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# Effects of Different Forms and Doses of Nitrogen Fertilizers on Safflower (*Chartamus tinctorius* L.)

Murat Tunçtürk and Bünyamin Yildirim
Department of Field Crops, Agricultural Faculty, Yüzüncü Yıl University, 65080 VAN-Turkey

**Abstract:** The aim of this study carried out in Van Turkey in 1997 and 1998 was to determine the effects of different forms and doses of nitrogenous fertilizers on the safflower (*Chartamus tinctorius* cv. Dinçer 5-118) yield and yield components. The nitrogenous fertilizers (Ammonium sulphate (21% N), urea (45% N) and ammonium nitrate (33% N) and their four different doses (0, 40, 80, 120 kg $ha^{-1}$) were examined in a Randomized Block Design with three replication. The plant height, the plant head number, the 1000 seed weight, the seed yield, the crude oil content and the crude oil yield were investigated. The nitrogenous fertilizer forms had a significant effects ($p<0.01$) on the seed yield in both years, but not on the crude oil content and the crude oil yield. The different nitrogenous fertilizer doses had a significant effects ($p<0.05$) on both the seed and the crude oil yields in both years, but not on the crude oil content. While the highest seed yield and crude oil yield (1994 kg seed $ha^{-1}$ and 497 kg oil $ha^{-1}$) were obtained from the application of the 120 kg N $ha^{-1}$ ammonium nitrate, the application of the 80 kg N $ha^{-1}$ urea gave the highest seed yield (1750 kg seed $ha^{-1}$ and the application of 80 kg N $ha^{-1}$ ammonium nitrate gave the highest crude oil yield (477 kg oil $ha^{-1}$) in 1998. While the highest average seed and the crude oil yields (1597 and 422 kg $ha^{-1}$, respectively) were obtained from the ammonium nitrate application, the 120 kg N $ha^{-1}$ application dose gave the highest average seed and the crude oil yields (1685 and 437 kg $ha^{-1}$, respectively).

**Key words:** Safflower, nitrogen forms, nitrogen doses, seed yield, oil yield

## INTRODUCTION

It is known that one of the essential nutrient in human consumption oil or fat, is applied from the plant animal sources. However there is a limited increase in animal fat production. Therefore, in order to meet the increasing need in oil production is bound to the improvement and growth in oil plants. The importance of oil plants in Turkish agriculture and economy is also getting increased[1].

Oil is important due to the fact that not only it is an energy source in human consumption but also it is essential in the use of A, D, E, K vitamins and it contains oleic, linoleic fatty acids[2].

Safflower is an important plant whose oil are useful for oil cake and flowers. Safflower which has high quality oil is successfully produced in arid and unirrigated Anatolia and passageway regions where precipitation is limited because of its tolerance to drought. Besides used in meals in kitchens, oil is also widely used in the paint, varnish, polish and soap industries. It is also getting increasingly used in margarine production due to its unsaturated oil content. Its oil cake is used animal feeding and its stalks and stems can be used as fuel[3]. Moreover the paint chartamine obtained from safflower flowers is used as crude matter in paints; its oil may be used in candles and its flowers may be used as coloring agent in some meals[3,4].

Safflower is not a very selective for soil and climate, it can be even produced in arid lands. Günel *et al.*[5] reported that they had positive results in safflower production in arid lands of Van, Turkey and got up to 1700 kg $ha^{-1}$ safflower seed yield. Nitrogen is an essential plant nutrient, but is also an important input increase the cost of the its production. Therefore, the determination of the most suitable form and dose of nitrogen fertilizer will both increase the yield decrease the cost.

The reactions of different safflower cultivars grown in different regions to the different forms and doses of the nitrogen fertilizers are varied much.

Ahmed *et al.*[6] reported that various doses of nitrogen had significant positive effects on the plant height, the number of branches, the flowering percentage, the seed yield, the 1000 seed number and the protein content in seeds.

Mahey *et al.*[7] obtained the highest seed yields in safflower from 40 and 60 kg N $ha^{-1}$ in a study in Punjab from 1983 to 1985. However They didn't observed any

**Corresponding Author:** Dr. Bünyamin Yıldırım, Assistant Professor, Department of Field Crops, Agricultural Faculty, Yüzüncü Yıl University, 65080 VAN-Turkey E-mail: byildirim71@hotmail.com

significant difference in the oil content of safflower supplied with various doses of nitrogen.

