

ACCUMULATION AND USE OF NITROGEN IN DURUM WHEAT CULTIVAR PREDEL AS INFLUENCE BY FERTILIZATION

Galia Panayotova¹, Lubov Plescuta¹, Antoniya Stoyanova¹

Abstract: A field study was conducted during 2012-2014 to assess the effect of nitrogen fertilization on the N concentration and uptake of durum wheat cultivar Predel. N in rates 0; 80; 120 and 160 kg ha⁻¹ was applied. The results showed that N fertilization increased grain yield with 33.7-60.9 %. The average total dry biomass in maturity was 9.7 t ha⁻¹. At N₁₆₀P₈₀ the dry biomass was 12.44 t ha⁻¹. The N concentration increased with went up of N rates. At the three rates the N concentration of grain increased with 8; 27 and 45 % to the unfertilized. NP fertilization improved the N concentration. N uptake with grain was in range 52.7 - 116.8 kg ha⁻¹, and upake with straw - 22 to 59 kg ha⁻¹.

Key words: *Triticum durum* Desf., nitrogen, fertilization, concentration, uptake

Introduction

The successful application of technology for the cultivation of cereals, including durum wheat depends on the specific economic and environmental conditions, predecessor, the genetic potential of varieties, fertilization and other agronomic factors, as a result of which there are differences in the final results (Delchev, 2009; Delchev et al., 2006; Gerdzhikova, 2015; Kostadinova et al., 2015).

The total uptake of N and P depends mainly on formed dry matter (Gorbanov and Kostadinova, 2000). The N content in grain is more closely connected to accumulation of dry matter after flowering, than phosphorus. With increasing the N rate and the soil fertility also increases the N content in grain and straw (Gerdgikova et al., 2011; Rharrabti et al., 2003). The fertilized plants move about 53 % more N to the grain compared to the unfertilized (Ricciardi, 2001).

The grain yield of durum wheat strongly varied depending on the area, weather conditions, genetic potential of the variety, soil fertility and applied fertilization. The main requirement for high yield combined with good grain quality was for the the plants to receive an optimal amount of nitrogen during vegetation (Semkova et al., 2007).

According to Motzo et al. (2004) and Brown et al. (2005) grain protein content is a function of total nitrogen uptake and of the partitioning of nitrogen and dry matter to the grain. Some authors (Bauer et al., 1987; Kostadinova et al., 2003) reported that the increasing N rate and rich soil fertility enhanced the content of grain protein and N in the straw.

The object of this study was to assess the effect of nitrogen fertilization in different levels under field conditions on the nitrogen concentration and uptake of durum wheat cultivar Predel.

¹ Trakia University, Faculty of Agriculture, Student' campus, 6000 Stara Zagora, Bulgaria

Material and methods

A field trial was carried out during 2012-2014 in the Institute of field crops - Chirpan, Bulgaria with durum wheat (*Triticum durum* Desf.) cultivar Predel at cotton-durum wheat crop rotation under non-irrigated conditions. Single and combination nitrogen as NH_4NO_3 in rates 0; 80; 120 and 160 kg ha^{-1} was studied. N was applied two times – 1/3 pre-sowing and 2/3 at early boot stage. The rates of P_2O_5 were 0; 80 and 120 kg ha^{-1} . The N concentration (%) in the aerial part of the plants was analyzed by a method of Kjeldhal. N content (kg/da) was the product of dry matter yield and concentration. An analysis of variance (ANOVA) was performed.

The soil was *Pellic Vertisols* (FAO) with sorbcium capacity 35-50 mequ/100g soil, bulk weight - 1.1-1.2 g/cm^3 , specific gravity - 2.6-2.7, humus content - 2.0-2.4 %, mineral N – 20-35 ppm, available phosphorus and potassium - 2-4 ppm and 26-30 ppm, respectively.

The studied years were with different meteorological conditions during the vegetation period (X-VI): 2012 was moderately warm (2361°C) and moderately dry, 2013 - very hot (2791°C) and dry, and 2014 – hot and humid (547.5 mm/m^2).

