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PhD DISSERTATION

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IMPACT OF NITROGEN TOPDRESSING ON THE QUALITY PARAMETERS OF WINTER WHEAT (*TRITICUM AESTIVUM L.*) YIELD

PhD DISSERTATION

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2. INTRODUCTION

The Earth's rising population growth is contributing to increasing hunger, as well as creating insufficient and unbalanced nutrition, all of which continue to be major problems for human survival. Although different opinions are put forward for the solution, the most notable consensus among experts has been to engineer an increase in plant and animal products. Wheat, the most widely grown plant species in the world, is a plant of high strategic importance due to the fact that it has been grown since the earliest times; its agricultural process is easier than other plants; the product is more adaptable to transportation and storage conditions; and its inherent high nutrition solves one of the most pressing economic problems. Wheat is also one of the most predominant cereal grains in Hungary and Turkey, and it retains high economic value. The goal of wheat production is two-fold: to provide both quantity and quality.

The milling and baking qualities of wheat are mainly determined by its genetic basis; however, it can be influenced by management techniques as well (Pollhamer, 1981; Grimwade et al., 1996; Vida et al., 1996; Pepó, 2010). The determination of wheat milling quality is complex because the quality measurements depend on the kernel hardness, protein, starch, internal insect infestation, color, disease, size, and moisture parameters (Posner, 2003). One of the most important parameters, in terms of nutritional content, is the protein ratio in wheat. Although it is determined genetically, the protein ratio is a feature that can also be increased by Nitrogen fertilizer applications. The desired ratio is 11-14% for red hard winter wheat. For optimum grain yield, the critical protein ratio was specified as 11.5% (Goos et al., 1982). However, it is required that this rate should not be less than 12.5% in order to increase the quality of bread. Baking quality of wheat flour is determined by grain protein concentration (GPC) and its composition, and is highly influenced by environmental factors such as Nitrogen (N) fertilization management (Xue et al., 2019). The protein content of wheat crops has an important impact on the nutritional quality for humans and livestock and on the crops' functional properties in food processing (Shewry and Halford, 2002). The economic value of winter wheat is affected by the genotype, cropping year, agro-climatic parameters, as well as the agronomic applications and coordination (Győri, 2006; Várallyay, 2008).

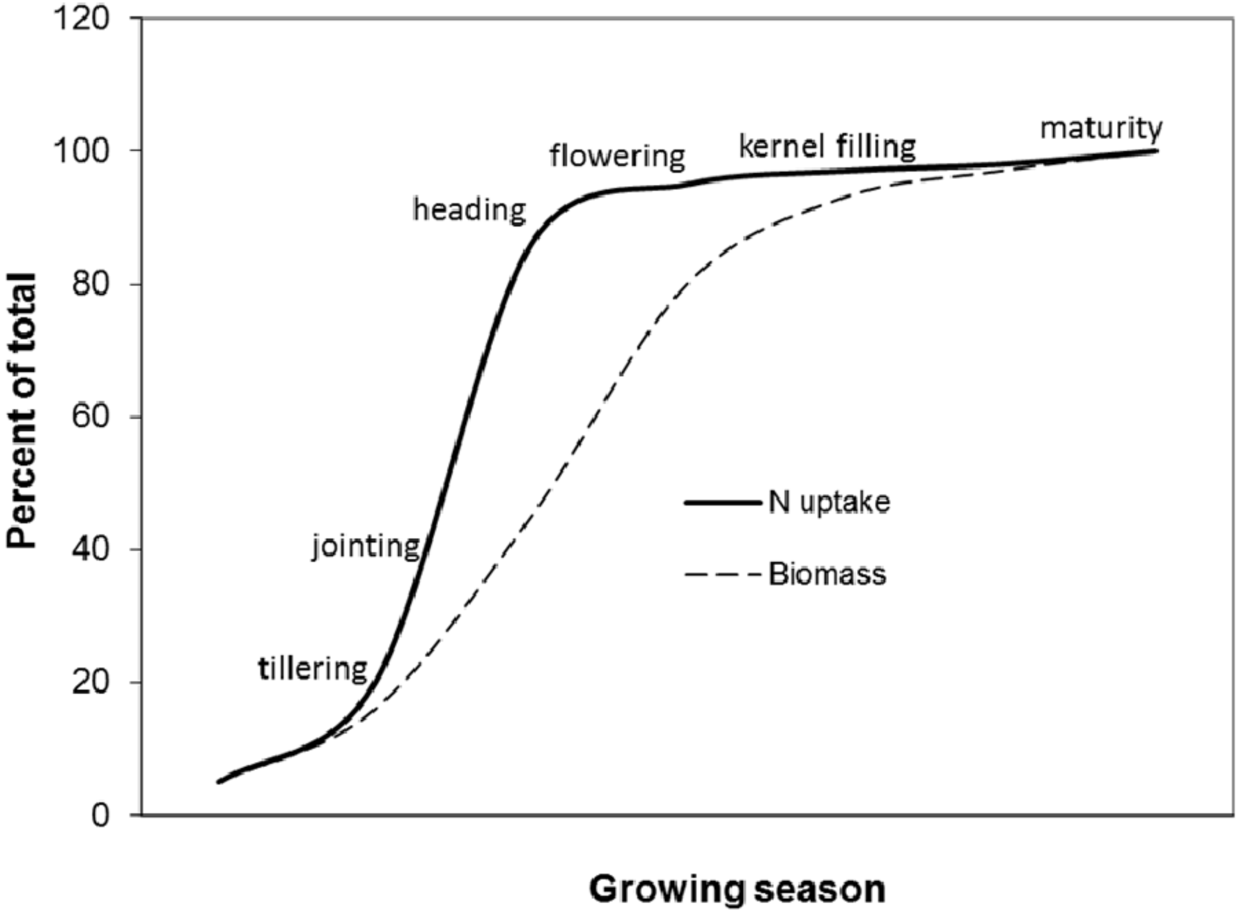
Varieties that differ greatly in terms of yield cause less variation in grain protein yields. Since the grain protein concentration is strongly related to the relationship between protein yield and grain yield, there is a somewhat significant inverse relationship between yield and protein concentration from this combination. The protein yield of wheat has increased significantly throughout its breeding history but could not keep up with the genetic yield increase in protein yield. The result was low protein concentrations (Van Lill and Purchase, 1995). Nitrogen (N) is one of the macronutrients required for plant growth, with high effect on quality and quantity values of winter wheat. The quality of wheat varieties is strongly influenced by crop year, season, genotype effects, and the effects of the management systems are also determinative of some physical and gluten quality characteristics of the grain (Rakszegi et al., 2016). Horváth and co-workers (2014) also established that increasing levels of N topdressing and increased number of applications had beneficial effects on the protein content as well as on wet gluten values of wheat grain. Szentpétery and co-workers (2005) proved that increasing fertilizer dose applications had a beneficial effect on the protein and gluten contents, as well as improvements in quality. Kismányoky and Tóth (2010) explained that the increasing rate of N fertilization application, as well as the additional organic fertilizers, has influenced the biomass production and N uptake of winter wheat. Additionally, as a result of intensive chemical fertilization, the amounts of organic matter and humus in the soil will decrease, and the fertilizers will be washed away as they cannot hold in the soil. Plant nutrients (fertilizer) will not be transformed into a chemical form in the soil that the plant could uptake; thus, the physical and chemical properties of the soil will deteriorate. As a result, the upper parts of the soil will be sandy while the lower parts will be stony. One of the biggest factors that cause environmental pollution and deterioration of the natural balance is agricultural activity where chemicals are used extensively. Moreover, the agricultural methods in which chemicals are used not only cause environmental pollution and deterioration of the natural balance, but also threaten the lives of all living things via the food chain. The aim of this study is to investigate the changes in qualitative parameters of the winter wheat varieties sown in four crop seasons, each of which had different levels of split and/or undivided dose applications of Nitrogen fertilizers. This practice would determine the optimum Nitrogen ratio required in order to reach the optimum protein rate in Nitrogen fertilizer applications with variable ratios. With the help of the equations obtained within the research, the aim is to determine the most appropriate Nitrogen dosage, to reach the highest level of efficiency and quality, and to apply the Nitrogen use at the best possible levels. Due to the fact that the Nitrogen requirement of the plant is not fully met, the results would include low yield, excessive fertilization, pollution of the environment, and economic losses due to the cost of fertilizers. A study conducted in France stated that Nitrogen fertilizer costs constitute 28% of wheat production (Quievreux, 1997). In temperate regions, wheat is the main crop grown for both human and animal consumption. Therefore, all research that focuses on raising wheat production efficiency, crop quantity, and quality characteristics is of utmost significance. The aim of this study is to find the quality changes on tested winter wheat varieties with the application of Nitrogen fertilizer. As Nitrogen fertilization has a considerably high economic and environmental effect on wheat farming and wheat quality, we therefore should find the most appropriate formula for supplying fertilizer to get the best results to be able to improve the quality of the winter wheat products, as well as consider the economic and environmental side effects of the this kind of farming approach.

