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NITROGEN FERTILIZATION EFFECTS ON SOME GRAVIMETRIC PARAMETERS FOR WHEAT

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Abstract

The aim of this study was to determine the values of some gravimetric parameters on aboveground parts of wheat. The research was conducted on the Ciprian cultivar. The experimental field was located at the Didactic Station from BUASMV Timisoara. Here the soil can be characterized as a slightly gleized cambic chernozem. The application of fertilizing substances is important due to the fact that it determines qualitative and quantitative changes in crops. Nitrogen is the most used fertilizer globally, due to the fact that it is essential in growth and development. A higher grain yield is assured after the application of ammonium nitrate. For this experiment, five experimental N doses were used: 0, 50, 100, 150 and 200 kg ammonium nitrate ha^{-1}, respectively. The research was realized on the aerial parts of wheat plants. The investigated indices included fresh and dry weights, but also ash content and initial water quantity. The results were analyzed and processed with PAST Software v3. Values lower than 0.05 were considered significant. All the investigated parameters presented the lowest values for N 0 probes and the highest values for N 200 probes, in both periods. Levene's test showed that the values of all parameters for periods 1 and 2 were heterogeneous. Welch F test showed that the data are significantly different.

Key words: *biomass, dry weight, fertilization, nitrogen, wheat.*

INTRODUCTION

Among the main staple crops across the globe, cereals such as wheat, rice and maize are the most important for providing daily calories and protein intake. Of these, wheat was the first crop to be domesticated and forms the major staple food globally (Tack et al., 2015). Wheat production is mainly concentrated in a few large areas: the European Union is responsible for around 21% of the entire production of wheat in the world (Eurostat Database). World food demand is expected to double during 2005-2050 (Borlaug, 2009). Particularly, global wheat yields need to increase by 38% from 2005 to 2050 to meet projected demand (Fischer et al., 2014).

Plant nutrition basic principles can be described as a series of methods useful for the establishment of fertilization programs and fertilizer doses in relation to different agricultural systems (Borlan and Hera, 1994; Cui et al., 2008; Chuan et al., 2013; Boldea et al., 2015; Sala et al., 2015, 2016). Inorganic and organic fertilizers are applied in order to maintain the nutritional condition of different cropping systems (Kayan et al., 2018).

Rational use of these substances plays an essential role in improving the quantity and quality of the yield; this means that it has great impact upon our food supplies (Steer et al., 1984; Dumitru, 2002; Rusu, 2002; Boldea and Sala, 2010; Sala and Boldea, 2011; Rawashdeh and Sala, 2015, 2016).

Nutrients in the soil or in applied fertilizers have a major role in plant development; their influence on the root and foliar systems in wheat is impacted by a series of factors (Ehdaie et al., 2010; Pedersen et al., 2010; De Giorgio and Fornaro, 2012; Raza et al., 2013).

However, the use of fertilizers is possible only when we are familiar with the following: the characteristics of the soil as nutrition environment for plants, crop requirements in terms of nutrition and fertilizer-soil-plant relations (Sala, 2008; Marinca et al., 2009).

Nitrogen is an essential element required for successful plant growth (Kayan et al., 2018). In conventional agriculture, the use of split application of mineral N fertilizers has been shown to increase fertilization efficiency and the harvest index of wheat (Fuertes-Mendizabal et al., 2010; Blandino et al., 2015). Small N doses limit the productivity and high doses increase the production costs and favor lodging (Ma et al., 2010), apart from environmental contamination by nutrient losses (Theago et al., 2014; Arenhardt et al., 2015).

In their nutrition, plants accumulate nitrogen from soil in ammonia and nitric form, and convert it through amination and transamination reactions in proteic substances (Borlan and Hera, 1994). In most intensive agricultural production systems, over 50% and up to 75% of the N applied to the field is not used by the plant and is lost through a combination of leaching, surface run-off, denitrification, volatilization, and microbial consumption (McAllister et al., 2012). High grain yield represents a higher crop nitrogen (N) requirement in total (Cassman et al., 2002). Moreover, plant nitrogen accumulation, as a product of plant nitrogen content and plant mass, strongly affects yield and the quality of grains (Feng et al., 2008).

Nitrogen is the main ingredient of wheat proteins and additional application helps increase its protein content (Borlan and Hera, 1994; Borugă et al., 2016). Although inorganic nitrogen compounds (i.e., NH_4^+, NO_2^-, and NO_3^-) account for less than 5% of the total nitrogen in soil (Brady and Weil, 2008), they are the main form of the element absorbed by most plants.