Results and discussion

The formed dry matter determine greatly the durum wheat productivity and accumulated nitrogen. Average for the period 2012-2014 fertilization proved very good influence on the productivity. Without fertilization was formed average grain yield of 2.50 t ha^{-1} in the range of 2.16 to 2.74 t ha^{-1} over the years. The differences in grain yield between nitrogen levels during the period were significant. Alone N fertilization showed an increase in average yield to N_{120} - 3.75 t ha^{-1} , with 49.9 % over unfertilized. High nitrogen rates N_{160} decreased the yield with 8.11 % compared to N_{120} . Very good results were at N_{80} - 3.39 t ha^{-1} , exceed the check with 35.6 % (Table 1). Favorable in meteorological regard 2013 was characterized by the highest grain yield at 120 kg N ha^{-1} - 3.94 t ha^{-1} . The application of increasing N and P rates increased grain yields. At fertilization with the highest N-P rate was obtained the highest yield. At $\text{N}_{160}\text{P}_{120}$ the yield increased - in 2012 with 72.3 % over unfertilized and the average for the period - with 55.64 %.

Analysis of variance for study showed that differences between factors - nitrogen rates (N), phosphorus rates (P) and years were essential. The level of N fertilization was the most powerful source of variation (14.02 % of the total factors influence), proven at $\text{P} \leq 0.001$. Conditions over the years also affected highly (9.99 %). The influence of P was insignificant.

The straw yield without fertilization was an average of 4.50 t ha^{-1} . At N_{80} the highest yield was received in harvest 2013 - 6,20 t ha^{-1} , 13.4 % above control. At alone fertilization straw yield was the highest at N_{120} - 6.98 t ha^{-1} . In 2012 straw yield was 7.05 t ha^{-1} , and in 2014 - 6.73 t ha^{-1} . At combined NP fertilization straw yield increased. At a rate $\text{N}_{80}\text{P}_{80}$ for the period the yield was an average 6.22 t ha^{-1} , and at $\text{N}_{160}\text{P}_{80}$ average yield was the highest - 7.24 t ha^{-1} , with 60.9 % over the control.

Table 1. Grain and straw yields of durum wheat at NP fertilization, 2012-2014 г. (t ha⁻¹)

| Fertilization | Grain yield | | Straw yield | |
|--|--------------------|--------|--------------------|--------|
| | t ha ⁻¹ | % | t ha ⁻¹ | % |
| N ₀ P ₀ K ₀ | 2.50 | 100.00 | 4.50 | 100.0 |
| N ₈₀ | 3.39*** | 135.61 | 6.02*** | 133.78 |
| N ₁₂₀ | 3.75*** | 149.87 | 6.98*** | 155.11 |
| N ₁₆₀ | 3.55*** | 141.76 | 6.95*** | 154.44 |
| P ₈₀ | 2.59 | 103.74 | 4.74 | 105.33 |
| N ₈₀ P ₈₀ | 3.68*** | 147.07 | 6.22*** | 138.22 |
| N ₁₂₀ P ₈₀ | 3.84*** | 153.38 | 7.06*** | 156.89 |
| N ₁₆₀ P ₈₀ | 3.79*** | 151.37 | 7.24*** | 160.89 |
| P ₁₂₀ | 2.60 | 103.96 | 4.65 | 103.33 |
| N ₈₀ P ₁₂₀ | 3.66*** | 146.40 | 6.70*** | 148.89 |
| N ₁₂₀ P ₁₂₀ | 3.94*** | 157.41 | 7.23*** | 160.67 |
| N ₁₆₀ P ₁₂₀ | 3.89*** | 155.64 | 7.20*** | 160.00 |
| Average | 3.44 | - | 6.29 | - |
| GD _{5%} | 0.27 | 10.79 | 0.76 | 16.94 |
| GD _{1%} | 0.36 | 14.27 | 1.04 | 23.03 |
| GD _{0.1%} | 0.46 | 18.42 | 1.39 | 30.98 |
| VC, % | 5.60 | | 7.16 | |

The average total dry biomass in maturity was 9.73 t ha⁻¹ (Table 2). The yield of biomass at alone N fertilization reached 10.73 t ha⁻¹ at N₁₂₀, with 53.23 % over the control. Average for the period at P₈₀ the biomass was 7.34 t ha⁻¹, with 4.75 % above the check. At combined fertilization with N₁₆₀P₈₀ the dry biomass increased significantly and in 2012 it was 12.44 t ha⁻¹, with 67.7 % more than the control. The highest results were achieved in 2012 at a rate N₁₆₀P₁₂₀ - 12.62 t ha⁻¹.

