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# The Influence of Different Nitrogen Doses on Yield and Yield Components of Buckwheat (*Fagopyrum esculentum* Moench)

## Farklı Azot Dozlarının Karabuğday (*Fagopyrum esculentum* Moench)'ın Verim ve Verim Öğelerine Etkisi

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# THE INFLUENCE OF DIFFERENT NITROGEN DOSES ON YIELD AND YIELD COMPONENTS OF BUCKWHEAT (*FAGOPYRUM eSCULENTUM* MOENCH)


## ABSTRACT

In this study, the effects of five different doses of nitrogen (0, 50, 100, 150 and 200 kg N ha-1) on yield and yield components of buckwheat (güneş variety) were investigated. The field experiments were carried out under Eskişehir of Turkey ecological conditions using randomized complete block design with three replications in 2018 and 2019. Depending on the nitrogen doses applied in the study, plant height, number of branches per plant, 1000 seed weight, hectoliter weight, crude protein content and seed yield values of buckwheat were determined. Considering the average values of the two years for the characters examined in the research, they varied between 70.34-93.76 cm, 1.41-2.61 number, 22.56-30.54 gr, 54.51-69.04 kg, 8.33-11.22% and 0.95-1.83 t ha-1, respectively. When the results obtained from the study were evaluated, it was determined that the most suitable nitrogen dose for buckwheat cultivation was 150 kg N ha-1.


***Keywords:*** Buckwheat, Nitrogen, Seed Yield, Crude Protein Content, Hectoliter Weight.

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# FARKLI AZOT DOZLARININ KARABUĞDAY (*FAGOPYRUM eSCULENTUM* MOENCH)'IN VERİM VE VERİM ÖĞELERİNE ETKİSİ


## ÖZ:

Bu çalışmada, beş farklı azot (0, 50, 100, 150 ve 200 kg N ha-1) dozlarının karabuğday (güneş çeşidi)'ın verim ve verim öğelerine etkisi incelenmiştir. Tarla denemeleri, Eskişehir ekolojik koşulları altında 2018 ve 2019 yıllarında tesadüf blokları deneme desenine göre 3 tekrarlamalı olarak yürütülmüştür. Çalışmada uygulanan azot dozlarına bağlı olarak karabuğdayın bitki boyu, dal sayısı, 1000 tohum ağırlığı, hektolitre ağırlığı, ham protein içeriği ve tohum verimi belirlenmiştir. Araştırmada iki yılın ortalama değerleri dikkate alındığında bitki boyu 70.34-93.76 cm, bitki başına dal sayısı 1.41-2.61 adet, bin tohum ağırlığı 22.56-30.54 gr, hektolitre ağırlığı 54.51-69.04 kg, ham protein oranı % 8.33-11.22 ve tohum verimi 0.95-1.83 t ha-1 arasında değişiklik göstermiştir. Çalışmadan elde edilen sonuçlar değerlendirildiğinde, karabuğday yetiştiriciliği için en uygun azot dozunun 150 kg N ha-1 olduğu tespit edilmiştir.


***Anahtar Kelimeler:*** Karabuğday, Azot, Tohum Verimi, Ham Protein Oranı, Hektolitre Ağırlığı.

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## INTRODUCTION

Buckwheat belonging to the *Fagopryrum* genus of the Polygonaceae family is an annual and dicotyledonous plant. Although the plant originated in Central Asia, it was later taken to Central and Eastern European countries by nomads (Schoenlechner et al., 2008; Wajid et al., 2015; Mota et al., 2016). There are two important species of the genus Fagopyrum, which are widely cultivated in different parts of the world. These are common buckwheat (*Fagopyrum esculentum*) and tatary buckwheat (*Fagopyrum tataricum*). The products of this two species are used as raw materials in the production of buckwheat tea, groats, flour and noodles (Zhang et al., 2012). It was reported that common buckwheat has nutritional properties such as proteins, minerals, natural antioxidants, vitamins (especially B group) and dietary fibre (Alamprese et al., 2007).

The seeds of the plant can be used for human and animal nutrition as well as for medicinal purposes (Janos and Gocs, 2009). For example, it is also used in the treatment of various diseases due to phenolic antioxidants, aromatic compounds and bioactive metabolites (fagopyrin, etc.) in the seed and vegetative part of the plant (Kreft et al., 1999). The flour obtained from seeds of plant have a effect on control of diabetes and in the treatment of cardiovascular and high blood pressure diseases (Bluett, 2001; Srinivasan et al., 2005). In addition, buckwheat is used to control weeds and as green manure (Janos and Gocs, 2009). Buckwheat, which has the potential to adapt to regions with different climates, is commonly cultivated in the northern hemisphere (Zhang et al., 2012; Mota et al., 2016). The fact that the high yield increases in the grain yield of cereals could not be achieved in buckwheat in the 20th century caused a worldwide decrease in the consumption and cultivation of buckwheat (Schoenlechner et al., 2008; Nurzynska-Wierdak, 2013).