To optimize the application of mineral nitrogen, wheat requirements must be taken into consideration, together with the conditions provided by the soil (Dincă et al., 2010; Gîdea et al., 2015; Borugă et al., 2016). However, when adequate N is applied, reactive forms of N (ammonia, nitrate, nitrogen oxides) are lost to the environment, causing water pollution, climate forcing, and loss of biodiversity (Ladha et al., 2016).

The aim of this paper is to determine the values of some gravimetric parameters for aboveground parts of wheat fertilized with ammonium azotate in five experimental doses.

MATERIALS AND METHODS

The study was conducted on *Triticum aestivum* (L.) ssp. *vulgare*, Ciprian cultivar. Wheat was cultivated under experimental conditions at the Didactic Station within Banat University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania", Timişoara, where the soil can be described as a slightly gleized cambic chernozem (Pîslea and Sala, 2012) with medium fertility, neutral reaction (pH = 6.7-6.8), good humus supply (H = 3.2%), nitrogen index IN = 2.8, high base saturation (88-90%), poor phosphorus supply (P = 11.4 ppm) and medium potassium supply (K = 130.5 ppm) (Sala et al., 2016).

The experimental treatments consisted of five ammonium nitrate rates: 0, 50, 100, 150 and 200 kg active substance ha^{-1}.

Aerial parts from 100 intact and healthy plants, with no visible damages were collected during spring. Each sampling was done in the morning and wheat plants were taken to physiology laboratory. The samples collected in April are considered to belong to period 1 and were in stem elongation stage. The samples collected in May are considered to belong to period no. 2 and were in booting stage. First, aboveground parts were weighted using a Kern analytical balance and FW - fresh weight was obtained. The samples were then placed into an oven at 85°C for 24 h. A reweighting after the drying process conducted to the determination of dry weight - DW values (Datcu, 2017). Dried samples were incinerated to ash in a furnace (Nabertherm model) at 500°C for 2 h. After the cooling process, the ash content (AC) was determined (Ianovici et al., 2012).

Ash content is the inorganic residue left after burning the organic matter and it is the reflection of the mineral content of biomass (Ianovici, 2016). Initial water quantity was calculated as the difference between FW and DW.

Data were processed using MS Excel 2013. Statistical analysis was realized using PAST software v3 (Hammer et al., 2001). Values lower than 0.05 were considered significant.

RESULTS AND DISCUSSIONS

For the samples harvested in period 1, the lowest means of FW (Figure 1) were obtained for N 0 probes (FW = 0.4635 g), and the biggest values corresponded to N 200 samples (FW = 4.5366 g).
A polynomial increase of FW depending on N dose was noticed and can be described by equation (1), statistical accuracy being assured (Table 1). Same tendency was observed for the samples collected in period 2.
Fresh biomass increased together with the increase of N dose, the lowest mean being determined for N 0 probes (FW = 1.14282 g) and the highest mean for N 200 probes (FW = 6.67053 g). This trend is best described by equation (2) (Table 1).

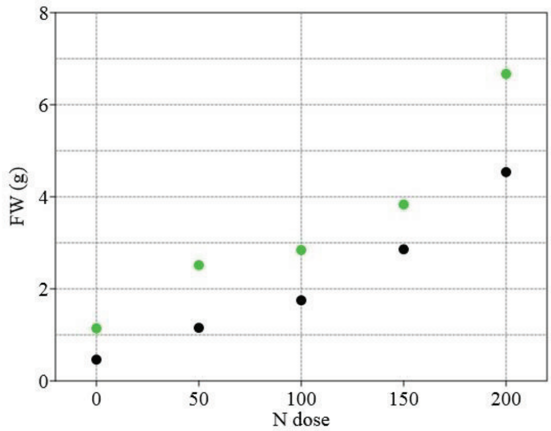

Figure 1. FW variation depending on N dose (black dots - period 1, green dots - period 2)

Regarding DW, polynomial increases depending on N dose were also observed (Figure 2). In period 1, the lowest mean was obtained for N 0 samples (DW = 0.11857 g) and the biggest mean value was recorded for N 200 samples (DW = 0.97816 g). For period 2, mean values were much bigger when compared to period 1, for both, N 0 samples (DW = 0.28275 g) and N 200 samples (DW = 1.7229 g). These increases can be described by equations (3) and (4) (Table 1).
The biomass of a wheat crop has on average 40% carbon by dry weight, and any increase in biomass production will require an increase in photosynthetic carbon fixation (Parry et al., 2011). Under nonlimiting water supply, the N status of a crop is the major factor controlling the rate of biomass accumulation (Jensen et al., 1990), and, at any given time, there is a strong relationship between N and biomass. Figure 3 contains the variation of AC for both periods depending on the five N doses.