2.1. ACRONYMS

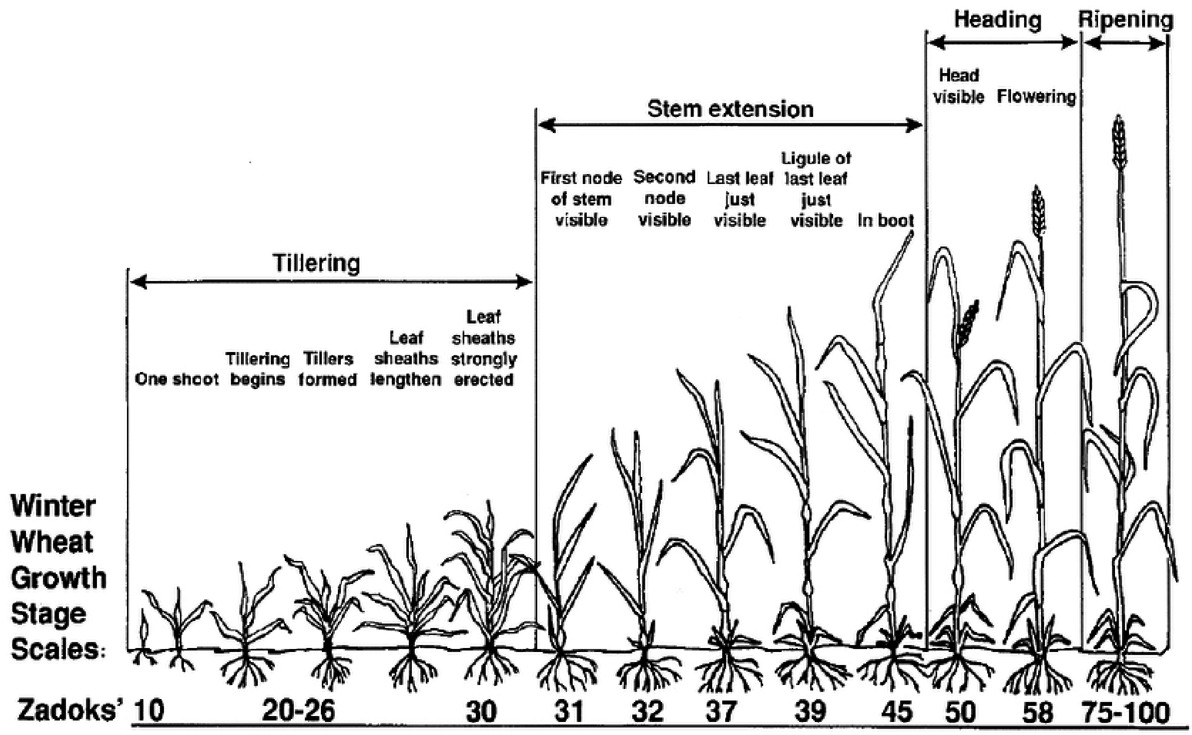
M	:	Arithmetic Mean
SPSS	:	Statistical Program for Social Sciences
SD	:	Standard Deviation
df	:	Degrees of Freedom
N	:	Frequency
%	:	Percent
p	:	Significance Value
t	:	t statistic
F	:	F statistic
r	:	Correlation Coefficient

3. OBJECTIVES TO ARCHIVE

It is possible to divide the development period of wheat into three periods depending on the nitrogen intake amount. The first period is from emergence to tillering, when nitrogen uptake is low (5-20%). Research has shown that the nitrogen of wheat is taken most intensively in the (Figure 1) period of tillering and earing (Zadoks' 25-58) according to the Figure 2 growth period in Zadoks (Brown et al., 2005; Orlof et al., 2012). Nitrogen in this period contributes positively to the amount of tillering and the number of grains per ear, which directly affects the yield. As seen in Figure 1, the third period is the period from spiking to harvest, and nitrogen uptake is slow in this period as well. The main purpose of fertilization is to keep the nitrogen needed by the wheat plant in the soil ready in time during its growth and development periods. For this reason, making fertilization according to growth periods increases the efficiency of nitrogen use. On the negative side, applying more nitrogen than the appropriate nitrogen dose can encourage vegetative growth, which causes a decrease in yield.



1. Figure Nitrogen uptake of wheat during the growth period (Brown et al., 2005; Orlof et al., 2012)



2. Figure Wheat growth stages for Zadoks and Feekes scale (Large, 1954; Zadoks et al., 1974)

4. LITERATURE OVERVIEW

4.1. Importance of the wheat

There are more lands planted with wheat in the world than with any other crop. It provides 20 percent of the world's caloric consumption; even 50 percent for the world's poorest, for whom it also provides 20 percent of their protein consumption (Washington Wheat Facts 2016/2017).

(Million tonnes)	2018	2019	2020 estimate	Change: 2020 over 2019 (%)
Asia	1 185.1	1 196.0	1 220.6	2.1
Far East	1 085.7	1 089.3	1 107.4	1.7
Near East	65.2	73.5	78.0	6.2
CIS in Asia	34.2	33.2	35.2	6.1
Africa	198.6	192.4	198.9	3.4

North Africa	37.5	36.2	32.7	-9.5
West Africa	66.0	65.5	66.9	2.1
Central Africa	6.8	6.7	6.6	-2.7
East Africa	56.6	55.4	56.4	1.8
Southern Africa	31.8	28.6	36.3	27.0
Central America and the Caribbean	42.5	42.4	42.7	0.6
South America	197.8	228.8	233.4	2.0
North America	495.4	479.3	496.8	3.7
Europe	497.2	542.0	518.9	-4.3
European Union[1]	294.2	324.1	281.5	-13.1
CIS in Europe	188.0	202.7	202.2	-0.2
Oceania	30.9	27.9	50.0	79.0
World	2 647.4	2 708.8	2 761.3	1.9
Developing countries	1 615.3	1 650.7	1 686.8	2.2
Developed countries	1 032.1	1 058.1	1 074.5	1.6
- wheat	732.1	760.7	774.0	1.7
- coarse grains	1 408.0	1 445.3	1 474.1	2.0
- rice (milled)	507.3	502.8	513.2	2.1

1. Table Giews Crop Prospects And Food Situation: World cereal production, FAO 2021
Note: Includes rice in milled terms. Totals and percentage change computed from unrounded data. [1]Data for the European Union from the year 2020 (including the 2020/21 marketing year) excludes the United Kingdom of Great Britain and Northern Ireland.