It is known that the two most important producing countries of buckwheat in the world are Russia and China, respectively (Zhang et al., 2012). In the last few decades, interest in buckwheat (*Fagopyrum esculentum*) has increased due to the increasing demand for gluten-free diets, and the area where the plant is grown has exceeded 2.5 million hectares and an annual production of approximately 2 million tons were realized (Mota et al., 2016).

Plants need sufficient nutritional element for optimal growth. It is known that a suitable mineral nutrition is an important factor in revealing the yield and quality potential of the plant by positively affecting both the appropriate nutritional status of the plant and the physiological balance between the nutrients in the plant. (Skubij et al., 2020).

It was reported that nitrogen fertilizations are important factors affecting grain yield and protein content of buckwheat (*Fagopyrum esculentum* Moench) (Baburkova et al., 1999). However, when nitrogen fertilizers are applied more or less than the optimum dose, the yield and quality of the product decreases. Moreover, when excessive nitrogen application is continuous, it also causes environmental problems (Moniruzzaman et al., 2014).

Some studies were conducted investigating the effect of nitrogen fertilizer on yield and yield components of buckwheat in different regions of the world (Omidbaigi et al., 2004; Inamullah et al., 2012; Okudan and Kara, 2015).

However, it is necessary to determine the most appropriate nitrogen dose by field experiments before a new plant is cultivated in a region.

In this study, it was aimed to determine the effect of various nitrogen levels on the yield and yield component of buckwheat under Eskişehir ecological conditions.

## 2. MATERIAL AND METHODS

The seeds of the Güneş variety of Buckwheat ((*Fagophyrum esculentum* Moench) obtained from the TR Ministry of Agriculture and Forestry Bahri Dağdaş International Agricultural Research Institute were used as plant material in field trials. Field trials were established in the Experimental field of Eskisehir Forest Nursery Directorate in 2018 and 2019 (39°46´N, 30°32´E, altitude 732 m). Soil samples taken from the experimental plots (at a depth of 60 cm) in both years were subjected to physicochemical analysis and the obtained values were presented in Table 1. As seen in Table 1, the soil samples analyzed in 2018 and 2019 had organic matter rates of 2.8% and 3.1%, $P_2O_5$ (56.7 and 53.8 kg $ha^{-1}$), $K_2O$ (2294 and 2379 kg $ha^{-1}$), a slight alkaline pH (7.3 and 7.4), 0.03 and 0.04 dS $m^{-1}$ EC and $CaCO_3$ ratios of 6.9% and 5.3%, respectively.

***Table 1.*** *Some physical and chemical properties of soils in experimental fields**

| Texture | Lime (%) | EC (dS $m^{-1}$) | Available Phosphorus (kg $P_2O_5$ $ha^{-1}$) | Available Potassium (kg $K_2O$ $ha^{-1}$) | pH | Organic Matter (%) |
|---|---|---|---|---|---|---|
| Loamy (2018) | 6.9 | 0.03 | 56.7 | 2294 | 7.3 | 2.8 |
| Loamy (2019) | 5.3 | 0.04 | 53,8 | 2379 | 7.4 | 3.1 |

* Soil analysis was carried out in the laboratory of Forest Soil and Ecology Research Institute-Eskisehir

The climate data of the experiment location were presented in Table 2. During the cultivation period of 2018 and 2019, when field trials were conducted, the total rainfalls and mean temperatures were recorded as 191.4 mm, 143.8 mm and

17.8°C, 17.6°C, respectively. It was determined that the precipitation and temperature values of the years in which the experiments were carried out were higher than the precipitation and temperature values of the long years of the region (Table 2).

Field trials were carried out using 5 different N doses (0, 50, 100, 150 and 200 kg $ha^{-1}$) in a randomized block design with 3 replications. On April 15, 2018 and April 18, 2019, seeds were sown with 80 kg $ha^{-1}$ sowing norm and 3-4 cm sowing depth on the trial plots where the necessary soil tillage was done (Acar et al., 2011; Katar and Katar, 2017; Kaya, 2018). There were 6 rows of plants in the plots, the row length was 5 m and the inter-row spacing was 25 cm (Güneş et al., 2012). All of the phosphorus fertilizer (40 kg $P_2O_5$ $ha^{-1}$) was applied during planting sowing. Half dose of nitrogen was applied during sowing and the other half dose of nitrogen was applied after two weeks from plants emergence.

