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***Research Article***

# THE EFFECT OF DIFFERENT LEVELS AND SPLIT APPLICATION OF NITROGEN ON YIELD AND YIELD COMPONENTS OF SESAME PLANT IN HAMIDIYEH WEATHER CONDITIONS

**Amin Kamravaie and *Alireza Shokohfar**
*Department of Agronomy, College of Agriculture, Ahvaz branch, Islamic Azad University, Ahvaz, Iran*
**Author for Correspondence*

## ABSTRACT
In order to investigate the effect of different levels and split application of nitrogen on yield and yield components of sesame plant in Hamidiyeh weather conditions, a split plot experiment in the form of randomized complete block design with four replications was carried out in 2014. The main factor included three levels of nitrogen fertilizer (50, 100, 150 kg/ha pure nitrogen) and the sub treatment included three methods of split application of nitrogen as $S_{1:}$ 70% during planting and 30% at 8-leag stage, $S_2$: 50% during planting and 50% at 8-leaf stage, $S_3$: 25% at planting and 50% at 8-leaf stage and 25% at the beginning of flowering stage). The results showed that different levels of nitrogen fertilizer and split application method significantly increased grain yield, number of capsules per plant, number of grains per capsule, and 1000-grain weight. The highest grain yield belonged to the treatment with application of 150 kg/ha nitrogen by 1199.62 kg/ha and S3split application method by 1058.75 kg/ha. Moreover, the most optimal level of the number of capsules per plant, number of grains per capsule, and 1000-grain weight belonged to the treatment with application of 150 kg/ha nitrogen and S3 split application method and the lowest levels belonged to the treatment with application of 50 kg/ha nitrogen and S1 split application method. In Examining the interactive effect of different levels and split application of nitrogen fertilizer, the highest yield by 1315.09 kg/ha belonged to the treatment with 150 kg/ha nitrogen and S3 split application method. Since there was no significant difference between the treatments with application of 100 and 150 kg/ha nitrogen in terms of most of the studied traits, and with regard to environmental and economic issues concerning less use of nitrogen fertilizers and reduction of costs, the treatment with application of 100 kg/ha nitrogen and S3 method can be introduced as the most favorable treatment of the experiment.

***Keywords*: *Sesame, Split Application of Nitrogen, Levels of Nitrogen, Grain Yield, Yield Components***

## INTRODUCTION
Various investigations indicate that Iran and Particularly Khuzestan Province have adequate facilities to achieve optimal production of oil plants, and the increase of production of edible oil is possible through the improvement of planting methods and modification of high oil cultivars and introduction of oil plants that are suitable for cultivation in each area. In this regard proper nutrition of plants is highly important and improves the qualitative and quantitative yield of crops and increases farmers' profitability and contributes to the development of cultivation of this valuable crop. Supplying adequate amounts of nutrients needed by plants in soil through the consumption of chemical fertilizers is one of the most important aspects of crop management in order to enhance production and to improve the quality of agricultural products (Saeidi, 2008).
Sesame is an annual plant and one of the most ancient oilseed crops that is compatible with semi warm and warm areas. Sesame is an important source of oil production and since every year large sums of currency (more than 90% of oil imports) will be spent on oil imports into the country, it seems necessary to care for this crop and to increase its production. The seeds of sesame contain 45% oil and 19 to 25% protein (Khajepoor, 2007).
Nitrogen is an element that is widely used by most plants as chemical fertilizer so that its deficiency limits the qualitative and quantitative yield of plants more than other nutrients. One of the aspects of nitrogen management is the appropriate level and time of its distribution. Nitrogen deficiency usually occurs when

a large amount of chemical nitrogen fertilizer is used suddenly and improperly. Matching nitrogen supply with sectional times when the plant highly needs this element will maximize the efficiency of nitrogen use, improve water efficiency, and reduce nitrate contamination of water resources because the interval between the application and uptake of fertilizer by plant specifies the length and exposure of nitrogen to reduction or loss due to the factors such as leaching and denitrification. Overuse of nitrogen disrupts carbon to nitrogen fertilizer and consequently soil organic matter will destroy due to the sudden increase of the population of carbon-consuming microbes (C/N). therefore, with regard to nitrate leaching in humid areas and the increase of its concentration in groundwater, ammonia sublimation and denitrification in water logging conditions will be important in order to save and increase the efficiency of nitrogen fertilizer consumption, nitrogen uptake and utility (Hosseini *et al.*, 2013).