The total global wheat output exceeded 776.7 million tons in 2021, according to FAOSTAT data (FAO, 2022). All over the world, 18.3% of daily calories and 19.8% of protein taken from foods are provided from wheat products (FAO, 2018). Wheat is the dominant crop in temperate countries being used for human food and livestock feed. Its success depends partly on its adaptability and high yield potential but also on the gluten protein fraction which confers the viscoelastic properties that allow dough to be processed into bread, pasta, noodles, and other food products. Globally, protein deficiency is a significant problem that takes second place to calorie deficiency in human nutrition (Robinson et al., 1986) – Table 1 shows that wheat is one of most widely produced crop products. Wheat also contributes essential amino acids, minerals, and vitamins, and beneficial phytochemicals and dietary fiber components to the human diet, and these are particularly abundant in whole-grain products (Shewry, 2009). Improving global food security is critical, given that over 800 million people remain food insecure (FAO, 2017) and its association with conflict and civil unrest (Kalkuhl et al., 2016; Bellemare, 2015). The leading wheat producers in the world are the EU, China, USA, Russia, India and Turkey, as shown in Table 2; however, wheat is not suitable for cultivation in certain parts of the world for climatic reasons. Some countries are completely foreign-dependent for this reason. Chief among these are Egypt, Indonesia, Algeria, Brazil, Japan and S. Korea, which import the most (Atar, 2017).

(Million tonnes)	Average 5yrs	2019	2020 estimate	2021 forecast
European Union[1]	143.1	155.7	125.2	137.0
China (mainland)	133.4	133.6	134.2	135.5
India	100.4	103.6	107.6	109.0
Russian Federation	78.4	74.5	85.9	79.0
USA	52.8	52.6	49.7	50.0
Canada	32.5	32.3	35.2	33.0
Ukraine	26.1	28.3	25.1	26.0
Pakistan	25.4	24.4	25.3	26.0
Australia	23.8	15.2	33.3	26.0
Turkey	20.3	19.0	20.5	19.5
Argentina	18.7	19.8	17.6	19.0
Iran	14.3	14.5	14.0	14.5
Kazakhstan	13.9	11.5	14.3	14.0
United Kingdom of Great Britain and Northern Ireland	-	-	9.7	14.0
Egypt	8.8	9.0	9.0	9.0
Other countries	66.6	66.9	67.5	68.5
World	758.4	760.7	774.0	780.0

2. Table Giews Crop Prospects and Food Situation: Wheat production: Leading producers, FAO 2021 ([1]Data for the European Union prior the year 2020 includes the United Kingdom of Great Britain and Northern Ireland.)

4.2. Quality criteria of the wheat

- Variety
- Test weight
- Thousand grain weight
- Vitreousness ratio
- Ash amount
- Protein and gluten content
- Pigment ratio
- Lipoxidase activity
- Gluten quality
- Milling efficiency

Güleç et al., (2010) stated the factors that determine the quality of wheat as per this list.

4.2.1. Factors that affect the quality of wheat

The three main factors that affect the quality of the wheat production described by (Denčić et al., 2012; Drezner et al., 2007; Gooding and Davies, 1997; Peterson et al., 1992) are listed below. However, the list might be extended depending on producer, manufacturer or end-users like transporters, storage facilities, millers, et al.

- Genotype
- Seed quality
- Environmental factors

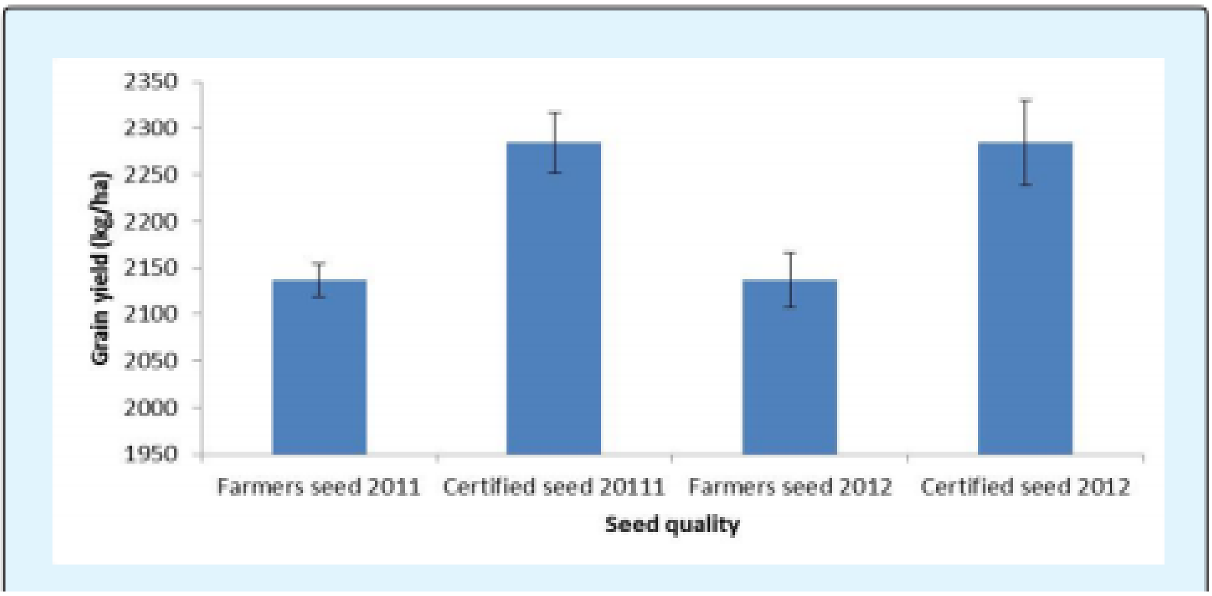
4.2.1.1. Genotype

Wheat (*Triticum aestivum* L.) quality may be improved by breeding elite varieties, improving crop/farming management practices and exploiting the synergism between genotype and the environment (Awulachew, 2019; Gaju et al., 2011; Peterson et al., 1992). Nass et al. (1976) tried different nitrogen doses in six bread wheat cultivars. They reported that the most important factor in providing yield increase with nitrogen application is the variety feature and while a significant increase in grain yield can be achieved with nitrogen fertilizer application in high-yielding varieties, there is little or no yield increase in medium and low-yielding varieties. It is known that certain quality parameters are highly influenced by genetic factors (i.e., hardness is clearly genetically determined) (Vázquez et al. 2012; Carson and Edwards, 2009; Wrigley, 2007). Although genotype is an important factor, the determining factor in the effectiveness of genotype is Genotype x environment interaction (Šramková et al., 2009; Johansson et al., 2020). Varieties with genotypically high yield and quality characteristics can show their yield and quality characteristics if they are grown in suitable ecological conditions and appropriate cultural practices are performed (Anonymous, 2012). A good genotype takes high amounts of nitrogen from soil and fertilizers and uses it to increase grain yield rather than stems. The efficiency of nitrogen use for crop production in low-input sustainable agriculture can increase yields, reduce costs, and reduce the harmful effects of excess fertilizer on the environment (Arpacioğlu., 2018). Šekularac et. al., (2018) research shows that genotype was the most significant factor on the gluten index variation.

4.2.1.2. Seed quality

The major seed quality characteristics are physical quality, genetic purity, physiological quality and seed health. The health status of seeds is judged by the presence or the absence of insect infestation and seed-borne diseases. Seed-borne refers to the particular plant diseases that are transmitted by seeds. Using seeds which are free from disease inoculum is a primary means of reducing the introduction of pathogens into fields; it also reduces inoculum production and the speed of secondary spread into the inoculum threshold and disease severity after it's diagnosed. The prime factor in guaranteeing an increase in productivity of at least 10–15% is seed quality. To achieve this quality level, all the production factors that will affect seed viability, guarantee genetic purity and lack of disease should be taken into account. The success of modern agriculture depends on using pathogen-free seeds with high yielding character, which, in turn, improves disease management (Gaur et al., 2020).