***Table 2.****The precipitation and temperature values of the experiment area for 2018-2019 and many years**

| Months | Monthly recipitation (mm) | | | Mean Temperature (°C) | | |
|---|---|---|---|---|---|---|
| | 2018 | 2019 | LYA** | 2018 | 2019 | LYA** |
| April | 16,80 | 38.6 | 43.1 | 13,60 | 10.2 | 9.6 |
| May | 72,00 | 30.3 | 40.0 | 16,40 | 17.4 | 14.9 |
| June | 60,60 | 57.5 | 23.7 | 19,30 | 21.1 | 19.1 |
| July | 42,00 | 17.4 | 13.1 | 21,90 | 21.8 | 22.1 |
| Total | 191,4 | 143.8 | 119.9 | - | - | - |
| Mean | - | - | - | 17.8 | 17.6 | 16.4 |

*Data were taken from Eskisehir Regional Meteorological Service,** LYA: Long Year Average

After the plants have completed their emergence, weed control was done manually and with a hoeing tool. The plots were irrigated twice in both 2018 and 2019, the first in the first half of June and the second at the end of June. No pesticides have been applied to combat diseases and pests. The plants were harvested on 19.07.2018 and 22.07.2019, when about 75-80% of the grains turned brown. During the harvest, the first and last rows of each parcel and 0.5 m from both ends of the rows were discarded as border effect.

Single plant values were determined by measuring and weighing 10 selected different plants from each plot. Harvested plants were dried in the shade for 7-10 days, then threshing and cleaning was done. Seed yields per hectare were calculated over plot yields. The samples taken from the grains obtained from the harvested plots were weighed in a 1/4 liter hectoliter instrument, and then the hectoliter weight was calculated by multiplying the obtained value by 4. In order to determine the crude protein ratios (%), the total nitrogen (N) contents of the whole grain samples were determined by using a nitrogen (N) analyzer (LECO FP628) working with the Dumas combustion method (AACC Metot 46-30), and then the nitrogen contents were calculated by multiplying by 6.25 (Ikeda et al., 2001; Elgun et al., 2002).

SPSS program was used in the statistical analysis of all data and the significant means were compared by the Tukey test at the 5% level.

## 3. RESULT AND DISCUSSION

Data regarding plant height of buckwheat as affected by various N doses are presented in Table 3. Years and different N doses had a significant impact on plant height. However, year x nitrogen doses interaction had not a significant effect on plant height. Plant height values of buckwheat were higher in 2019. This difference could be due to the monthly change of climatic factors such as temperature. Ekberli et al. (2005) reported that functional relationships among N fertilizer doses, grain and straw yield depending on climatic conditions, and different amount of grain yield with fertilizer applications were determined. The researchers used the relationships between grain yield and fertilizer doses, hydrothermic constant (HTC) and precipitation. In addition, they reported that when amount of nitrogen fertilizer was 22.68 kg da$^{-1}$ and HTC≈0.504, maximum yield was estimated as 1043.63 kg da$^{-1}$ , when total precipitation amount was 126.1 mm and amount of nitrogen fertilizer was 22.69 kg da$^{-1}$ in the same vegetation period (June-September), maximum yield was estimated as 945.21 kg da$^{-1}$. Plant height increased significantly in application of nitrogen compared to the control plants. The highest plant height (93.76 cm) was obtained in the nitrogen application of 200 kg ha$^{-1}$ (Table 3). Similar to these findings, it were reported that plant height increases with increasing nitrogen levels in buckwheat (Saini and Negi, 1998; Inamullah et al., 2012; Okudan and Kara, 2015).

Data regarding number of branches per plant of buckwheat affected by nitrogen levels are presented in Table 3. The table shows that nitrogen affected number of branches per plant significantly ($p<0.01$). The number of branches per plant of buckwheat depending on different nitrogen levels varied between 1.41 and 2.61. Maximum number of branches per plant was produced in plots which received 200 kg N ha$^{-1}$ while the lowest number of branches per plant was produced in plots where N was not applied (Table 3). In studies on buckwheat, Katar and Katar (2017) and Kaya (2018) found the number of branches per plant to be 1.71-3.13 and 0.33-2.86 number, respectively. In parallel with this study, Inamullah et al. (2012) reported that number of branches per plant increased significantly increasing N applicaiton in *Fagopyrum esculentum*.

