢١ كجم للفدان للموسمين على التوالي). كذلك أعطت تجزئة السماد النيتروجيني ثلاث مرات اعلي متوسط للصفات المشار اليها في الموسمين. يوجد تأثير معنوي للتفاعل بين الكثافة النباتية وتجزئة السماد النيتروجيني على تلك الصفات لكلا الموسمين وتم الحصول علي اعلي متوسطات لصفة محصول البذور للفدان (٢٨٣٣,٣٣ و٢٧٢٨,٥٨ كجم للفدان) من زراعة عباد الشمس بكثافة نباتية بمعدل ٢٠٠٠٠ نبات/الفدان وتجزئة السماد الازوتي على ثلاث جرعات.