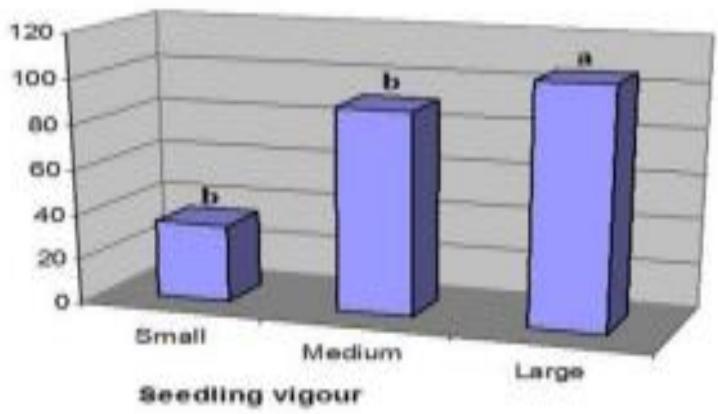
Seed quality is defined via standards of excellence in certain characteristics and/or attributes that will determine the performance of the seed when sown or stored (Banu et. al. (2004) and effect on the performance of the quality and quantity of the wheat production as well, as shown in Figure 3.



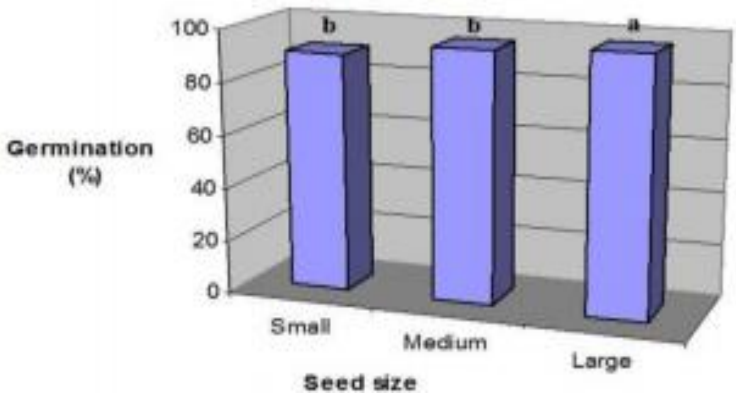
3. Figure Effect of seed quality on grain yield, Kumar. D, and Seth. R, (2004)

High quality seed is important to ensure maximum seed germination and seedling vigor, which in turn is instrumental in achieving maximum yield. Poorer quality seeds show low viability, reduced germination and emergence rates, poor tolerance to sub-optimal conditions and low seedling growth rates as shown in Figure 4 and Figure 5. The seed quality is also reflected in the final growth, maturity of plants, their uniformity and stability of yield. Seed size is an important physical indicator of seed related to yield, market grade factors and harvest efficiency (Gadisa, 2019).

The concentrations of P and K in the seed were significantly associated with grain yield where source was a significant factor and it affected the yield up to 8% in the research of McDonald and Hussein (2017); however, researchers have found that using larger size seeds resulted in a 4-5% yield increase as well.



4. Figure Effect of seed size on seedling vigor in wheat Simmone et. al., (2000)



5. Figure Effect of seed size on germination percentage Hossein et. al., (2011)

4.2.1.3. Environmental factors

The expression of the genetically determined good properties are influenced by environmental factors (Horváth, 2016). A study done with 12 varieties at 10 different locations by Miezan et al., (1977) reveal that protein content was affected by both the experiment site and nitrogen fertilization; however, Bayfield (1936) found that protein content in wheat increased as soil texture became heavier and as the soil fertility increased. Some ecological factors, including soil physiological and chemical properties and geographic latitude, can also affect wheat quality (Awulachew, 2019). Another experiment by Terman (1979) held in pots shows that nitrogen and moisture supply, light, temperature, and other growth factors greatly affect yield-protein relationships among cultivars. Naturally, weather impacts may have direct or indirect influence on the performance of agricultural production and the food industry. Weather and climate remain the major uncontrollable driving forces in agricultural production; despite advances in technology and crop varieties, those factors still present more constraints on yield and affect production management practices from seedbed preparation to harvest than do soil management and agronomic practices (Decker, 1994; Olesen et al., 2000). An experiment in northeast Austria showed that a warming of 2°C in the air temperature would shorten the crop-growing period by up to 20 days and would decrease the potential winter wheat yield on nearly all of the soil types in the region (Thaler et al., 2012), as well as Lv, Z. et al. (2013) found that under rain-fed conditions, wheat yield is reduced in the north regions of China in three future periods, while wheat yield increases in the south regions of China.

Future climate scenarios may be beneficial for wheat in some regions, but could reduce productivity in zones where optimal temperatures already exist (Ortiz et al., 2008).

Water availability can be considered a basic factor related to yield quality and quantity performance of grain crops (Jolánkai et al., 2016). If cultivars that provide genotypically high quality products are not grown in suitable environments and care is not taken with the cultivation techniques, they do not reflect the desired quality characteristics.

It should be taken into consideration that every single environmental unit has effects on crop production -- e.g., hedgerows which reduce the wind speed. Those have been predicted to have particularly positive effects on winter wheat production (Thaler et al., 2012); however, results showed that N supply was the topmost environmental factor affecting protein content and composition (Triboi et al., 2000; Johansson et al., 2001).

4.3. Ecological requirements of the winter wheat

Wheat is an annual plant and is grown almost all over the world because it has many varieties that can be grown in all climates and soil conditions.

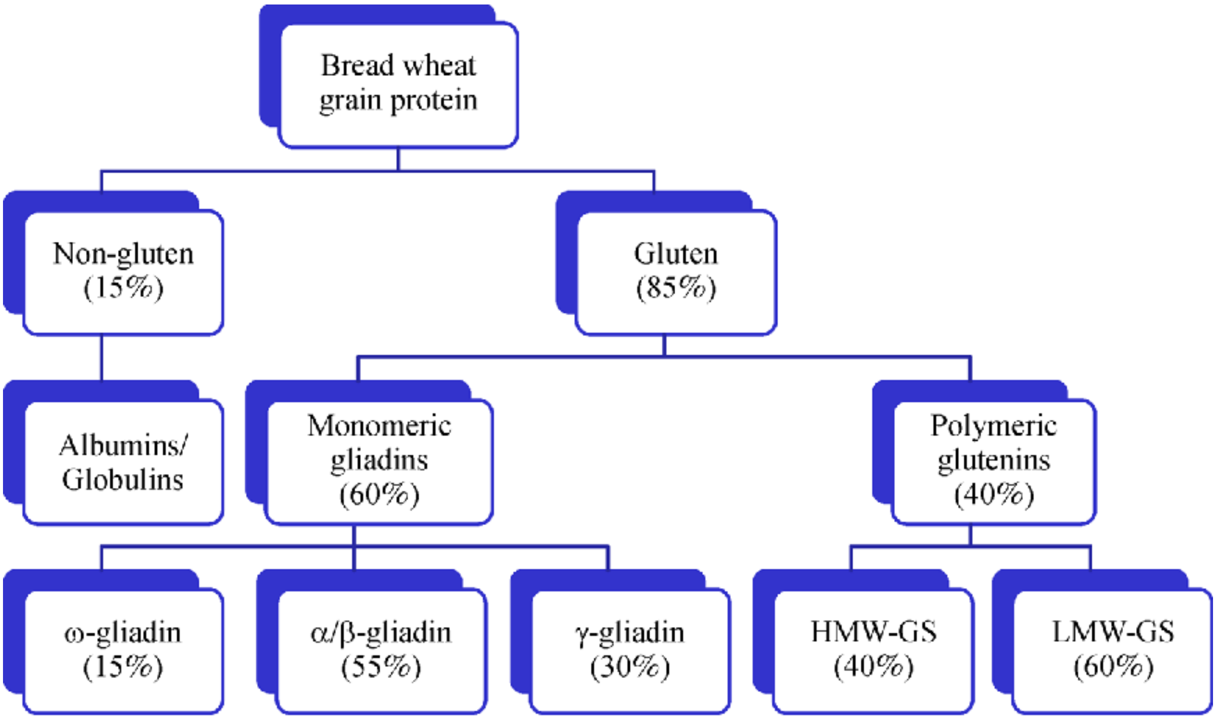
Wheat is generally grown in warm and cool climate conditions. Wheat does not like high temperatures in the early stages of development (germination, tillering). If the average humidity is above 60%, the plant continues to develop normally. It does not require much heat in the advanced stage of vegetative growth. A temperature of 10-15ºC with a relative humidity of 66% and little light are suitable ingredients for decent growth. Wheat grows best in temperatures between 21ºC/70ºF and 24ºC/75º F. The minimum temperature that wheat can handle during its growth cycle is about 4ºC/ 40ºF. Wheat does not grow well if temperatures exceed 35ºC/95º