With regard to insufficient research in relation to the effect of different levels and split application of nitrogen on yield and yield components with an appropriate management in Khuzestan Province, this research was conducted that can have a significant impact on nitrogen economy and the increase of revenue and decrease of production costs.

## MATERIALS AND METHODS

This research was carried out in 2014 in Hamidiyeh Town at longitude 31°25´ N and latitude 48°26´ E and 20 m above the sea level. The soil of experiment site had clay-loam tissue with pH=7.8 and EC=4.7 S/m. the experiment was conducted as a split plot in the form of randomized complete block design with four replications. The main factor included three levels of nitrogen fertilizer (50, 100, 150 kg/ha pure nitrogen) and the sub treatment included three methods of split application of nitrogen as $S_{1:}$ 70% during planting and 30% at 8-leag stage, $S_2$: 50% during planting and 50% at 8-leaf stage, $S_3$: 25% at planting and 50% at 8-leaf stage and 25% at the beginning of flowering stage). The experiment totally included 36 plots and each experimental plot included 6 planting lines as long as 6 m. the distance between plants on the rows was 10 cm and the distance between replications was 1 m. after preparing the land, in order to supply the required phosphorus, 60 kg/ha pure phosphorus was added to the soil as strip and manually. Different levels of nitrogen fertilizer as the base and before planting and based on split application treatment were calculated and added to the soil as strip and manually.

### *Measurement of the Final Yield Traits*

In order to measure the grain yield, the plants were harvested from an area of 1.5 $m^2$ at the maturity stage and after eliminating 0.5 m of the beginning and end of each plot and they were kept standing in the open air to get dry completely. Then, the grains were separated by shaking plants inside the sack in a few steps. When the plants and seeds got dry completely, grains were weighed and the grain yield was measured at 14% humidity. In order to determine the number of capsules per square meter, ten samples out of the total number of taken capsules were counted and considered as the number of capsules. In order to calculate the number of grains per capsule, 10 capsules out of the total capsules of the same area of 1.5 $m^2$ were randomly selected and after separating all the grains they were counted and via dividing the number of grains by the number of capsules the number of grains per capsule was calculated. In order to measure 1000-grain weight, the seeds were completely cleaned at first and then two 500-seed samples were counted and weighed. The data were analyzed using SAS software. In order to compare the means, Duncan's multi range test was used at 5% probability level. Diagrams were drawn using Excel 2010 software.

## RESULTS AND DISCUSSION

### *Number of Capsules per Plant*

The ANOVA results (Table 1) indicate that the effect of different levels of nitrogen fertilizer on the number of capsules per plant was significant at 1% probability level. The number of capsules per plant was not significantly different in treatments with application of 100 and 150 kg/ha nitrogen, but these two treatments were significantly different from the treatment with application of 50 kg/ha nitrogen. The highest number of capsules per plant by 36.67 belonged to the treatment with application of 150 kg/ha nitrogen and the lowest number by 27 belonged to the treatment with application of 50 kg/ha nitrogen (Table 2). Generally, the number of capsules per plant determines the yield potential because the capsules contain the number of grains on one hand, and supply the required assimilates for grains and determine their weight on the other hand. Nitrogen level can somewhat lead to the production and formation of capsules. The effect of split application of nitrogen on the number of capsules per plant was significant at 1% probability level. The highest number of capsules per plant by 34.50 belonged to S3 treatment and the lowest number of capsules per plant by 32.00 belonged to S1 treatment. Nitrogen uptake leads to the increase of assimilates production and their allocation to reproductive organs. Therefore, the increase of supply during the flowering stage leads to the protection of reproductive organs and fertile flowers particularly young capsules that result in the increase of the number of mature capsules (Paul, 2001). Other studies indicate that the number of capsules per plant is influenced by genetic properties and a significant difference between the numbers of capsules in different varieties of sesame is reported (Mahmoud *et al.,* 2003).

