

THE EFFECT OF NITROGEN DOSES ON DRY MATTER DISTRIBUTION AND NITROGEN UPTAKE OF THE PLANT IN MATURITY PERIODS OF OAT (*AVENA SATIVA* L.)

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Abstract

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This study was carried out in test ground of Uludag University Vocational School of Technical Sciences. The test used Randomized Block Design with 3 replications and Seydisehir forage oat cultivar. 4 different doses of nitrogen (0, 5, 10, 15 kg N da⁻¹) and ammonium sulfate fertilizer containing 21% N and ammonium nitrate fertilizer containing 26% N were used. Plant specimens were collected in 3 replications in milk stage (MS), dough stage (DS) and physiological stages (PS) of the plant. It was found that the lowest total dry weight (DW) was obtained in PS, while the highest total DW was obtained in DS. In all organs excluding the grains, Dry matter (DM) amount was found to be the highest in MS; however, it decreased in next stages of maturity. It was found that applied nitrogen doses had a significant effect on grains, flag leaf and other leaves on DM production. On the other hand, nitrogen contents decreased as the maturity periods progressed in above ground organs excluding the grains.

Key words: oat fertilizer, milk stage, dough stage, physiological stage, growing phase

Abbreviations: MS:Milk stage; DS:Dough stage and; PS:Physiological stages; DW:Dry weight; DM: Dry matter

Introduction

Oat (*Avena sativa* L.) is a cereal crop that is used worldwide for human and livestock nutrition (Welch 1995, Lasztity1998). Oat production ranks sixth in world cereal production following wheat, corn, rice, barley and sorghum with its 11.5 million ha cultivation area; 11.42 million tons of production and 214.7 kg da⁻¹yield (FAO, 2010). Compared to other cereal crops, oat is reputed to be better suited for production under marginal environments, including cool, wet climates and soils with low fertility. In addition, oat is a valuable crop since it increases yield and has a phytosanitary role in cereal crop rotations (Adamiakand, 1992; Svihus and Gullord, 2002). Although grain yield and quality is genetically determined, it is strongly modified by weather conditions (Doehlert et al., 2001; Givens et al., 2004; Peterson et al., 2005), which affect

plant development nutrient uptake ability and photosynthesis effectiveness. Many authors (Gooding and Lafever, 2001, Garret et al., 2006) have explained that weather conditions cause changes in plant assimilation area and photosynthesis rate, which determine the quantity of storage materials in the seed-its biomass- and as a result grain yield per unit area.

Nitrogen (N) plays a key role in plant nutrition. It is the mineral element required in the greatest quantity by the cereal crop plant and it is the nutrient, which is most often deficient. Due to its critical role and low supply, the management of N resources is an extremely important aspect of crop production (Novoa and Loomis, 1981). Nitrogen is currently the most widely used fertilizer nutrient and the demand for it is likely to grow in future (Godwin and Jones, 1991). Nitrogen is the most important component of protein and nucleic acid

and when nitrogen amount in soil is not optimal, growth is reduced (Wienhold et al., 1995).

The optimum N rate is not constant for a specific crop or field, but can vary substantially even from cultivar to cultivar (Mackenzie and Taureau, 1997). Variability in grain protein can also be attributed to differences in genetic potential of cultivar (Smith and Gooding, 1996; Lopez-Bellido et al., 1998). The greatest influence of N fertilizer on grain quality is achieved through its effect on grain protein concentration. Nitrogen fertilization contributes significantly to the increase in protein content, especially when fertilizer rates satisfy the requirements of both yield and protein formation (Bereset et al., 2012; Menget et al., 2012; Raun, 2012; Solie et al., 2012). In addition, it was found that as nitrogen content increased, grain filling period was extended (Wolff and Floss, 2008).

The development phase during which photosynthesis organs of the plant are more active should be known to understand yield formation in cereals. Produced assimilates are mostly stored in stems; however, in the forthcoming periods, the heads gain dominance and compete with stem and leaves (Celik, 1998). DM production and sharing of active photosynthesis sources in a mature grain can vary according to nitrogen amount in the soil in addition to genotype and environmental factors (May, 2004; Zhao, 2009).

Material and Methods

This study was carried out in test ground of Uludag University Vocational School of Technical Sciences. Seydisehir forage oat cultivar was used as seed material. This cultivar has an alternative nature; it is resistant to lodging and is tall.

Ammonium sulfate fertilizer containing 21% N and ammonium nitrate fertilizer containing 26% N were used in the test. Soil data of the specimen collection area are presented in Table 1.

The study used Randomized Block Design with three replications. Four different doses of nitrogen were used in the test (0, 5, 10, 15 kg N da⁻¹). Test parcels were determined as 1.2x5m=6m². The seeds were planted in autumn distributing 500 seeds per m² and half of nitrogenous fertilizer was applied in ammonium sulfate form with the cultivation, while the other half was applied in the form of ammonium nitrate in stem formation stage.