F. Wheat will grow optimally in a deep, fertile, well-irrigated and well-aerated soil at a pH between 5.5 and 7.5 (Nasa (n.d.)). Wheat can be grown in climatic regions with an annual precipitation of 350-1150 mm. A good quality and abundant product can still be produced in places with annual precipitation of 500-600 mm or in irrigations that will provide this moisture in the soil.

Sandy loam soils with deep, clayey, loamy-clay and sufficient organic matter, phosphorus and lime, guarantee the best wheat. The higher the organic matter in the soil, the higher the wheat yield. (T.C. Tarim ve Orman Bakanligi (n.d.)).

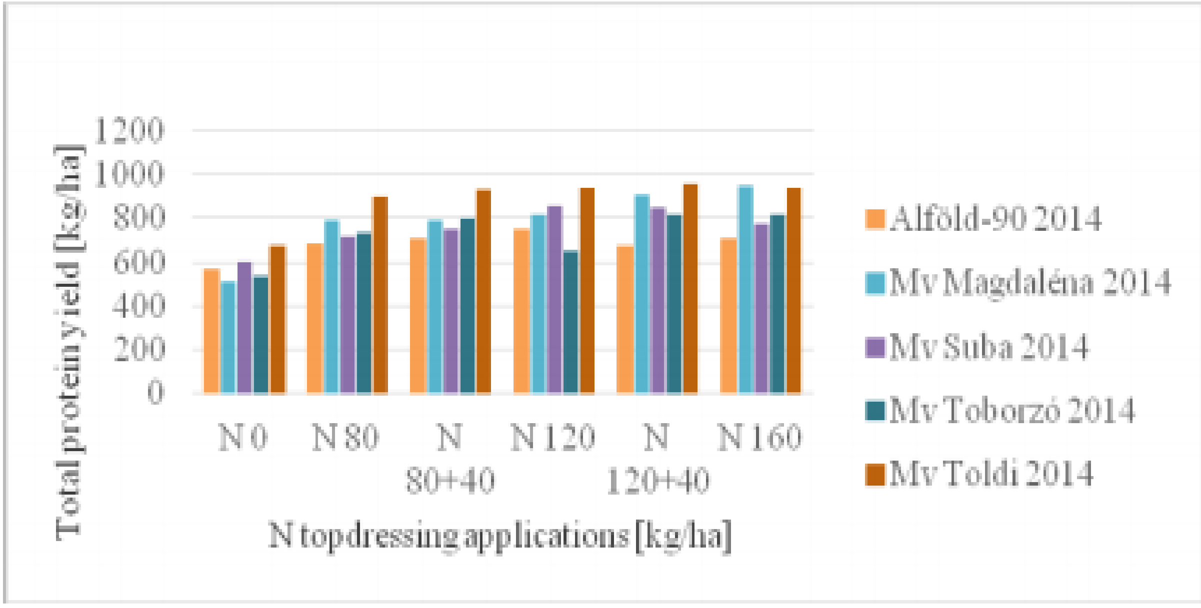
4.4. The grain protein

Wheat germ is well-known high-quality nutritional product. Wheat germ has 10.80% water, 26.50% crude protein, 8.56% crude fat and 4.18% ash content on a dry weight basis. Wheat germ contains lipids (10%-15%), proteins (26%-35%), sugars (17%), fiber (1.5%-4.5%) and minerals (4%). It also contains substantial amount of biologically active compounds like tocopherols, phytosterols, policosanols, carotenoids, thiamin and riboflavin as 300-740 mg / kg, 24-50 mg / kg, 10 mg / kg, 4-18 mg / kg, 15-23 mg / kg and 6-10 mg / kg, respectively (Mughal., 2019). Protein is the primary quality component of cereal grains. Protein concentration is influenced by both environmental and genotypic factors that are difficult to separate (Fowler et al., 1990). Wheat grain proteins are classically categorized and separated according to solubility in albumin, globulin, gliadin and glutenin (Osborne, 1907). Proteins make up 7–22% of wheat's dry weight (Godfrey et al., 2010); according to some sources, the protein content in wheat grain can be up to 25% (Gooding and Davies, 1997).



6. Figure Wheat gluten protein and its impacts on wheat processing quality. Ma et al., (2019). Frontiers of Agricultural Science and Engineering.

One study stated that the protein ratio is the most important quality criterion determining the quality of wheat, and it determines the water absorption, stability, resistance and elasticity values of the flour (Bilgin and Korkut, 2005). In more recent times, gliadin and glutenin make up between 60-80% of total grain protein (Langenkämper and Zörb, 2019). Gluten is a large family of proteins, and accounts for up to 80% of the total protein content. It is responsible for the unique elasticity and stickiness of wheat dough -- the properties that make it so useful in bread making (Arnarson, 2019). Eser et al., (2017) mention (and show in Figure 7) that the results obtained suggest that a strong correlation was detected between the total amount of protein and the experimental treatments, regardless of the impact of crop years.



7. Figure Total protein yields in the non-favorable crop year. Nagygombos 2014. Eser et. al. (2017)

In comparative studies with varieties developed in different breeding periods, it is stated that modern varieties provide a yield advantage of at least 50% compared to the improved varieties, but it is quite difficult to improve the yield and grain protein percentages together with the variety breeding methods due to the negative relationship between these two (Slafer et al., 1994). Similarly, Van Lill and Purchase (1995) mention that while high-yielding new varieties were obtained with the breeding studies for yield, the progress in terms of grain protein ratio and bread quality in the obtained varieties remained at a certain level. Research has shown that one of the most important cultivation techniques -- fertilization applied at the right time and in the appropriate amount -- can increase the quality of products that can satisfy the demands of the producers, consumers and industrialists.