Table 2. Total biomass in maturity of durum wheat at fertilization, 2012-2014, t ha⁻¹

| Fertilization | 2012 | | 2013 | | 2014 | | Average | |
|---|--------------------|--------|--------------------|--------|--------------------|--------|--------------------|--------|
| | t ha ⁻¹ | % | t ha ⁻¹ | % | t ha ⁻¹ | % | t ha ⁻¹ | % |
| N ₀ P ₀ K ₀ | 7.42 | 100.0 | 5.84 | 100.0 | 7.76 | 100.0 | 7.00 | 100.0 |
| N ₈₀ | 9.62 | 129.74 | 9.68 | 165.78 | 8.95 | 115.34 | 9.42*** | 134.43 |
| N ₁₂₀ | 11.01 | 148.55 | 10.99 | 188.32 | 10.19 | 131.31 | 10.73*** | 153.23 |
| N ₁₆₀ | 11.32 | 152.66 | 10.69 | 183.03 | 9.50 | 122.36 | 10.50*** | 149.89 |
| P ₈₀ | 8.22 | 110.86 | 6.04 | 103.36 | 7.76 | 100.00 | 7.34 | 104.75 |
| N ₈₀ P ₈₀ | 10.30 | 138.91 | 9.77 | 167.25 | 9.64 | 124.29 | 9.90*** | 141.38 |
| N ₁₂₀ P ₈₀ | 12.08 | 162.87 | 10.96 | 187.67 | 9.67 | 124.61 | 10.90*** | 155.63 |
| N ₁₆₀ P ₈₀ | 12.44 | 167.70 | 10.75 | 184.07 | 9.89 | 127.45 | 11.03*** | 157.47 |
| P ₁₂₀ | 7.88 | 106.34 | 6.36 | 108.87 | 7.52 | 96.91 | 7.25 | 103.55 |
| N ₈₀ P ₁₂₀ | 10.74 | 144.79 | 9.87 | 169.04 | 10.50 | 135.24 | 10.37*** | 147.99 |
| N ₁₂₀ P ₁₂₀ | 12.14 | 163.79 | 10.53 | 180.30 | 10.83 | 139.56 | 11.18*** | 159.54 |
| N ₁₆₀ P ₁₂₀ | 12.62 | 170.26 | 11.00 | 188.39 | 9.67 | 124.61 | 11.10*** | 158.43 |
| Average | 10.48 | 141.38 | 9.37 | 160.51 | 9.32 | 120.14 | 9.73 | 138.84 |
| GD _{5%} GD _{1%} GD _{0.1%} = 119.44; 162.34; 218.39 | | | | | | | | |
| VC, % = 7.25 | | | | | | | | |

N content in plant organs was changed depending on fertilization, but significant was the influence of alone and combined N fertilization. The N concentration in the

grain without fertilization was 2.12 % (Table 3). The increase of N rate and the richer soil fertility went up the grain and straw N concentration. The N content of grain at the three tested rates increased with 8.0; 27.4 and 45.3 %, respectively as compared to the unfertilized, proven at $P \leq 0.001$. The highest N concentration was formed in 2013 – average 2.79 %, when the periods of grain filling and maturity coincided with high temperatures and insignificant rainfall. NP fertilization improved the N concentration in the grain, but the values were close to the established at alone N fertilization. Among the N content in the grain and N rates there was a high positive correlation ($r = 0.942-0.985$). There was also very well expressed a positive correlation between the N content in the grain and in straw. The straw N concentration was 3.55-4.3 times lower compared to the grain N concentration.

Table 3. N concentration in durum wheat grain, 2012-2014, % of dry matter

| Fertilization | Year | | | Average | |
|--|------|------|------|---------|------------|
| | 2012 | 2013 | 2014 | % | % to check |
| N ₀ P ₀ K ₀ | 2.14 | 2.27 | 1.94 | 2.12 | 100.0 |
| N ₈₀ | 2.29 | 2.52 | 2.06 | 2.29 | 108.0 |
| N ₁₂₀ | 2.44 | 2.94 | 2.71 | 2.70 | 127.4 |
| N ₁₆₀ | 2.83 | 3.57 | 2.85 | 3.08 | 145.3 |
| P ₈₀ | 2.24 | 2.32 | 1.98 | 2.18 | 102.8 |
| N ₈₀ P ₈₀ | 2.31 | 2.44 | 2.05 | 2.27 | 107.1 |
| N ₁₂₀ P ₈₀ | 2.59 | 2.95 | 2.87 | 2.80 | 132.1 |
| N ₁₆₀ P ₈₀ | 2.69 | 3.15 | 2.98 | 2.94 | 138.7 |
| P ₁₂₀ | 2.23 | 2.31 | 1.96 | 2.17 | 102.4 |
| N ₈₀ P ₁₂₀ | 2.39 | 2.62 | 2.14 | 2.38 | 112.3 |
| N ₁₂₀ P ₁₂₀ | 2.65 | 3.04 | 2.45 | 2.71 | 127.8 |
| N ₁₆₀ P ₁₂₀ | 2.87 | 3.36 | 2.76 | 3.00 | 141.5 |
| Average | 2.47 | 2.79 | 2.40 | 2.55 | 120.3 |
| <i>GD 5 %; 1 %; 0,1% = 0.25; 0.34; 0.46</i> | | | | | |
| <i>VC, % = 5.77</i> | | | | | |