Ahmadi and Bohran (2009), Dey (2000) stated that the number of capsules per plant is the most important factor influencing the sesame grain yield and any increase or decrease of the number of capsules per plant can affect the grain yield. The number of capsules per plant can be considered as a graph of the number of inoculated flowers per plant. The increase of the number of capsules per plant results in the increase of the number of grains per plant which greatly affects the yield (Shokoohfar, 2005). Akhani and Haghighat (2006) reported that the increase of nitrogen increased the number of capsules and grain yield in sesame. In Canola, nitrogen consumption at early flowering stage (three split applications of nitrogen) stimulated plant to increase the number of lateral branches in plant and through the increase of photosynthesis level and more assimilates production a larger number of flowers changed into pods (Zangani, 2002).

***Number of Grains per Capsule***

The ANOVA results (Table 1) show that the effect of different levels and split application of nitrogen on the number of grains per capsule was significant at 1% probability level. The highest number of grains per capsule by 46.17 grains belonged to the treatment with application of 150 kg/ha nitrogen and the lowest number of grains per capsule by 36.42 grains belonged to the treatment with application of 50 kg/ha nitrogen (Table 2). It seems like that the plant has been able to produce more assimilates by taking advantage of environmental conditions and absorbing nitrogen and solar radiation and the assimilates have been allocated to the grains. Mean comparison results show that the highest number of grains per capsule by 43.83 belonged to S3 treatment and the lowest number of grains per capsule by 40.92 belonged to S1 treatment (Table 2). It can be due to the fact that in case of deficit nutrients particularly nitrogen at the flowering stage fewer grains have been produced. It is quite clear that through the use of a high percentage of nitrogen during the planting and lack of adequate nitrogen during the flowering stage a fewer number of flowers have been inoculated or the produced grains have been aborted due to the lack of nutrients and consequently fewer number of grains have been formed (Macadam, 2009). In other words, nitrogen availability during the critical period of grain formation has affected the number of grains through the increase of plant growth rate during the three-stage split application of nitrogen (S3: 25% during planting, 50% during 8-leaf stage, 25% at early flowering). Oust Boons (1997) and Sujatama (2003) stated that fertilization significantly increased the number of grains per capsule. Saeidi (2008) have stated that the number of capsules per plant and the number of grains per capsule are considered as the main components of grain yield and this point is referred to in Veis studies (2000) as well.

***1000-Grain Weight***

The ANOVA results (Table 1) showed that 1000-grain weight in sesame was significantly affected by different levels and split application of nitrogen at 1% level. Mean comparison results showed that the highest 1000-grain weight by 3.54 g belonged to the treatment with application of 150 kg/ha nitrogen and the lowest 1000-grain weight by 3.02 g belonged to the treatment with application of 50 kg/ha nitrogen. There was no significant difference between 1000-grain weight in treatments with application of 100 and150 kg/ha nitrogen, but these two treatments were significantly different from the treatment with application of 50 kg/ha nitrogen (Table 2). The results show that nitrogen has increased the weight of

1000-grain by increasing the mobilization of assimilates made by plant into grains. Molki *et al.*, (1987) and Siadat *et al.*, (1994) have also studied and confirmed this matter. 1000-grain weight is directly affected by assimilates after pollination. They can be supplied through plant current photosynthesis pr remobilization of assimilated stored in stems, leaves, or capsules (Karzani and Ahmadi, 2010). Increase of nitrogen led to the increase of dry matter production and leaf area continuity and consequently the increase of current photosynthesis during the grain filling stage. In a study conducted by Olger *et al.*, (1997) as nitrogen levels increased, 1000-grain weight increased too and the increase of this yield component in turn led to the increase of grain yield. According to Oust Bounsa (1997) the use of nutrients (particularly nitrogen) had no significant effect on the yield components of sesame (number of capsules per plant, number of grains per capsule, and 1000-grain weight). However, the findings of Alhani and Haghighat Nia and some other results showed that fertilization significantly increased the number of grains per capsule and 1000-grain weight. These differences in results could be due to different cultivars, environmental conditions and the soul of experiment site.