4.3.1. Quality of the protein

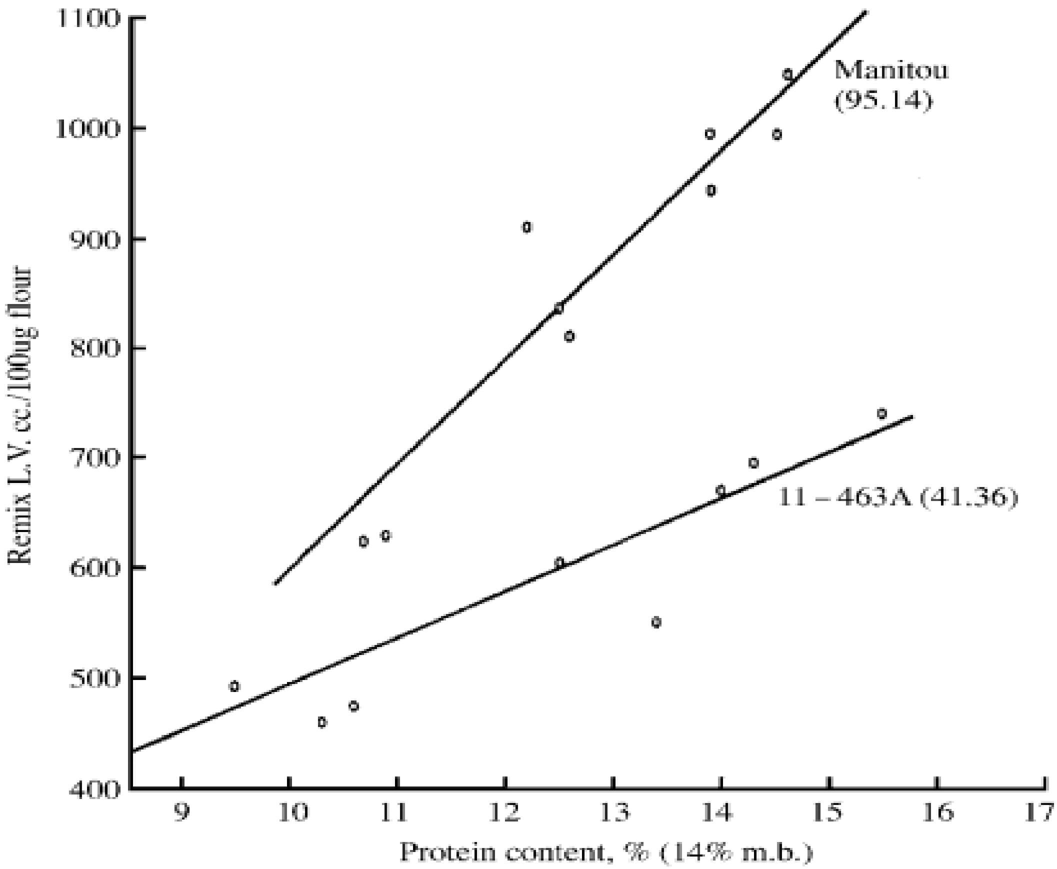
Protein has two components associated with it, namely, the quantity or protein content and the quality of this protein. Both are affected by the levels of nitrogen and sulphur in the plant as it develops through the season (Yara, n.d.). More valuable nutrients for the nutrition of humans and animals are found in the outer parts of the wheat grain, especially in the aleurone layer. Proteins in the aleurone layer (albumin and globulin) constitute approximately 20% of the total protein in the grain and have different structural properties from gluten proteins. The aleurone layer's proteins do not have viscoelastic properties and thus do not take part in dough formation, but are important for physiological nutrition (Erekul et. al., 2016).

Gluten material forms the skeleton of the dough and holds in the gases created by the yeasts, allowing the bread to retain a shape. Protein quality is related to gluten quantity and characteristics -- although the quality of the protein of wheat is affected by agronomical applications, and it depends on its inherent variety as well. The elongation and its resistance to it, shape, elasticity, gas holding power, and capacity of the dough all depend on these properties. When it comes to protein quality, it is there to provide the essential amino acids that are important in human and animal nutrition; but the suitability of the physical properties of the protein is for bread making, rather than the nutritional and biological value of the protein. Whether the protein quality is high or not is determined by the sedimentation test performed on the flour. A high sedimentation value indicates that the quality is high and the volume of breads made from such flour is also high. In this respect, we should take into account not only the protein amount but also the protein quality in the flour to be baked; in other words, the quality difference in the amount of protein in breads made from the same flour arises from the protein quality (Ertugay, 1982). Apart from the amount of protein for wheat, the desired quality of these proteins is also a necessary criterion (Edwards et. al., 2007). Some researchers explain that the low sedimentation value is an important quality parameter, as high temperatures (>30°C) in the grain filling period increase the amount of gliadin (Panozzo and Eagles 2000). As a result, we can say the following: the amount and quality of protein in the flour are the two most important factors that determine the highest usefulness value in the flour.

4.4. The baking quality

The effects of nitrogen fertilization are clearly seen on gluten and gluten index values, which are important criteria of bread quality in sedimentation measurements made on the protein amounts. The proper arrangement of protein webs is effective for a good flour yield as well as warding off pest damage (Todab, n.d.).

Baking quality of wheat flour is determined by grain protein concentration (GPC) and its composition. It’s also highly influenced by environmental factors, such as nitrogen (N) fertilization management (Xue et al., 2019). Increasing the level of protein content will raise the baking quality (Gabriel, et al., 2017; Wrigley and Batey, 2003).



8. Figure Remix loaf volume results for flour samples of two Canadian genotypes (Manitou and the unnamed line 11-463A), with a range of protein contents. Baking quality is indicated as loaf volume (L.V.) and protein content is expressed on the basis of 14% moisture basis (m.b.). Bushuk et al. (1969).

Studies in the Bushuk et al., (1969) (Figure 8) indicate the strong correlation between protein content of the grain and the baking quality.

Besides bread making quality, the flour milling performance of wheat is also of considerable technological importance (Kent, 1984). Much less is known about the factors that affect intracultivar variation in milling quality than those that affect bread-making quality, but starch damage level which, in turn, affects water absorption and dough rheology, is another aspect. A minor protein fraction associated with the starch granule surface has been implicated as having a role in controlling grain endosperm texture (hardness), an important component of milling quality (Schofield and Greenwell, 1987).

9. Figure Baking quality of wheat is determined by wheat cultivar, the interplay of natural grain constituents' proteins, carbohydrates and lipids, growing conditions of wheat as well as milling and baking technology. Langenkämper et al.(2019)

Quality bread production depends mainly on the raw material from which the bread is made, as well as the processing capacity of factories and bakeries, the methods used in the enterprise, the equipment, and the state of the equipment. A quality bread requires a quality wheat that provides quality flour. In this respect, the wheat and flour quality and the factors affecting the quality should be examined separately (Ertugay, 1982).

4.5. The nitrogen fertilizer

The nitrogenous fertilizer industry also produces synthetic ammonia, nitric acid, ammonium nitrate, and urea. Synthetic ammonia and nitric acid are used primarily as intermediates in the production of ammonium nitrate and urea fertilizers. The following is a list of primary specific products classified as nitrogenous fertilizers (Khan et al., 2018):

-ammonia liquor

-ammonium nitrate

-ammonium sulfate

-anhydrous ammonia

-aqua ammonia

-fertilizers, mixed, produced in nitrogenous fertilizer plants

-fertilizers, natural

-nitric acid

Nitrogenous fertilizer application is one of the most critical factors that can increase the quality of wheat. The dose and time of application of nitrogenous fertilizers are also important in terms of positively affecting the quality characteristics of wheat. The nitrogen fertilizer, as applied during the growing period and especially during tillering, plays an important role in the quality of the grain (Hoeser and Schafer, 1969).

4.5.1. Effect of nitrogen on quality, yield and development

Among the nutrients used in wheat nutrition, nitrogen is the greatest nutritional element that affects the yield and quality of wheat (Başar et al., 1998; Arpacioğlu., 2018), and its importance is constantly emphasized (Gallagher et al., 1983; Gauer et al., 1992). Nitrogen is often the most limiting factor in crop production. Hence, application of fertilizer nitrogen results in higher biomass yields and protein yield; additionally, concentration in plant tissue is commonly increased. Nitrogen often affects amino acid composition of protein and, in turn, its nutritional quality, says Blumenthal et al., (2008); moreover, the increasing nitrogen supply generally improves kernel integrity and strength, resulting in better milling properties of the grain. In Sohail et al., (2018), a study to determine the effect of different nitrogen fertilizer application methods on yield and quality in wheat, nitrogen fertilization (12 kg/da of pure nitrogen) was applied separately in wheat sowing, tillering, stem lift and grain filling development periods and reached the highest yield with 506.0 kg/da and 14.9% protein value. It stated that the grain protein ratio was lower in the nitrogen fertilizer application applied when the planting had been done. The study concluded that the nitrogen fertilizer applied in the early periods increased the vegetative development and tillering potential, the nitrogen fertilizer applied in the tillering and booting-heading periods increased the grain protein and gluten content, and the importance of nitrogen in terms of quality was emphasized. Reddcliffe et al., (2000) showed results in their study in which they used the divided N application as 0 - 175 kg N/ha at the stage of tillering and 0-40-80 kg N/ha at the flag leaf stage in New Zealand, showing that grain yield and protein ratio increased with increasing nitrogen fertilizer amount.