Nitrogen uptake with grain was in the range 52.7 - 116.8 kg ha⁻¹ (Table 4) and upake with straw - 22.0 to 59.0 kg ha⁻¹. Average over the three years durum wheat grown without fertilization exported 74.7 kg N ha⁻¹ and at three N levels uptake was more with 49.5; 102.0 and 118.3% (Table 5). At NP fertilization with participation of N₁₆₀ was realized the highest N uptake - 167.3-175.8 kg ha⁻¹. The low grain yield and straw at alone phosphorus fertilization was a prerequisite for uptake of N in quantities exceeding poorly received at without fertilization.

Conclusion

The average total dry biomass in maturity was 9.73 t ha⁻¹. The yield of biomass at alone N fertilization reached 10.73 t ha⁻¹ at N₁₂₀, with 53.23 % over the control. Average for the period at P₈₀ the biomass was 7.34 t ha⁻¹. At combined fertilization with N₁₆₀P₈₀ the dry biomass increased significantly and in 2012 it was 12.44 t ha⁻¹, with 67.7 % more than the control. The highest results were achieved in 2012 at a rate N₁₆₀P₁₂₀ - 12.62 t ha⁻¹.

The concentration of N in plant increased with went up of N rates. The N concentration in the grain without fertilization was 2.12 %. The increase of N rate and the richer soil fertility went up the grain and straw N concentration. The N content of grain at the three rates increased with 8.0; 27.4 and 45.3 % to the unfertilized. The highest N concentration was formed in 2013 – average 2.79 %. NP fertilization improved the N concentration in the grain. The straw N concentration was 3.55- 4.3 times lower compared to the grain N concentration.

Table 4. Nitrogen uptake with durum wheat grain at fertilization, 2012-2014, kg ha⁻¹

| Fertilization | 2012 | 2013 | 2014 | Average | |
|--|-------|-------|------|---------------------|-------|
| | | | | kg ha ⁻¹ | % |
| N ₀ P ₀ K ₀ | 56.0 | 49.0 | 53.2 | 52.7 | 100.0 |
| N ₈₀ | 79.7 | 87.7 | 66.5 | 78.0 | 148.0 |
| N ₁₂₀ | 94.3 | 115.7 | 93.8 | 101.3 | 192.2 |
| N ₁₆₀ | 110.9 | 129.8 | 88.2 | 109.6 | 207.9 |
| P ₈₀ | 62.7 | 50.9 | 55.4 | 56.3 | 106.8 |
| N ₈₀ P ₈₀ | 87.8 | 87.0 | 75.5 | 83.4 | 158.2 |
| N ₁₂₀ P ₈₀ | 108.2 | 114.4 | 99.5 | 107.4 | 203.8 |
| N ₁₆₀ P ₈₀ | 117.7 | 117.4 | 97.4 | 110.8 | 210.2 |
| P ₁₂₀ | 62.1 | 52.1 | 54.3 | 56.2 | 106.6 |
| N ₈₀ P ₁₂₀ | 90.5 | 89.9 | 81.0 | 87.1 | 165.3 |
| N ₁₂₀ P ₁₂₀ | 113.0 | 114.5 | 92.8 | 106.8 | 202.6 |
| N ₁₆₀ P ₁₂₀ | 129.3 | 126.7 | 94.4 | 116.8 | 221.6 |
| Average | 89.4 | 94.6 | 79.3 | 88.9 | - |