The highest 1000-grain weight (3.40 g) belonged to S3 treatment and the lowest 1000-grain weight (3.22) belonged to S1 treatment. S2 and S3 treatments were not significantly different in terms of 1000-grain weight, but they were significantly different from S1 treatment (Table 2). It seems like that high weight of 1000-grain in S3 compared with S1 and S2 is the increase of the increase of nitrogen uptake available for plant, the increase of leaf area index, and consequently the increase of flowering stage and mobilization of produced assimilates into grain. Asghar *et al.*, (2003) reported that 1000-grain weight increased to some extent due to the effect of nitrogen fertilizer. In a three-year experiment conducted by Tavakoli *et al.*, (1998), in the first year the treatment with consumption of ½ fertilizer during planting and ½ at the beginning of stem elongation, ¼ during the spike development was superior to the other treatments due to greater number of grains per spike and the increase of 1000-grain weight in wheat.

The positive effect of split application of nitrogen in S3 (25% during planting + 50% during stem elongation + 25% during reproduction stage) on leaf area index and the increase of leaf longevity and current photosynthesis durability due to the effect on grain filling stage significantly increased this treatment compared with S1 treatment (100% during planting). The result was consistent with the findings of Banziger *et al.*, (2002) who reported that delayed application of nitrogen, due to positive effect on leaf area duration and consequently the increase of grain filling stage increased the weight of maize grain.

Tohidi (1994) reported that 1000-grain weight increased in split application of nitrogen as ⅓ during planting + ⅔ equally at 6-to-7-leaf stage and 12-to-14-leaf stage. Since the increase of nitrogen led to the increase of dry matter production and leaf area duration and consequently the increase of current photosynthesis during the grain filling stage, the grain weight was expected to increase as the nitrogen consumption increased. The result was consistent with the findings of Veis (2000).

***Grain Yield***

The ANOVA results (Table 1) showed that grain yield in sesame was significantly affected by different levels and split application of nitrogen at 1% level. Mean comparison results (Table 2) showed that the highest grain yield by 1199.62 kg/ha belonged to N3 treatment with application of 150 kg/ha nitrogen which was not significantly different from N2 treatment with application of 100 kg/ha nitrogen and the lowest grain yield by 596.31 kg/ha belonged to N1 treatment with application of 50 kg/ha nitrogen. High grain yield at above conditions could be due to genetic features and the level of nitrogen fertilizer because nitrogen uptake has enabled the plant to use this element better in physiological and hormonal activities and to show better reaction. It seems like that the increase of grain yield results from the increase of nitrogen consumption due to the development of a strong source, i.e. greater number of grains and the source activity, i.e. greater leaf area index and its longer duration. Moreover, the effect of nitrogen on grain yield is through the increase of the number of grains per capsule, 1000-grain weight, and development of photosynthetic level. In other words, the positive effect of nitrogen on production of proper plant shoots, due to nitrogen uptake and mobilization into photosynthetic organs, increased the grain yield. The results were consistent with the findings of Balal *et al.*, (2012) and Sajadi *et al.*, (2010).

Grain yield in S3 treatment significantly increased in comparison to S1 treatment. The highest grain yield by 1058.75 kg/ha belonged to S3 treatment and the lowest grain yield by 863.40 kg/ha belonged to S1 treatment (Table 2).

**Table 1: The ANOVA results of mean squares of the studied traits in sesame**

| Grain yield | 1000-grain weight | Number of grains per capsule | Number of capsules per plant | Degree of freedom | Sources of variations |
|---|---|---|---|---|---|
| 1323 ns | 0/0077 ns | 0/741 ns | 0/704 ns | 3 | Replications (R) |
| 1246295** | 0/886** | 324/250** | 344/333** | 2 | Nitrogen fertilizer (N) |
| 4826 | 0/0256 | 1/435 | 2/704 | 6 | Error a |
| 114688** | 0/113** | 25/583** | 19/000** | 2 | Split application (S) |
| 19579** | 0/011 ns | 1/208 ns | 1/833 ns | 4 | Interactive effect (N*S) |
| 3612 | 0/0083 | 2/481 | 1/926 | 18 | Error b |
| 6/23 | 2/73 | 3/72 | 4/18 | Coefficient of variations (CV%) | |