Cabı[8] detected significant differences in the number of branches, the number of head and the protein contents in seed of two safflower cultivars grown under different nitrogen fertilizer forms and doses in Samsun, Turkey. They recommended the calcium ammonium nitrate in the 150 kg N $ha^{-1}$ doses in order to get optimum seed yield in that region.

Das and Ghosh[9] examined the effects of four different doses of nitrogen on safflower in India, found that fertilizer doses significantly affected yield and yield components and recommended the 60 kg N $ha^{-1}$ dose as an optimum dose. Nimje[10] reported that the water use efficiency was increased by nitrogen application. Many others studies[11-20] also showed significant effects of nitrogen fertilizers and doses on safflower grown various part of world and Turkey. However these effects varied much depending on the fertilizer forms and doses besides various environmental conditions. Therefore, in this study it was aimed to detect the effects of different fertilizer forms and doses on safflower grown in Van, Turkey.

## MATERIALS AND METHODS

This study was carried out at the experimental farm of the university of Yüzüncüyıl, Van, Turkey in 1997 and 1998. Dinçer 5-118 safflower cultivar which has orange flowers, white and spineless seeds was used as a plant material.

The climatic data of the region are represented in Table 1. Temperate climatic condition is ruled in the region. The soil has sandy-clay loam texture and low organic matter and nitrogen rich potassium and lime content medium phosphorus and is low alkaline (pH 7-7.6) (Table 2).

The study was planned in factorial block design with three replications, three forms of nitrogen fertilizer (Ammonium nitrate, ammonium sulfate and urea) and four doses of them (0, 40, 80, 120 kg $ha^{-1}$ 9 were applicated on safflower and their effects on yield and yield components were investigated. Result were tested in variance analysis and means were grouped in Duncan Multiple Comparison Test[21].

## RESULTS AND DISCUSSION

**Plant height:** Fertilizer forms significantly affected ($p<0.05$) the plant height. In both years (Table 3) obtained the highest plant height in the plots applied with ammonium nitrate in both years, respectively as 69.4 and 68.4 cm. Plant fertilized with either ammonium sulfate or urea had similar plant heights. It is assumed that plants have taken fertilizer with nitrate much more easily and fast. Therefore the nitrate fertilizer is more effectively than others [22].

Different nitrogenous doses significantly affected ($P<0.01$) the plant height in both year. As the nitrogen doses increased, plant height also increased. While the application 120 kg N $ha^{-1}$ gave the highest plant height

Table 1: Climatic data of Van in 1997 and 1998 and long term*

| | Precipitation (mm) | | | Temperature (°C) | | | Relative humidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| Months | 1997 | 1998 | Long term | 1997 | 1998 | Long term | 1997 | 1998 | Long term |
| January | 23.6 | 29.8 | 38.3 | -1.7 | -3.6 | -4.0 | 56.6 | 74.4 | 70.0 |
| February | 22.6 | 39.0 | 33.4 | -2.8 | -5.0 | -3.6 | 56.7 | 69.7 | 70.0 |
| March | 74.5 | 27.0 | 45.1 | -2.0 | 1.9 | 0.7 | 60.0 | 72.0 | 69.0 |
| April | 32.5 | 41.6 | 54.4 | 6.2 | 8.7 | 7.2 | 53.0 | 71.0 | 63.0 |
| May | 23.3 | 36.0 | 46.3 | 13.9 | 14.0 | 12.9 | 49.6 | 67.8 | 57.0 |
| June | 25.0 | 10.7 | 18.4 | 18.7 | 20.9 | 17.8 | 41.3 | 57.1 | 50.0 |
| July | 31.6 | 1.0 | 5.1 | 21.7 | 23.6 | 22.0 | 44.2 | 54.0 | 44.0 |
| August | - | 1.2 | 3.9 | 22.5 | 23.1 | 21.5 | 27.4 | 54.4 | 42.0 |
| September | 10.7 | - | 10.5 | 17.1 | 18.0 | 17.0 | 51.3 | 61.3 | 43.0 |
| October | 56.4 | 0.3 | 45.4 | 11.8 | 11.8 | 10.3 | 70.4 | 62.4 | 59.0 |
| November | 10.8 | 14.8 | 47.5 | 5.1 | 8.8 | 4.3 | 76.1 | 67.0 | 67.0 |
| December | - | 57.5 | 32.1 | -0.2 | 3.0 | -1.1 | 73.0 | 72.0 | 69.0 |
| Total/average | 311.0 | 258.4 | 380.4 | 9.2 | 10.4 | 8.8 | 56.6 | 65.2 | 59.0 |