The years and nitrogen doses had a significant effect on 1000 seed weight (g). While mean 1000 seed weight was 27.46 g in 2018, it was 28.82 g in 2019. According to the mean of two-year, the seed yield ranged from 22.56 to 30.54 g and the highest value was determined in 200 kg N ha$^{-1}$. However, in terms of 1000 seed weight, there was no statistically significant difference between 150 kg N ha$^{-1}$ and 200 kg N ha$^{-1}$ doses (Table 3). These findings are in agreement with Inamullah et al. (2012) and Kara et al. (2016), who found that 1000 seed weight of buckwheat increases with nitrogen application.

The results in Table 3 indicated that there were significant differences among N doses for hectoliter weight of buckwheat. The increase in the doses of applied N also increased hectoliter weight of the buckwheat. As the mean of two-year, the maximum hectoliter weight (69.04 kg) were recorded by 200 kg N ha$^{-1}$ doses, meanwhile in the control plants recorded the lowest value (54.51 kg) (Table 3). These results indicate that the best hectoliter weight of buckwheat was obtained with 200 kg ha$^{-1}$ annual nitrogen. In addition, the effect of years was significant on hectoliter weight of buckwheat. This can be explained by the fact that climate factors such as temperature and solar radiation change from year to year. Kara and Gurbuzer (2018) found the hectoliter weight of buckwheat to be between 51.88-56.47 kg hL$^{-1}$. It was reported that the hectoliter weight in wheat varies depending on factors such as genotype, cultivation practices, environmental conditions, diseases and pests (Atli, 1999).

The effects of the years and nitrogen doses on crude protein content were found to be significant. The crude protein content was higher in 2019 compared to 2018 (Table 3). This is probably due to the average temperature values of annual, higher in 2019 than in 2018 (Table 2). The crude protein content of buckwheat ranged from 8.33% to 11.22% and the highest value was recorded in 200 kg N ha$^{-1}$ doses. However, the crude protein content of buckwheat increased significantly up to 50 kg N ha$^{-1}$ (Table 3). It has been reported that the protein content of buckwheat varies between 8.51% and 18.87% depending on the species (Yildiz and Yalcin, 2013). In addition, the crude protein content of buckwheat is affected by genetic material used, climate and soil characteristics of the cultivation location (Vojtiskova et al., 2012). Furthermore, it were reported that especially the high amount of mineral nitrogen in the soil increases the protein content in buckwheat cultivation (Barta et al., 2004; Omidbaigi et al., 2004).The results of the study are in agreement with the observations by Kara et al. (2016), who reported that crude protein content increases using nitrogen fertilizer in buckwheat.

The most important characteristic of buckwheat is undoubtedly the seed yield per hectare. The results in Table 3 show that nitrogen application had significant effect on the seed yield. The lowest seed yield (0.95 t ha$^{-1}$) was harvested from control treatment (N0). The highest seed yield (1.83 t ha$^{-1}$) was collected from the plants treated with 200 kg N ha$^{-1}$. However, there was no significant difference between 150 and 200 kg N ha$^{-1}$. In the studies conducted on buckwheat by Kara et al. (2016), Fang et al. (2018) and Kaya (2018), seed yield per hectare, were found to be 0.34-1.45 t, 1.13-1.40 t and 0.44-1.65 t, respectively. The differences of seed yield obtained in the studies may be due to the difference of the plant material used (different genotypes) and the changing ecological conditions of study areas such as temperature, light intensity etc. This results were in agreement with the findings of Omidbaigi et al. (2004) and Inamullah et al. (2012), who recorded that seed yield of buckwheat increases with increasing nitrogen.