Plant specimens were collected in three replications in MS, DS and physiological stage. Main stems were selected as material. 20 plants were randomly selected from each parcel by cutting from root neck. Collected specimens were separated into parts from different sections in laboratory and were dried at 70°C for 48 hours. Dry weights of dried plant material were identified; they were grinded and nitrogen contents were determined according to Kjeldahl method.

Results

Dry Matter

It was found that there were significant variations between maturity periods in terms of total DM (p<0.01). The lowest total dry weight was found in physiological stage, while the highest total dry weight was determined in DS (Table 2). As for plant sections, dry mater amount was found to be the highest in MS in all organs excluding the grains. It decreased in next stages of maturity (Table 3).

It was found that applied nitrogen doses had no statistically significant effect on DM production of plants in Axis+Glume+Awn and Other leaves. On the other hand, there was a statistically significant effect on other sections of the plant. Application until 10 kg N da⁻¹ on grains, stem and flag leaf increased DM amount; however, 15 kg N da⁻¹ applied after this dose decreased DM amount. This decrease was not found to be statistically different in grains; however, it

Table 1
Some physical and chemical properties of soil in test ground

Soil texture	pH	Total Nitrogen, %	CaCO ₃ , %	P ₂ O ₅ ppm	Organic substance
Clayey	8.04	0.081	6.87	9.72	1.04

Table 2
The effect of maturity periods in oat cultivar on dry matter amount (g) and distribution in plant

Stages	Seed	Stem	Flag leaf	Other leaves	Axis+Glume+Awn	Total DM
Milk stage	0.33 c**	0.72 a**	0.83 a**	0.79 a**	0.87 a**	3.54 b**
Dough stage	0.84 b**	0.65 b**	0.80 a**	0.75 b**	0.79 b**	3.83 a**
Physiological stage	0.95 a**	0.50 c**	0.46 b**	0.38 c**	0.33 c**	2.62 c**

** : p<0.01

was found to be statistically significant and difference in the trunk and flag leaf.

The effect of nitrogen doses on DM production and sharing of plant according to maturity periods are presented in Figure 1.

As indicated in Figure 1, DM production showed a rapid increase from MSto DSin parallel to increasing nitrogen doses in grains and decreased in physiological stage. On the other hand, in other organs excluding the grains, DM amount decreased based on maturity stages, however increased nitrogen doses of each stage increased DM production. The highest DM production was identified in 10 kg N da⁻¹ in each maturity stage.

Nitrogen Contents

Analysis of nitrogen contents of plant sections shows that nitrogen contents of these sections varied according to maturity stages ($p < 0.01$). Nitrogen contents decreased during maturity periods in above ground plant organs excluding the grains. On the contrary, nitrogen content of grains increased due to maturity. Thus, the highest nitrogen content (1.63%) in plant organs was identified in physiological stage, while the lowest value (0.44%) was identified in axis, glume and awn (Table 4).

Applied nitrogen doses affected DM content rate in plant sections (Table 5). As nitrogen dose increased, nitro-

Table 3
The effect of different nitrogen doses in dry matter amount (g/plant) and distribution in plant in oat cultivar (g)

Doses, kg N da ⁻¹	Seed	Stem	Flag leaf	Other leaves	Axis+Glume+Awn	Total DM
0	0.67 b**	0.58 d**	0.66 c**	0.62 ns	0.19 ns	2.72 c**
5	0.71 a**	0.61 c**	0.72 a**	0.63 ns	0.25 ns	2.92 b**
10	0.73 a**	0.70 a**	0.73 a**	0.63 ns	0.27 ns	3.06 a**
15	0.72 a**	0.67 b**	0.69 b**	0.62 ns	0.25 ns	2.95 b**

** : $p < 0.01$

Table 4
Nitrogen contents in maturity periods of various sections of oat (% of DM)

Stages	Seed	Stem	Flag leaf	Other leaves	Axis+Glume+Awn
Milk Stage	1.34 c**	0.78 a**	1.46 a**	1.39 a**	0.85 a**
Dough Stage	1.38 b**	0.73 b**	1.40 b**	1.30 b**	0.58 b**
Physiological Stage	1.63 a**	0.65 c**	0.97 c**	1.14 c**	0.44 c**