4.5.2. Other effects of nitrogen fertilizer

Nitrogenous fertilizer application increased the protein amount in the flour in parallel with the increase in the protein amount in the grain, and this increase was found to be statistically significant (Horváth et al., 2014; Ercan and Bildik, 1993). Studies have also determined that protein ratio, gluten amount and sedimentation value increase linearly with the increase of nitrogen fertilizer application (Paredes et al., 1985).

Nitrogenous fertilizer application in dry farming not only increases the yield in winter wheat but also increases the use of water (Xu et al., 2020). Fertilized plants can also use water from the lower layers of the soil. While nitrogen-free winter wheat achieves its water intake from the 90 cm profile, it uses 180 cm moisture profile when nitrogen is given (Hagin and Tucker, 1982). By promoting plant growth with application of nitrogenous fertilizer, a faster and deeper root system is developed, and plants can benefit from deeper water. As the nitrogen dose increases, the efficiency increases and in parallel with this, the efficiency of using water -- which then increases up to 35%. In the following studies, the difference between the fertilizers in terms of the protein content of the grain was found to be significant, and ammonium nitrate fertilizer gave better results than others in this respect (Yılmaz and Şimşek 2013; Başar et al., 1998; Akkaya A. 1994). Soil or foliar Fe fertilizers had little or no effect on the green parts and grain Fe content; however, increasing N applied in any Fe fertilization strongly increased the green portion and grain Fe content. The results show that improving the N nutritional status of plants through fertilization is an important agricultural practice in increasing the grain Fe content and resulting improvement in human health (Özden, 2012). The effects of different nitrogen (N) applications on the Zn uptake and accumulation of corn and wheat were investigated by Rehman (2019). As N applied to wheat and maize increased, more Zn accumulated in green portions and the uptake of foliar applied Zn increased significantly.

4.5.3. Negative effects of nitrogen fertilizer

The negative effects of nitrogen fertilizer have great importance -- in terms of the input costs of production. Thus, the high costs of the production of nitrogen fertilizers, the high energy requirement, the excess nitrogen fertilizer used, and the economic as well as environmental impacts should be considered (Atar et al., (2017); Wang et al., (2017); Gündoğmuş, (1998); Abad et al., (1996). However, it has been shown that increasing the nitrogen doses after a certain level (i.e., overdosing) does not provide the desired increases in yield (Johnson et al., 1973); Styk ve Dziamba, (1984); Eser et al., (1999)). In summation, the nitrogen fertilization is effective and good for winter wheat production, but due to side effects such as cost and environmental harms, it should not be overdosed.

Burkart and Stoner, (2008) and Hamlin, (2006) mention that once a shallow aquifer has been contaminated by nitrate, it may take decades for the groundwater quality to improve even after pollution controls have been implemented. Therefore, in the quest for increasing agricultural production, public health should also be considered a critical factor.

It's generally accepted that fertilization increases soil microbial biomass in agricultural soils on the short and long term (Nguyen et al., 2018), however, application of solely continuous N fertilizer can decrease soil microbial biomass (Wallenstein et al., 2006; Treseder, 2008). Additionally, it may even alter the soil microbial stoichiometry and diversity via the nitrogen (Wang et al., 2018a, b). Osmotic stress conditions and C substrate deficiency caused by the extreme amounts of applied nitrogen also suggest that nitrogen fertilizer should never be overdosed (Yevdokimov et al., 2008).

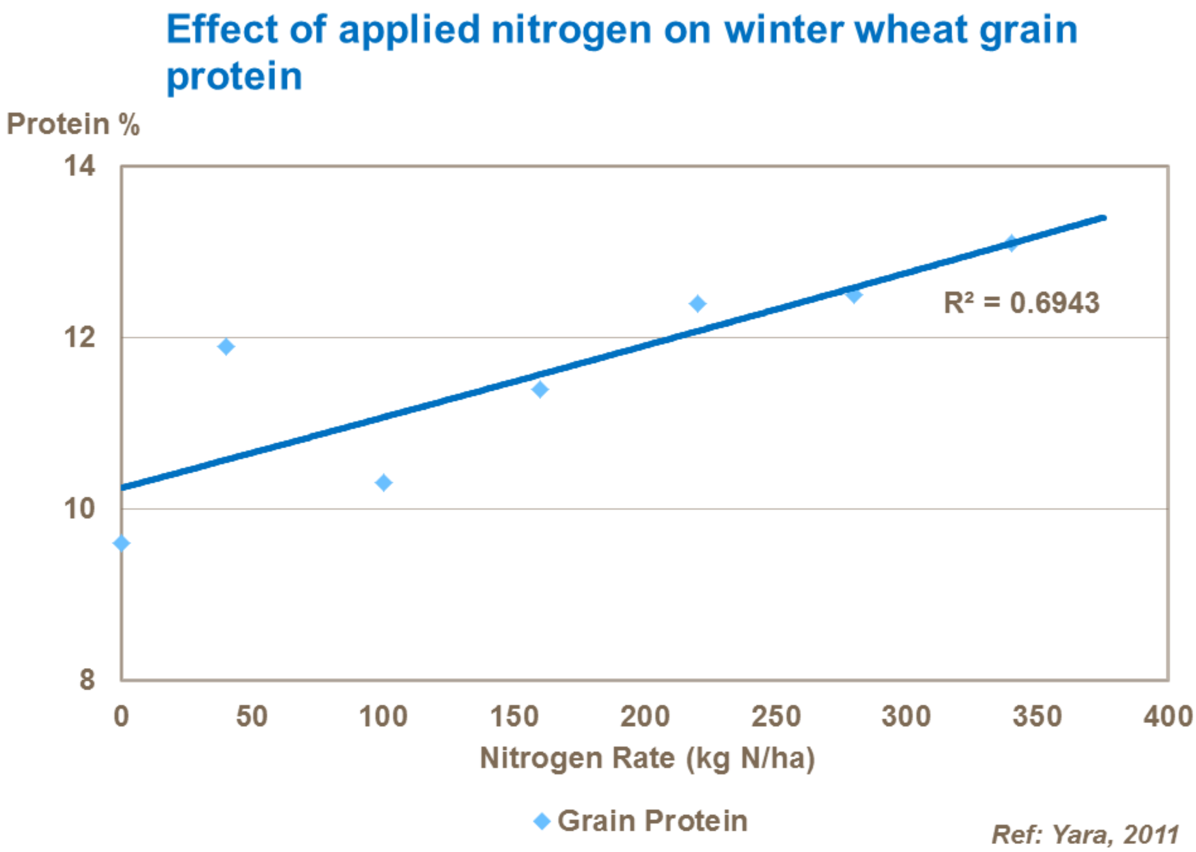
4.5.4. Efficiency of the split dose application of nitrogen fertilizer

Split fertilizer N application has been proposed for improving N uptake efficiency in wheat (*Triticum aestivum L.*) production systems (Belete et al., 2018; Rahman et al., 2011; Jia et al., 1996; Alcoz et al., 1993). Studies have demonstrated that the split N application under unfavorable conditions for cultivation result in higher N use by the plant, reducing its losses to the environment with a yield increase (Brezolin et al., 2016; Ferrari et al., 2016). The timing of its application is one of the most important factors on what effects are produced (Gooding and Davies, 1992). The availability of nitrogen for the wheat during various phases of its growth and development is another important factor influencing the yield and quality of grain (Zende et al., 2005). Application of N fertilizer to wheat, preferably as a top dressing between tillering and stem elongation, is a strategy to be recommended from the standpoint of both the environment and farmer returns, says Lopez-Bellido et al., (2005). Their research affirms the mean wheat use of N fertilizer ranging from 14.1% when applied at sowing, to 54.8% as applied as a top dressing at the beginning of stem elongation. Delayed nitrogen fertilization had no significant increase on the percentage of the protein (Lloveras et al., 2001). Split dose application of the Nitrogen fertilizer has positive effects on most of the crops such as rice production (Sathiya and Ramesh, 2009; Shaiful et al., 2012; Djaman et al., 2018), cotton production (Hallikeri et al., 2010), Brassica species (Ahmad et al., 1999), maize production (Joshi et al., 2014; Hammad et al., 2011), potato production (Ayyub et al., 2019; Al-Moshileh et al., 2005), poppy production (Lošák and Richter, 2004), soybean production (Singh and Singh, 2013a), sunflower production (Khanzada et al., 2016), barley production (Singh et al., 2013b), oats production (Alipatra et al., 2013), tomato production (Singandhupe et al., 2003), sugarcane production (Koochekzadeh et al., 2009), and others.