*Taken from the recording of Meteorogical Department in Van

Table 2: Results of some chemical and physical analysis of experimental soil*

| | Texture analysis | | | | | |
|---|---|---|---|---|---|---|
| Depth (cm) | Texture class | lime (%) | Salty (%) E.C. | Organic matter (%) | pH | Available P (ppm) |
| 0-20 | Sandy-clay | 11.97 | 1.6 | 0.85 | 7.5 | 5.04 |
| 20-40 | Sandy-clay | 19.07 | 1.4 | 0.83 | 7.6 | 2.40 |

*Soil analysis were done at the laboratories of Rural Affairs 9th Region Department

Table 3: Mean and compared values of the various forms and doses of nitrogenous fertilizers on the plant height (cm) in safflower

| Years | Nitrogenous fertilizer forms | Nitrogenous fertilizer doses (kg ha$^{-1}$) 0 | 40 | 80 | 12 0 | Form average | Average of both year's forms | Average value of years |
|---|---|---|---|---|---|---|---|---|
| 1997 | A. sulfat | 63.8 | 68.9 | 68.1 | 68.9 | 66.0b | 65.7b | |
| | Urea | 63.8 | 65.3 | 66.9 | 68.2 | 66.1b | 65.8b | 67.3 |
| | A. nitrate | 63.8 | 72.2 | 70.8 | 72.9 | 69.4a | 69.1a | |
| | Average of doses | 63.8b | 66.9ab | 68.6a | 70.0a | | | |
| 1998 | A. sulfat | 63.5 | 62.4 | 70.3 | 65.2 | 65.3b | | |
| | Urea | 63.5 | 63.5 | 65.4 | 69.8 | 65.8b | | 66.4 |
| | A. nitrate | 63.5 | 68.2 | 71.1 | 70.4 | 68.4a | | |
| | Average of doses | 63.5b | 64.7b | 68.9a | 68.5a | | | |
| Average of both year's doses | | 63.7b | 65.8b | 68.8a | 69.3a | | | |

Difference indicated with same letter(s) are non-significant

Table 4: Mean and compared values of the various forms and doses of nitrogenous fertilizers on the plant head (number) in safflower

| Years | Nitrogenous fertilizer forms | Nitrogenous fertilizer doses (kg ha$^{-1}$) 0 | 40 | 80 | 120 | Average of forms | Average of both year's forms | Average values of years |
|---|---|---|---|---|---|---|---|---|
| 1997 | A. sulphate | 10.2 | 11.6 | 11.3 | 9.8 | 10.7 | 11.4 | |
| | Urea | 10.2 | 11.0 | 10.3 | 14.1 | 11.4 | 12.6 | 11.4b |
| | A. nitrate | 10.2 | 11.2 | 11.2 | 15.4 | 11.9 | 12.2 | |
| | Average of doses | 10.2b | 11.3ab | 10.9ab | 13.1 a | | | |
| 1998 | A. sulphate | 11.3 | 11.1 | 12.2 | 13.4 | 12.0b | | |
| | Urea | 11.3 | 13.1 | 16.1 | 14.7 | 13.8a | | 12.8a |
| | A. nitrate | 11.3 | 11.7 | 13.3 | 13.6 | 12.5ab | | |
| | Average of doses | 11.3 | 12.0ab | 13.9a | 13.9 a | | | |
| Average of both year's doses | | 10.8c | 11.6bc | 12.4ab | 13.5a | | | |