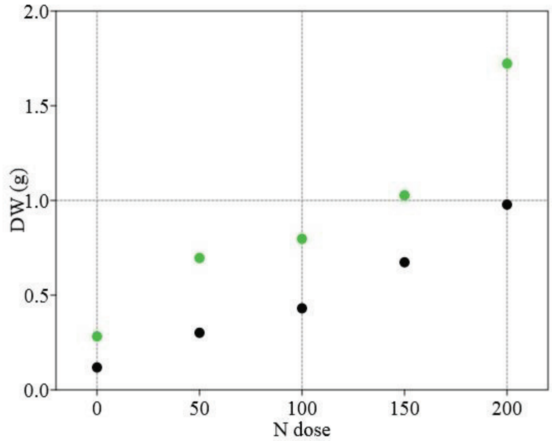

Figure 2. DW variation depending on N dose (black dots - period 1, green dots - period 2)

It is a known fact that more than 90% of crop biomass is derived from photosynthetic products (Makino, 2011). Although the ash content was really small when compared to the first two parameters, it was observed that the lowest means were also specific to N 0 (AC 1 = 0.016 g; AC 2 = 0.0275 g) probes collected in both periods and N 200 probes presented the highest values (AC 1 = 0.0792 g; AC 2 = 0.2083 g).

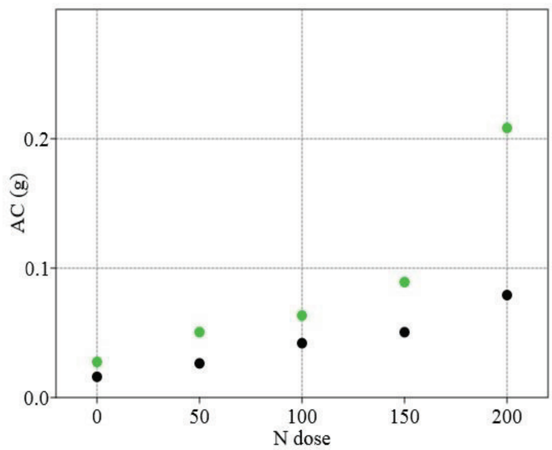

Figure 3. AC variation depending on N dose (black dots - period 1, green dots - period 2)

Initial water quantity variation depending on N dose, for both periods can be observed in Figure 4. The lowest means of this parameter were determined from the samples belonging to N 0 plants (IWQ1 = 0.3449 g; IWQ2 = 0.8601 g) and the biggest means for N 200 samples (IWQ1 = 3.5585; IWQ2 = 4.9476 g).

In grains, on the other hand, the water quantity shows very little variation throughout the period of dry matter deposition (Schnyder and Baum, 1992).

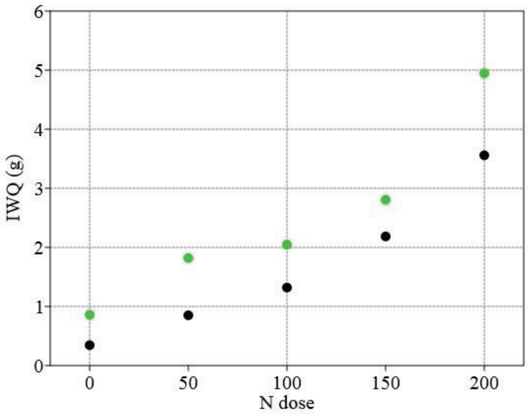

Figure 4. IWQ variation depending on N dose (black dots - period 1, green dots - period 2)

Analysis of differences for aboveground biomass samples fertilized with different N doses and for two periods can be observed in Table 2. Levene's test showed that the values of all parameters for periods 1 and 2 were heterogeneous.

Welch F test showed that the data are significantly different. Thus, ammonium azotate has a strong influence on all parameters.

Aboveground biomass (AGB) plays an important role in plant functioning because it reflects the status of crop growth and is related to solar-energy consumption and grain quality (Huang et al., 2016).

The determination of aboveground biomass is part for climate change researches (Chen et al., 2016).