Table 5. Influence of fertilization on the total nitrogen uptake with grain and straw of durum wheat cultivar Predel, 2012-2014 r., kg ha⁻¹

| Fertilization | 2012 | 2013 | 2014 | Average | |
|--|-------|-------|-------|---------------------|-------|
| | | | | kg ha ⁻¹ | % |
| N ₀ P ₀ K ₀ | 84.8 | 61.9 | 79.8 | 74.7 | 100.0 |
| N ₈₀ | 117.8 | 113.7 | 103.7 | 111.7 | 149.5 |
| N ₁₂₀ | 137.2 | 162.3 | 152.4 | 150.9 | 202.0 |
| N ₁₆₀ | 161.2 | 180.6 | 147.1 | 163.1 | 218.3 |
| P ₈₀ | 105.0 | 66.3 | 76.2 | 81.4 | 109.0 |
| N ₈₀ P ₈₀ | 139.8 | 121.7 | 105.9 | 122.0 | 163.3 |
| N ₁₂₀ P ₈₀ | 173.0 | 159.7 | 147.9 | 160.4 | 214.7 |
| N ₁₆₀ P ₈₀ | 183.0 | 165.1 | 153.0 | 167.3 | 223.9 |
| P ₁₂₀ | 109.5 | 69.7 | 72.3 | 83.2 | 111.4 |
| N ₈₀ P ₁₂₀ | 153.0 | 129.8 | 114.6 | 132.7 | 177.6 |
| N ₁₂₀ P ₁₂₀ | 185.5 | 161.8 | 135.7 | 160.3 | 214.6 |
| N ₁₆₀ P ₁₂₀ | 205.6 | 180.2 | 143.2 | 175.8 | 235.3 |
| Average | 143.0 | 131.1 | 119.3 | 132.0 | - |

Nitrogen uptake with grain was in range 52.7 - 116.8 kg ha⁻¹, and upake with straw - 22.0 to 59.0 kg ha⁻¹. Durum wheat without fertilization exported 74.7 kg N ha⁻¹ and at three N levels uptake was more with 49.5; 102 and 118 %. The amount was significantly changed by the applied N fertilization and dry biomass.

Such information would enhance nutrient management strategies and may use for durum wheat development / yield models.

References

- Brown B., Westcott M., Christensen N., Pan B., Stark J. (2005). Nitrogen management for hard wheat protein enhancement. Pacific Northwest Extension publication, 578: 1-14. <http://www.cals.uidaho.edu/edComm/pdf/pnw/pnw0578.pdf>
- Gorbanov St., Kostadinova S. (2000). The effect of phosphorus and potassium fertilization on the yield and grain quality of winter wheat. Proc. of the Regional IPI Workshop “Potassium and Phosphorus: Fertilization effect on soil and crops”, October, 23-24, 2000, Dotnuva Akademija, Lithuania: 132-137.
- Delchev G., (2009). Influence of some complex and foliar fertilizers on the productivity of durum wheat. Soil Science, Agrochemistry and Ecology, 43 (3): 49-54.
- Delchev G., Kolev T., Zhelyazkova Ts. (2006). Influence of some mixed mineral fertilizers in combination with foliar feeding on the grain yield and grain quality of the durum wheat. Safe food, Novi Sad, Vol. I: 255-260.
- Gerdzhikova, M. (2015). Influence of various predecessors and nitrogen fertilization rates on yield structure characteristics of common wheat (*Triticum aestivum* L.). Science & Technologies, V (6): 162-173 (Bg).
- Kostadinova S., Kalinova S., Hristoskov A., Samodova A. (2015). Efficiency of some foliar fertilizers in winter wheat, Bulgarian J. of Agricultural Science, 21 (4): 742-746.
- Kostadinova S., Tomov T., Manolov I. (2003). Productivity Assessment of Wheat Genotypes in Dependence of Nitrogen Fertilization, Bulgarian J. of Agricultural Science, 9 (4): 469-473.
- Motzo R., Fosi S., Giunta F. (2004). Relationship between grain yield and quality of durum wheats from different eras of breeding. Euphytica, 140: 147-158.
- Rharrabti Y., Villegas D., Royo C., Martos-Núñez V. and García del Moral L. (2003). Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters. Field Crops Research, 80 (2): 133-140.
- Ricciardi L. (2001). Evaluation of durum wheat genotypes under low-nitrogen fertilization. Agricultura mediterranea, 131 (3-4): 91-101.
- Semkova N. (2014). Comparative studies on the biological and economic properties of new varieties of durum wheat. PhD Thesis, Agricultural University - Plovdiv.