Difference indicated with same letter(s) are non-significant

Table 5: Mean and compared values of the various forms and doses of nitrogenous fertilizers on the seed yield (kg ha$^{-1}$) in safflower

| Years | Nitrogenous fertilizer forms | Nitrogenous fertilizer doses (kg ha$^{-1}$) 0 | 40 | 80 | 120 | Average of forms | Average of both year's forms | Average values of years |
|---|---|---|---|---|---|---|---|---|
| 1997 | A. sulphate | 1298 | 1339 | 1339 | 1615 | 1397b | 1454b | |
| | Urea | 1298 | 1428 | 1690 | 1369 | 1446ab | 1492b | 1496 |
| | A. nitrate | 1298 | 1679 | 1605 | 1994 | 1644a | 1597a | |
| | Average of doses | 1298b | 1482ab | 1545ab | 1659a | | | |
| 1998 | A. sulphate | 1393 | 1482 | 1505 | 1658 | 1509b | | |
| | Urea | 1393 | 1455 | 1557 | 1750 | 1538ab | | 1532 |
| | A. nitrate | 1393 | 1362 | 1723 | 1720 | 1550a | | |
| | Average of doses | 1393c | 1433c | 1595b | 1709a | | | |
| Average of both year's doses | | 1345c | 1457bc | 1570b | 1685a | | | |

Difference indicated with same letter(s) are non-significant

Table 6: Mean and compared values of the various forms and doses of nitrogenous fertilizers on crude oil ratio (%) in safflower

| Years | Nitrogenous fertilizer forms | Nitrogenous fertilizer doses (kg ha$^{-1}$) 0 | 40 | 80 | 120 | Average of forms | Average of both year's forms | Average values of years |
|---|---|---|---|---|---|---|---|---|
| 1997 | A. sulphate | 25.2 | 28.1 | 27.8 | 26.1 | 26.8 | 27.6 | |
| | Urea | 25.2 | 25.5 | 25.7 | 24.3 | 25.2 | 26.4 | 25.7b |
| | A. nitrate | 25.2 | 23.1 | 27.0 | 25.2 | 25.1 | 26.3 | |
| | Average of doses | 25.2 | 25.6 | 26.8 | 25.2 | | | |
| 1998 | A. sulphate | 27.7 | 29.6 | 29.1 | 26.8 | 28.3 | | |
| | Urea | 27.7 | 28.4 | 27.5 | 26.7 | 27.6 | | 27.8a |
| | A. nitrate | 27.7 | 27.4 | 27.7 | 26.5 | 27.3 | | |
| | Average of doses | 27.7 | 28.5 | 28.1 | 26.7 | | | |
| Average of both year's doses | | 26.5 | 27.1 | 27.5 | 25.9 | | | |

Difference indicated with same letter(s) are non significant

(70 cm) in 1997, the application of 80 kg N ha$^{-1}$ obtained the highest height (68.9 cm) in 1998. There was no significant difference in plant heights of 80 and 120 kg N ha$^{-1}$ applications. The control plants had the smallest plant in both years (Table 3.) According the mean values of both years, the ammonium nitrate fertilizers and the application of 120 kg ha$^{-1}$ had the highest plant heights as 72.9 and 70.4 cm, respectively. The interaction between the dose and form of nitrogenous fertilizer was found significant ($p<0.05$) in 1998. The application of nitrogenous fertilizer increases the vegetative growth in plants. Esendal[2], Ahmet *et al.*[6] Bayraktar and Ülker[23],

Table 7: Mean and compared values of the various forms and doses of nitrogenous fertilizers on crude oil yield (%) in safflower

| Years | Nitrogenous fertilizer forms | Nitrogenous fertilizer doses (kg ha$^{-1}$) 0 | 40 | 80 | 120 | Average of forms | Average of both year's forms | Average values of years |
|---|---|---|---|---|---|---|---|---|
| 1997 | A. sulphate | 327 | 379 | 372 | 421 | 375 | 397 | |
| | Urea | 327 | 364 | 434 | 327 | 363 | 394 | 388b |
| | A. nitrate | 327 | 389 | 442 | 497 | 413 | 422 | |
| | Average of doses | 327b | 377ab | 416a | 415a | | | |
| 1998 | A. sulphate | 386 | 438 | 439 | 446 | 427 | | |
| | Urea | 386 | 414 | 429 | 470 | 425 | | 425a |
| | A. nitrate | 386 | 373 | 477 | 457 | 423 | | |
| | Average of doses | 386c | 408bc | 448ab | 458a | | | |
| Average of both year's doses | | 357b | 393ab | 432a | 437a | | | |

Difference indicated with same letter(s) are non-significant

Das and Gosh[9] reported positive results in plant height with the increasing doses of nitrogenous.