*ns, **, *: men squares of treatments are respectively non-significant, significant at 1% and 5% levels*

**Table 2: Mean comparison results of the effect of different levels and split application of nitrogen fertilizer on the studied traits in sesame**

| Grain yield (kg/ha) | | 1000-grain weight (g) | | Number of grains per capsule | | Number of capsules per plant | | Treatment |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Nitrogen fertilizer |
| 596/31 | b | 3/02 | b | 36/42 | b | 27/00 | b | N1 = 50 kg/he |
| 1094/41 | a | 3/43 | a | 44/42 | a | 35/83 | a | N2 = 100 kg/he |
| 1199/62 | a | 3/54 | a | 46/17 | a | 36/67 | a | N3 = 150 kg/he |
| | | | | | | | | Split method |
| 863/40 | c | 3/22 | b | 40/92 | b | 32/00 | b | S1 |
| 968/19 | b | 3/37 | a | 42/25 | a | 33/00 | ab | S2 |
| 1058/75 | a | 3/40 | a | 43/83 | a | 34/50 | a | S3 |

*According to Duncan's multi range test, the means with similar letters in each column are not significantly different at 5% level.*

**Table 3: Mean comparison results of the interactive effect of different levels and split application of nitrogen fertilizer on the studied traits in sesame**

| Grain yield (kg/ha) | | Split method | Nitrogen fertilizer | |
|---|---|---|---|---|
| 554/17 | f | S1 | N1 | |
| 596/68 | ef | S2 | | 50 kg/ha |
| 638/09 | e | S3 | | |
| 957/28 | d | S1 | N2 | |
| 1102/88 | c | S2 | | 100 kg/ha |
| 1223/08 | ab | S3 | | |
| 1078/76 | c | S1 | N3 | |
| 1205/01 | b | S2 | | 150 kg/ha |
| 1315/09 | a | S3 | | |

*According to Duncan's multi range test, the means with similar letters in each column are not significantly different at 5% level*

More application of needed required by plant during the high nitrogen uptake in S3 treatment resulted in more development of shoots and grain yield compared with S1 treatment because in these critical stages sufficient food should be provided for plant to be able to enter reproductive phase and produce more assimilates to be absorbed and transferred into the seeds (Hogging and Stopper, 2001). The ANOVA results (Table 1) show that the interactive effect of different levels and split application of nitrogen on grain yield is significant at 1% level. Mean comparison results show that the highest grain yields by 1315.09 kg/ha belongs to N3S3 treatment and the lowest grain yield by 554.17 kg/ha belongs to N1S1 treatment (Table 3). This is due to the fact that in N3S3 treatment the level of fertilizer is high and it has been provided for the plant during the food needs of the plant. The findings of Noorolah *et al.*, (2002) and the researchers on canola indicate that the increase of nitrogen application affects grain yield via influencing the yield components. In other words, the increase of nitrogen application increases grain yield and enhances the oil yield per area unit by decreasing the percentage of flowers abscission and increasing the number of pods per area unit and also by affecting 1000-grain weight.

***Conclusion***

The results showed that different levels of nitrogen fertilizer and different methods of split application of nitrogen significantly increased grain yield, number of capsules per plant, number of grains per capsule, and 1000-grain weight, so that the highest grain yield belonged to the treatment with application of 150 kg/ha nitrogen by 1199.62 kg/ha and also S3 treatment by 1058.75 kg/ha. Moreover, the highest levels of the number of capsules per plant, number of grains per capsule, and 1000-grain weight belonged to the treatment with application of 150 kg/ha nitrogen and S3 treatment and the lowest levels belonged to the treatment with application of 150 kg/ha nitrogen and S1 treatment. In examining the interactive effect of nitrogen fertilizer and split application method, the highest grain yield by 1315.09 kg/ha belonged to the treatment with application of 150 kg/ha nitrogen and S3 treatment. Considering environmental and economic issues in relation to lower use of nitrogen fertilizers and reduction of costs, the treatment with application of 100 kg/ha nitrogen and S3 treatment can be introduced as the most favorable treatment.

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