

DETERMINATION OF BIOLOGICAL NITROGEN FIXATION CAPACITIES OF WINTER AND SPRING LENTIL VARIETIES BY USING ^{15}N METHODOLOGY

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ABSTRACT

In order to determine the biological nitrogen fixation capacities of winter and spring varieties of lentil which have of agronomic importance under the Central Anatolia region, the field experiments (winter and spring) were carried out. In both experiments, the effects of two different inoculants and different harvesting times on the biological nitrogen fixation capacities of lentil varieties, were investigated.

The field experiments were conducted using by randomized block design as split-split plot for 4 replications. Barley was selected as the reference crop and 20 cm row spacing were used for lentil and barley. Inoculations were done immediately before sowing. 10.0 kgN/ ha for lentil varieties as 10.0 % ^{15}N atom excess and 40.0 kgN/ ha for barley (reference crop) as 2.0 % ^{15}N atom excess ammonium sulphate fertilizer were applied. In addition, 60.0 kgP₂O₅/ ha were applied as triplesuperphosphate for all treatments. Plants were harvested at the different growth stages and than plant materials prepared for the analysis. Total nitrogen and % ^{15}N atom excess analysis were done by Kjeldahl method and Emission spectrometer, respectively. The amount of nitrogen fixation capacities of winter and spring lentil varieties were calculated according to the A-Value method (IAEA 1990).

The results showed us that the winter varieties of lentil had higher dry matter yields and nitrogen fixation capacities than the spring varieties. Inoculation treatments had no statistically significant effects on the percentage of nitrogen derived from atmosphere (% Nd_{fa}) and the amount of fixed nitrogen (kgN/ ha) for both experiments. In comparison between the harvesting times, the highest amount of fixed nitrogen was found at the pod formation stage for all cultivars. The average amounts of % Nd_{fa} and fixed nitrogen (kgN/ ha) were 75.0 and 70.0 for winter cultivars, 70.0 and 45.0 for spring cultivars, respectively.

INTRODUCTION

Nitrogen is the most essential element to the plants and hence for human nutrition in the world. Generally, N fertilizer is not used very efficiently by farmers in the Central Anatolia, due to misuse of application methods, amounts and timing of N fertilizers. In addition, low soil organic matter, high soil pH, low and irregular precipitation during the growing season of crops in these regions are the main limiting factors on the availability of N fertilizers for obtaining a reliable

production. For these reason, one of the best alternative to optimize high yields is to grow legumes and being increase of their N₂ fixation capacities could be a reliable approach to the farmers under these region. Different types of legumes have been cultivated in the different parts of Turkey. Especially, lentil, chickpea, bean and vetch are the main legume crops in the Central Anatolia. Lentil is generally cultivating without any N fertilizers by farmers. However, 20 kgN/ ha as the starter N dose at sowing time for a good production is adviseable for legumes by the researchers. In addition, some of the researchers advise to use rhizobium inoculants before sowing due to the lack of rhizobium strains into the soil. Besides, in the crop rotation systems using the legumes before the cereals, there is very likely N residual effect to the subsequent crops. Therefore, legumes are able to play an important role on the farming systems, especially for increasing the soil organic matter and for obtaining good productions. The objective of these experiments were to determine the N₂ fixation capacities of different lentil varieties (both winter and spring) on the different harvesting times which have of agronomic and economic importance for the region by using ¹⁵N tracer technique.

MATERIAL AND METHODS

The field experiments were carried out at the experimental site of the Ankara Nuclear Agriculture and Animal Research Center which is located about 30 km. distance from Ankara. The soil characteristic of the experimental site is the silty clay loam with low organic matter content (1.07 %) and alkaline soil reaction (pH 8.1) and it has low N (0.1 %) and P (6.0 ppm) contents. In addition, low annual precipitation (average 350 mm) which is represent the soil and climatic conditions of the Central Anatolia region.

In the field experiments, the effect of three factors were namely:

1.) Inoculant:

I₀ : Non inoculation

I₁ : Azotec; obtained from Soil and Fertilizer Research Institute, Ankara

I₂ : Entite; obtained from private producer, Yenikent, Ankara

2.) Varieties of Lentil:

V₁ : Pul-11 (alternative variety, both winter and spring sowing)

V₂ : Kislik Kirmizi-51 (winter variety)

V₃ : Sultan-1 (spring variety)

3.) Harvesting Times:

H₁: Maximum vegetative devolopment

H₂: Beginning of the pod formation

H₃ : Physiological maturity, were investigated.

The field experiments were conducted using split-split plot design for 4 replications. Barley was selected as the reference crop and 20 cm row spacing were used for both lentil and barley. Winter varieties were sowed on October and spring varieties on March. The placement of

treatments were; inoculations where in the main plots, varieties of lentil where in the sub-plots and harvesting times where in the sub-subplots. Inoculations were done immediately before sowing for all I₁ and I₂ treatments. Nitrogen fertilizer was applied at 10.0 kgN/ ha level as a starter dose to all lentil plots as 10.0 % ¹⁵N atom excess labelled ammonium sulphate and at 40.0 kgN/ ha level to all reference crops as 2.0 % ¹⁵N atom excess labelled ammonium sulphate. 60.0 kgP₂O₅/ ha as a triplesuperphosphate was applied to the all plots before sowing. Plants were harvested at three different growth stages. Fresh samples were weighted, subsampled and dried in an oven at 70 °C until constant weight at every growth stages. The sub-samples were finely grounded to pass a 1 mm sieve. Total N (by using Kjeldahl method) and % ¹⁵N atom excess (by using emission spectrometer) analysis were done (Faust, 1981) . The equation used in % Ndfa, Fixed N (kgN/ha) and % NUE calculations were (According to the A-Value Concept);

$$\% \text{Ndfa} = 100 \left(1 - \frac{\% \text{Ndff}_F}{n \times \% \text{Ndff}_{NF}} \right) + \% \text{Ndff}_F \left(\frac{1}{n} - 1 \right)$$