** : $p < 0.01$

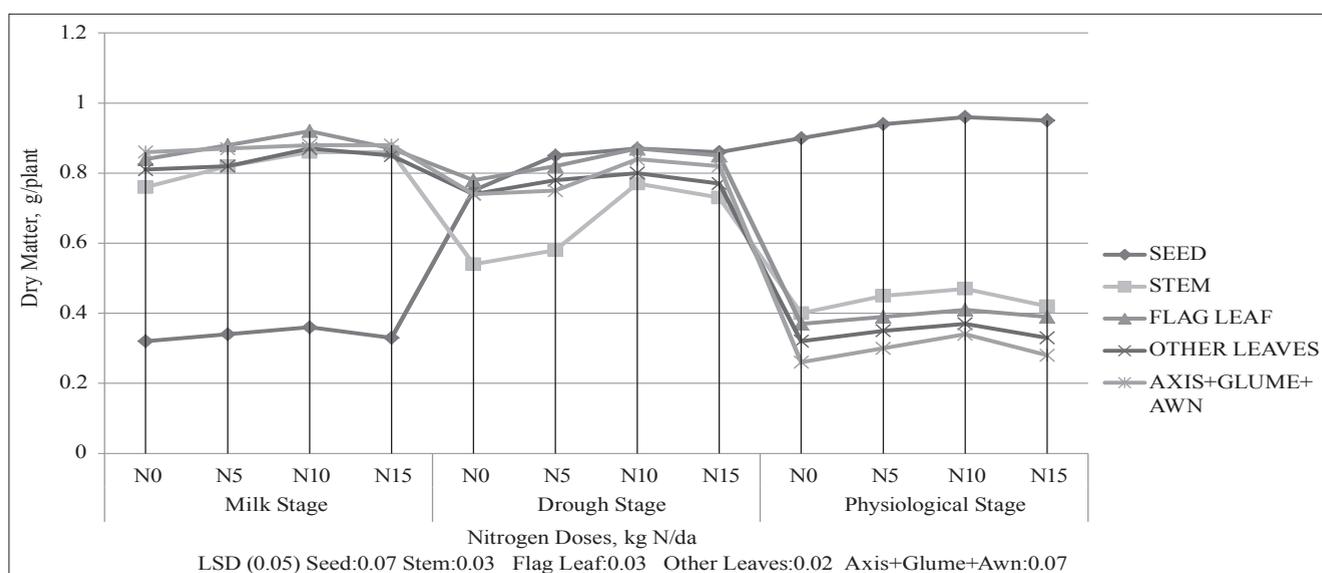


Fig. 1. The effect of nitrogen doses on dry matter production and distribution of plant in various maturity periods

gen amount in different plant organs increased and these increases were found to be statistically significant ($p < 0.05$). Figure 2 presents the values related to nitrogen contents of above ground organs in different maturity stages of oat cultivar in which different nitrogen doses were applied.

Analysis of the effect of nitrogen doses on nitrogen content of grains and maturity stages reveals that nitrogen content showed a significant decrease in plant sections excluding the grains, while maturity stages progressed. Nitrogen content of grain reached the highest level in physiological stage, which was followed by other leaves and flag leaf. It was found that there was no statistically significant difference between 10 kg Nda⁻¹ and 15 kg Nda⁻¹ in axis+glume+awn in DS.

Discussion

The highest above ground DM weight was reached in dough maturity period and at 10 kg Nda⁻¹. It was observed

that 15 kg Nda⁻¹ applied after this dose decreased DM amount. This decrease was found to be statistically significant in maturity stages; however, it was not found to be statistically significant in other leaves and axis+glume+awn applied nitrogen doses. In other words, increased nitrogen doses did not cause significant increases or decreases in DM contents of these plant sections. However, interaction of Nitrogen Doses x Maturity Stages was found to be statistically significant ($p < 0.05$). In other words, nitrogen doses affected DM amount over maturity stages. This can be explained by the fact that plant organs having photosynthesis areas, which are directly effective on grain yield, continue their photosynthetic activities until DS. The literature contains numerous studies reporting that applied nitrogen doses affect photosynthetic activity and cause increase within the scope of carbohydrate and thus in DM amount (Mohr, 2007; da Silva 2009; Zhao, 2009).

It was observed that as the dough period of produced DM progressed, it moved to the grains. It is believed that DM, which accumulated in the grains particularly in DS increased

Table 5
The effect of nitrogen doses on nitrogen contents in different plant sections of oat (% of dm)

Doses, kg N da ⁻¹	Seed	Stem	Flag leaf	Other leaves	Axis+Glume+Awn
0	1.37 d**	0.61 d**	1.20 d**	1.17 d**	0.57 d**
5	1.43 c**	0.69 c**	1.26 c**	1.24 c**	0.61 c**
10	1.48 b**	0.76 b**	1.30 b**	1.32 b**	0.64 b**
15	1.53 a**	0.83 a**	1.34 a**	1.38 a**	0.67 a**