**The number of plant head:** The effects of various nitrogenous fertilizer forms on the number of head was non significant in 1997 and 1998. However overall average values of forms in combined years was significant ($p<0.05$). There was significant difference ($p<0.05$) on the number of head between two years. The application of ammonium nitrate fertilizer had the highest number of head in 1997 as 11.9 per plant, respectively. The application of ürea had the highest number of head in 1998 as 13.8 per plant, respectively. As the doses of nitrogen increased, the number of head increased. The application of 120 kg N ha$^{-1}$ obtained the highest number of head in both years (Table 4). Günel *et al.*[5] obtained 7.8-9.9 head per plant in the cultivar Dinçer in Van conditions and Bayraktar and Ülker[23] got 10.75-11.40 head per plant. Moreover, Esendal[2], Ahmed *et al.*[6], Cabı[8], Nimje[10], Singh *et al.*[24] reported significant increases at the number of plant head by increasing doses of nitrogen. Present results are in line with these studies.

**Seed yield:** Both the forms and doses of nitrogenous fertilizers had significant effects on the seed yield of safflower in both years. While the highest seed yield was obtained from ammonium nitrate, ammonium sulphate gave the lowest seed yield in both years (Table 5). Ammonium nitrate become more effective than others because plant uptake it much more easily and quickly than others[22]. Cabı[8] reported the significant effects of nitrogenous fertilizer forms on the safflower seed yield and found that the highest seed yield was obtained from ammonium nitrate. The application of 120 kg N ha$^{-1}$ obtained the highest seed yield in both years (Table 5). These are similar results which indicated that increase in the seed yield by increasing doses of nitrogenous fertilizer in the studies of Katole and Meane[25], Mahey *et al.*[7], Nimje[10], Singh *et al.*[24], Rajput[12], Koç and Altınel[14].

**Crude oil ratio:** There was significant difference in the crude oil ratios obtained in 1997 and 1998 due to the different environmental factors. The forms and doses of nitrogenous fertilizers had no significant effect on the crude oil ratio (Table 6). Cabı[8] also reported the significant effect the forms of nitrogenous fertilizer on the crude oil ratio in safflower. However the crude oil ratio decreased (though insignificant) at the application of 120 kg N ha$^{-1}$. Esendal[2], Mahey *et al.*[7] and Cabı[8] reported that the nitrogenous fertilizer doses didn't significantly effect on the crude oil ratio in safflower. However, Sepetoğlu[26], Günel and Arslan[27] reported decreases (though insignificant) at the crude oil ratio in safflower beyond a threshold levels of nitrogenous fertilizer.

**Crude oil yield:** The doses, but not forms, of nitrogenous fertilizers had significant effects on the crude oil yield in safflower (Table 7).

There was also significant difference between the crude oil yields obtained in 1997 and 1998. The crude oil yield was increased as the crude oil yield by nitrogenous fertilizer doses of which increased. Cabı[8] found significant effects of nitrogenous fertilizer forms on the crude oil yield. Esendal[2], Cazzato *et al.*[14] reported significant effects of nitrogenous fertilizer doses on it.

This study was carried out in Van Turkey ecological condition in 1997 and 1998 in order to determine the effects of various doses and forms of nitrogenous fertilizer on the yield and some components of safflower, is an alternative oil crop for the region's crop design. The application of increasing doses of nitrogenous fertilizers had significantly positive effects on seed and crude oil yields. The safflower seed yield was also significantly effected by the forms of nitrogenous fertilizer. Overall average yields of ammonium sulphate, urea and ammonium nitrate were 1454, 1492 and 1597 kg seed ha$^{-1}$ and 397, 394, 422 kg crude oil ha$^{-1}$. Based on this the two year's experiment, the application of ammonium nitrate at the 120 kg N ha$^{-1}$ dose is recommendable for safflower growing in this region.

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