***Table 3.*** *The effect of different nitrogen doses on yield and yield components of buckwheat*

| Nitrogen Doses (kg ha$^{-1}$) | Plant Height (cm) | | | Number of Branches Per Plant | | |
|---|---|---|---|---|---|---|
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 0 | 69.78 | 70.89 | 70.34 e | 1.39 | 1.44 | 1.41 d |
| 50 | 79.93 | 81.95 | 80.95 d | 1.79 | 1.87 | 1.83 c |
| 100 | 84.51 | 87.79 | 86.15 c | 1.88 | 1.98 | 1.93 c |
| 150 | 89.44 | 91.65 | 90.54 b | 2.15 | 2.28 | 2.22 b |
| 200 | 91.32 | 96.21 | 93.76 a | 2.54 | 2.67 | 2.61 a |
| Mean | 83.00 B | 85.70 A | | 1.95 B | 2.05 A | |
| Years (Y) | | ** | | | ** | |
| Nitrogen (N) | | ** | | | ** | |
| Y x N | | ns | | | ns | |
| CV (%) | | 10.31 | | | 21.42 | |
| **Nitrogen Doses (kg ha$^{-1}$)** | **1000 Seed Weight (g)** | | | **Hectoliter Weight (kg hl$^{-1}$)** | | |
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 0 | 22.14 | 22.98 | 22.56 c | 53.50 | 55.51 | 54.51 d |
| 5 | 28.03 | 29.31 | 28.67 b | 61.63 | 64.47 | 63.05 c |
| 10 | 28.45 | 29.95 | 29.20 b | 62.68 | 66.00 | 64.34 bc |
| 15 | 28.91 | 30.55 | 29.73 ab | 64.15 | 67.81 | 65.98 b |
| 20 | 29.78 | 31.30 | 30.54 a | 67.32 | 70.75 | 69.04 a |
| Mean | 27.46 B | 28.82 A | | 61.86 B | 64.91 A | |
| Years (Y) | | ** | | | ** | |
| Nitrogen (N) | | ** | | | ** | |
| Y x N | | ns | | | ns | |
| CV (%) | | 10.88 | | | 8.61 | |
| **Nitrogen Doses (kg ha$^{-1}$)** | **Crude Protein Content (%)** | | | **Seed Yield (t ha$^{-1}$)** | | |
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 0 | 8.18 | 8.47 | 8.33 b | 0.92 | 0.97 | 0.95 d |
| 5 | 10.37 | 10.85 | 10.61 a | 1.43 | 1.50 | 1.46 c |
| 10 | 10.90 | 11.48 | 11.19 a | 1.61 | 1.69 | 1.65 b |
| 15 | 10.77 | 11.38 | 11.07 a | 1.70 | 1.80 | 1.75ab |
| 20 | 10.94 | 11.50 | 11.22 a | 1.78 | 1.87 | 1.83 a |
| Mean | 10.23 B | 10.73 A | | 1.49 B | 1.56 A | |
| Years (Y) | | ** | | | ** | |
| Nitrogen (N) | | ** | | | ** | |
| Y x N | | ns | | | ns | |
| CV (%) | | 12.38 | | | 21.69 | |

** Significant at the $p \leq 0.01$ probability level, ns: Not significant, CV: Coefficient of variation.

The difference between the means in the same columns followed by the same small letters and in the same rows followed by the same capital letters is statistically insignificant according to the Tukey test.

In the study, a positive correlation was found between plant height, number of branches, 1000 seed weight, hectoliter weight, crude protein content and seed yield. Positive correlation between seed yield and plant height, seed yield and 1000 seed weight, respectively, was the strongest. On the contrary, the lowest positive correlations were observed between the number of branches and crude protein content, 1000 seed weight and the number of branches, respectively (Table 4).

***Table 4.*** *Coefficient of correlation between the examined parameters of buckwheat in relation to different nitrogen doses*

| | Plant Height | Number of Branches | 1000 Seed Weight | Hectoliter Weight | Crude Protein Content |
|---|---|---|---|---|---|
| Number of Branches | 0.922** | | | | |
| 1000 Seed Weight | 0.915** | 0.793** | | | |
| Hectoliter Weight | 0.945** | 0.912** | 0.919** | | |
| Crude Protein Content | 0.841** | 0.721** | 0.892* | 0.828** | |
| Seed Yield | 0.964** | 0.857** | 0.945** | 0.918** | 0.844** |

**: significant correlation at a level of $p \leq 0.01$

## 4. CONCLUSION

Nitrogen fertilizer had significant effects on the plant height, number of branches per plant, 1000 seed weight, hectoliter weight, crude protein content and seed yield of common buckwheat. The all characters examined in the study increased with nitrogen fertilizer. While the crude protein content was affected the least by nitrogen application, plant height, number of branches per plant and hectoliter weight were affected the most. As a result of this research, it can be said that the most suitable nitrogen level for buckwheat cultivation is 150 kg N $ha^{-1}$.

### Conflict of İnterests

The authors declare that they have no conflict of interest

### Ethic

This study does not require any ethics committee approval

### Author Contribution Rates

Design of Study: NK (%40), DK (%40), MC (%20)

Data Acquisition: NK (%40), DK (%40), MC (%20)

Data Analysis: NK (%25), DK (%25), MC (%50)

Writing up: NK (%20), DK (%20), MC (%60)

Submission and Revision: NK (%20), DK (%20), MC (%60)

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