** : $p < 0.01$

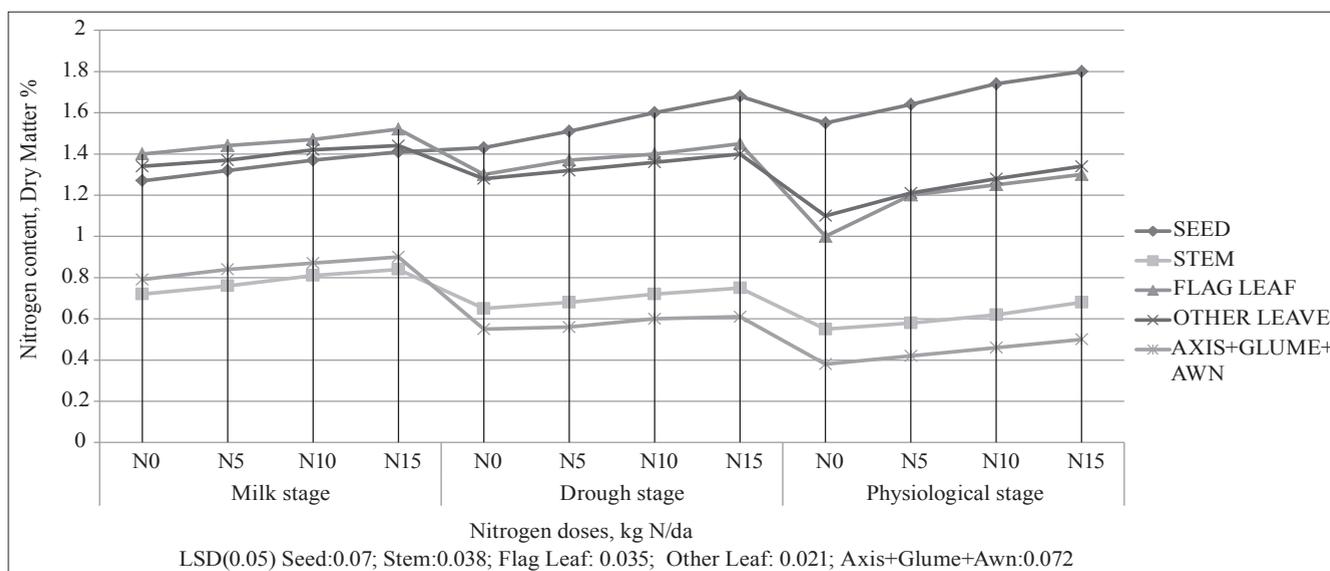


Fig. 2. The effect of nitrogen doses on nitrogen amount and distribution of plant in different maturity periods of oat

by the movement of assimilates produced in other organs to the grain. Flag leaf is effective organ in photosynthesis. DM content of flag leaf was high until physiological stage; however, no significant decrease was found in DM amount after physiological stage. On the other hand, weight losses in dry weight of the plant in physiological stage can be considered because of loss of photosynthetic activity due to aging in plant organs, losses due to leaf loss and increased respiratory loss in parallel to high temperature in this period, (Hay and Walker, 1989). However, despite DM loss in next maturity stages after MS and in all nitrogen doses, increased DM in grains can be considered to prove that plant nutrition matters stored in other organs of the plant due to maturity were moved to the grains.

Analysis of nitrogen content revealed that nitrogen content of all plant sections excluding the grains decreased as the maturity periods progressed (Figure 2). On the other hand, analysis of nitrogen doses individually showed that increasing nitrogen doses also increased nitrogen amount in the plant. The results obtained from increased nitrogen contents of plant sections in parallel to increasing nitrogen doses were found to be consistent with the findings of previous researchers (Mohr, 2007; da Silva, 2009).

However, it was observed that although nitrogen doses increased in Maturity Period x Nitrogen Doses interaction due to maturity, there was nitrogen loss in plant sections excluding the grains. It is believed that this resulted from transfer of plant nutrition substances stored in plant sections due to maturity to the grains and the nitrogen stored in early period was transferred to generative region (Hay and Walker, 1989).

In addition, it is believed that as the maturity periods progressed, even if there is enough nitrogen in the soil, since the roots slowly began to lose their function, they failed to get nitrogen from soil. The plants dry from their leaves, which are one of the important organs of photosynthesis; as the photosynthesis area decreased in size, nitrogen amount in plant organs are believed to decrease.

Conclusions

The highest above ground DM weight was reached in dough maturity period and at 10 kg N da⁻¹. It was observed that 15 kg N da⁻¹ applied after this dose decreased DM amount. Increased nitrogen doses did not cause significant increases or decreases in DM contents of these plant sections. However, interaction of Nitrogen Doses x Maturity Stages was found to be statistically significant (p<0.01). Nitrogen content of grain reached the highest level in physiological stage which was followed by other leaves and

flag leaf. It was found that there was no statistically significant difference between 10 kg N da⁻¹ and 15 kg N da⁻¹ in axis+glume+awnin DS.

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