Table 1. Equations and statistical safety parameters for the investigated indices in the both periods

Factor	Parameter	Period	Function	Eq. No.	χ^2		p	R^2	F
N Dose	FW	1	$FW_1 = 4.398E\text{-}07x^3 - 6.091E\text{-}05x^2 + 0.01496x + 0.4713$	(1)	0.004227		0.025919	0.99959	803.92
		2	$FW_2 = 1.93E\text{-}06x^3 - 0.0004763x^2 + 0.04572x + 1.15$	(2)	0.00374		0.018847	0.99978	1520.8
	DW	1	$DW_1 = 7.695E\text{-}08x^3 - 1.29E\text{-}05x^2 + 0.0038x + 0.1217$	(3)	0.000696		0.050144	0.99845	214.47
		2	$DW_2 = 5.189E - 07x^3 - 0.0001359x^2 + 0.01362x + 0.2842$	(4)	0.000148		0.014605	0.99987	2532.8
	AC	1	$AC_1 = 1E\text{-}08x^3 - 2.157E\text{-}06x^2 + 0.0003474x + 0.01543$	(5)	2.24E-05		0.12354	0.99056	34.962
		2	$AC_2 = 6.907E\text{-}08x^3 - 1.486E\text{-}05x^2 + 0.001114x + 0.02669$	(6)	4.64E-05		0.061104	0.9977	144.29
	IWQ	1	$IWQ_1 = 6.085E\text{-}05x^2 + 0.003354x + 0.4039$	(7)	0.031111		0.004877	0.99512	204.06
		2	$IWQ_2 = 1.411E\text{-}06x^3 - 0.0003404x^2 + 0.03209x + 0.866$	(8)	0.0024		0.0203	0.99975	1310.9

Table 2. Analysis of differences for some aboveground biomass parameters depending on N dose

			N 0	N 50	N 100	N 150	N 200	Levene's test	Welch F test
FW (g)	1	Min	0.2859	0.8941	1.0039	1.6815	3.1143	p = 0.001022	F = 89.62, df = 19.64, p = 2.5E-12
		Max	0.6493	1.9888	2.5106	4.0119	5.7150		
	2	Min	0.7054	1.8483	1.7980	3.0587	5.5258	p = 0.0375	F = 103.7, df = 21.14, p = 1.428E-13
		Max	1.4880	3.4400	3.9575	5.0048	8.5406		
DW (g)	1	Min	0.0725	0.2298	0.2404	0.5023	0.5865	p = 0.00922	F = 63.04, df = 20.18, p = 4.076E-11
		Max	0.1828	0.5296	0.6064	1.1036	1.2874		
	2	Min	0.1643	0.5060	0.5030	0.8538	1.4365	p = 0.04984	F = 110.1, df = 20.74, p = 1.177E-13
		Max	0.3635	0.9651	1.0064	1.4006	2.2567		
AC (g)	1	Min	0.0097	0.0192	0.0246	0.0301	0.0587	p = 0.002183	F = 60.94, df = 20.37, p = 4.802E-11
		Max	0.0191	0.0423	0.0555	0.0737	0.1031		
	2	Min	0.0152	0.0302	0.0377	0.0721	0.1392	p = 0.003781	F = 41.37, df = 20.11, p = 1.963E-09
		Max	0.0360	0.1088	0.1085	0.1211	0.3862		
IWQ (g)	1	Min	0.1989	0.6643	0.6817	1.1711	2.5278	p = 0.002443	F =91.87, df =19.48, p =2.325E-12
		Max	0.4772	1.6611	1.9170	3.1025	4.4276		
	2	Min	0.5081	1.3423	1.2769	2.1897	4.0893	p = 0.02816	F = 96.55, df = 21.32, p = 2.441E-13
		Max	1.1773	2.4973	2.9511	3.6042	6.2839		

Moreover, some studies have estimated aboveground biomass using a combination of narrow spectral bands and vegetation indices (Meroni et al., 2004).

Aboveground biomass, reported in fresh or dry units is considered as one of the most important crop biophysical indices, and its accurate estimation can help improve crop monitoring and yield prediction (Jin et al., 2016).

CONCLUSIONS

The aim of this study was to determine the values of some gravimetric indices: FW, DW, AC and IWQ depending on N dose for aerial parts of wheat, Ciprian cultivar. Polynomial trends were observed when the amount of ammonium azotate applied to the crops increased. Significant differences between the experimental variants were observed after the completion of Levene's and Welch F tests for fresh, dried and incinerated samples, but also for the initial water quantity.

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