Where; F: fixing crop, NF: non-fixing crop (reference crop)

$$\% \text{Ndff} = \frac{\% \text{ }^{15}\text{N a.e. plant}}{\% \text{ }^{15}\text{N a.e. fertilizer}} \times 100 \quad n = \frac{\text{amount of fert. to F crop (kgN/ha)}}{\text{amount of fert. to NF crop (kgN/ha)}}$$

$$\text{Fixed N (kgN/ha)} = \frac{\% \text{Ndfa} \times \text{Total NF}}{100}$$

$$\text{Total N yield (kgN/ha)} = \% \text{N} \times \text{Dry Matter yield (kg/ha)}$$

$$\% \text{NUE} = \frac{\% \text{Ndff} \times \text{Total N yield (kgN/ha)}}{\text{Applied N fertilizer rate (kgN/ha)}} \times 100$$

Statistical analysis of experimental datas were done by using MSTAT-C statistics programme.

RESULTS AND DISCUSSION

According to the obtained results, the winter varieties of lentil had higher total dry matter yield (kg/ha), total N yield (kgN/ha), % Ndfa (percent nitrogen derived from atmosphere), fixed N (kgN/ha) and % NUE (percent nitrogen use efficiency) values than the spring varieties. The inoculation treatments did not have any improvement effects on the biological nitrogen fixation

capacities of winter and spring varieties. According to the harvesting times, N_2 fixation capacities were higher at the beginning of pod formation stage than the other growth stages.

The average of total dry matter yields for winter varieties were found that 3688 and 4363 kg/ha (statistically significant at the level of $p < 0.05$) for Pul-11 and Kislik Kirmizi-51; and for spring varieties were 2723 and 2603 kg/ha (no-significant) for Pul-11 and Sultan-1, respectively.

The average of total N yield values for winter varieties were found that 87.8 and 99.5 kgN/ha ($p < 0.05$) for Pul-11 and Kislik Kirmizi-51; and for spring varieties were 64.0 and 63.3 kgN/ha (no-significant) for Pul-11 and Sultan-1, respectively.

The average of % Ndfa values for winter varieties were found that 74.4 and 74.6 % (no-significant) for Pul-11 and Kislik Kirmizi-51; and for spring varieties were 66.7 and 74.3 % ($p < 0.05$) for Pul-11 and Sultan-1, respectively.

The average of fixed N values for winter varieties were found that 65.9 and 74.2 kgN/ha ($p < 0.05$) for Pul-11 and Kislik Kirmizi-51; and for spring varieties were 43.0 and 47.2 kgN/ha ($p < 0.05$) for Pul-11 and Sultan-1, respectively.

The average of % NUE values for winter varieties were found that 16.7 and 19.2 % ($p < 0.05$) for Pul-11 and Kislik Kirmizi-51; and for spring varieties were 6.5 and 5.0 % ($p < 0.05$) for Pul-11 and Sultan-1, respectively.

Inoculation treatments had not give any increasing effects on the % Ndfa and fixed N (kgN/ha) values of winter and spring varieties. The average of % Ndfa and fixed N (kgN/ha) values for winter varieties were 74.9, 73.1, 75.3 % (no-significant) and 71.8, 65.1, 73.3 kgN/ha (no-significant) for I_0 , I_1 , I_2 and for spring varieties were 69.3, 69.0, 73.3 % (no-significant) and 42.3, 43.5, 48.5 kgN/ha (no-significant) for I_0 , I_1 , I_2 treatments, respectively.

Beside of this, % Ndfa and fixed N (kgN/ha) values of winter and spring varieties had significantly effected by the harvesting times. Obtained average % Ndfa and fixed N (kgN/ha) values of winter varieties were 76.7, 72.2 % ($p < 0.05$) and 80.7, 59.4 kgN/ha ($p < 0.05$) for H_2 , H_3 (H_1 was not sampled) and for spring varieties were 71.2, 73.3, 67.1 % ($p < 0.05$) and 48.2, 50.9, 36.2 kgN/ha ($p < 0.05$) for H_1 , H_2 , H_3 treatments, respectively.

The results of these experiment can be summarized as follows:

- The winter varieties of lentils had higher total dry matter yields, % Ndfa and fixed N (kgN/ha) capacities than the spring varieties.
- The inoculation treatments did not have any improvement effects on the biological nitrogen fixation capacities of winter and spring lentil varieties.
- Inside the winter cultivars, V_2 variety (Kislik-Kir.51) had higher N_2 fixing capacity than the V_1 variety (Pul-11). Inside the spring cultivars V_2 variety (Sultan-1) had higher N_2 fixation capacity than the V_1 variety (Pul-11).

- According to harvesting times, N₂ fixation capacities were higher at the beginning of pod formation stage compared to other growth stages for both experiments.
- % Nitrogen Use Efficiency values were higher for winter varieties than spring varieties when starter N dose applied.
- Applied as a starter dose to lentil at 10.0 kgN/ ha level as 10.0 % ¹⁵N atom excess labelled ammonium sulphate fertilizer was sufficient amount for tracing ¹⁵N on the optical emission spectrometer in our conditions.
- Barley was suitable reference crop for both winter and spring sowing. It can be advisable for future studies.
- The average of fixed nitrogen by lentils about 60 kgN/ ha which is equal to 300 kg/ha Ammonium Sulphate or 110 kg/ ha Urea fertilizer. That is the importance of legumes for farmers economy.
- In crop rotation studies under dryland conditions of Central Anatolia, lentil-cereal rotations can be advisable.

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