The results of Madan and Munjal's (2009) research showed that splitting the recommended dose of nitrogen recorded higher total protein content (12.68%) as compared to control (10.23%), and splitting of recommended dose of nitrogen increased the grain yield by 4.1%. The investigation by Xue et al., (2016) demonstrates the same thing with an application of nitrate and the urea form of the nitrogen fertilizer. Nitrogen applied at the late growth stages (boot stage or heading) had considerable increase on baking quality and nitrate, showing a greater effect than the urea form. The results of Rahman et al., (2011) research shows that plant N uptake was significantly influenced by N rate and N splitting, and also the interaction of N rate and N splitting. Total N uptake was maximum under N rate of 120 kg/ha applied as three equal splits as 1/3rd basal with 1/3rd as top dress at CR1 plus 1/3rd as top dress at 1st node stage. Late-stage growth with N fertilization increased the loaf volume of wheat flour by raising grain protein concentration and altering its composition. However, splitting the N changed grain protein composition by enhancing the percentages of gliadin and glutenin as well as certain high molecular weight glutenin subunits (HMW-GS), which led to an improved baking quality of wheat flour. Thus, splitting nitrogen application had greater results on baking quality. What should be considered as well is the wheat's N dose and time of application, which is determined by the amount of organic matter in the soil, the previous crop, and the anticipated yield.

4.5.5. Amount of the nitrogen application

Numerous studies stipulate that overdose application, rather than the appropriate amount of nitrogen fertilizer application, had no significant positive effect on wheat quality parameters (Abedi et al., 2011; Cui et al., 2010; Chen et al., 2004; Lloveras et al., 2001) and even dropped the yield performances (Jolánkai, 1985). Nitrogen use efficiency is closely related to fertilization, the genetic and morphological characteristics of the plant, as well as the climate and soil characteristics.



10. Figure Effect of applied nitrogen on winter wheat grain protein. Yara, (2011)

The research of Khalilzadeh et al., (2012) found that there was high variation among genotypes in terms of nitrogen utilization efficiency.

Following the research of Mandic et al., (2015) they advised that the use of large amounts of N increases production costs and reduces the economic benefits. The findings of Liu et al., (2016) reveal that the recommended N rates reduced the residual inorganic N, nitrate leaching, and direct nitrous oxide emissions by 8–27%, 29–52%, and 19–36% in the three regions, respectively. These findings suggest that this N recommendation method provides an option to balance the yield, grain quality, income, nitrogen use efficiency, and environmental impacts of winter wheat production. It should be noted that the optimal nitrogen requirements of each species differ in different environmental conditions and different agricultural applications. Gelinas et al., (2009) and Öztürk and Gökkuş (2008) expressed the effect of the environmental factors on the quality parameters of winter wheat. Arpacioğlu (2018) research ran five different nitrogen dose applications (0-50-100-150-200 kg N/ha) on wheat; the trials showed that plant height, spike length, grain yield, thousand grain weight, gluten index and nitrogen uptake efficiency increased to about 150 kg/ha nitrogen application and decreased after this dose.

While the maximum unit area yield in grain yield was obtained from the application of nitrogen dose of 150 kg/ha, this value was determined as 153 kg N/ha in the economic analysis. Çetin et al., (1999) suggested 140 kg N/ha dose of nitrogen fertilizer base on their study where the 0-60-120-240 kg N/ha doses were tested. Researchers found positive correlation between protein content of the grain and the increasing level of N application; however, protein content of the tested grains varied between 10.1-19.4%. The trials of Zecevic et al., (2010) with 60-90-120 kg N/ha results showed that 120 kg N/ha application gave the best sedimentation value, while Hussein et al., (2006) trials with 0-50-100-150-200 kg N/ha application showed that even the grain yield and biological yield were statistically similar at doses of 150 kg N/ha and 200 kg N/ha. However, a dose of 200 kg N/ha, compared to a dose of 150 Kg N/ha, significantly increased the protein content. Similarly, the results of Yousaf et al., (2014) with 0-80-100-120-150 kg N/ha applications showed that 120 and 150 kg N/ha achieved the highest plant height, a greater number of tillers, the maximum number of fertile tillers, and highest yield respectively, as compared to the control and other treatments. However, 120 kg N/ha is still recommended for maximum growth and wheat yield.

Similar to above, Mantai et al., (2015) with 0-30-60-120 kg N/ha application on oats; Grabowska and Kozlara (2006) with 40-80-120 kg N/ha application on hemp; Biesiada and Kus (2010) with 50-150-250 kg N/ha application on sweet basil; Djaman et al., (2018) with 0-60-90-120-150 kg N/ha application on rice; Mut et al., (2005) with 0-60-120-180 kg N/ha application on triticale; Szulc et al., (2022) with 150 and 150-soil content kg N/ha application on maize; Singh et al., (2019) with 70-100-130 kg N/ha application on canola, cereals and many more other doses and plants, showed similar results.

4.6. The grain moisture

The moisture content of wheat is a relevant issue for harvest, transport, storage and even the milling properties and the required energy for milling. Importantly, lowering the grain moisture led to about a twofold decrease in the required milling energy (Hassoon et. al., (2021) & Jung et. al., (2018)). Excess water in wheat reduces the commercial value as it causes a decrease in dry matter, and it makes storage difficult as it encourages germination as a result of bacterial and fungal activity. Factors such as growing needs, storage conditions, and harvest time affect the water rate in wheat. Specifically, the grain moisture content is higher in the product years that receive more precipitation during the maturity period of wheat (Bulut, 2012). Worldwide, most grain farming is carried out in climatic regions that are not suitable for storage because of temperature and humidity values. Grains stored under high temperature and relatively high humidity conditions also deteriorate. In addition to the losses in the quantity and quality of the grain due to these deteriorations, risks are posed to consumer health. In addition, the use of spoiled grains in animal nutrition indirectly poses risks to human health (Posner and Hibbs, 2005; Brooker et al., 1992). The upper limit for moisture content in wheat is 14.6% for storing the wheat (Ünal, 2002). Moisture content is also used for determining the most suitable harvest time (Ankara, 2015). What is the impact of moisture on end-product quality? High-moisture grain risks becoming infested with insects, mold and other unwanted organisms. In extreme cases, this can lead to toxins that end up in flour to the detriment of end-product quality. Conversely, too low a moisture level is also a problem: grain with less than nine per cent moisture requires additional processing to achieve the required conditioning level. High moisture content may be due to early harvesting, before the grain has dried below 12.5 per cent, or wet conditions around harvest time. Often, early harvesting is practiced avoiding wet weather. There are steps that can be taken to reduce the moisture content of harvested grain, including drying before storage, blending, or drying in storage using silos with aeration systems. It is important not to store grain with high moisture content and, especially, to avoid storage of high-moisture grain in silo bags (Qail 2018).

5. MATERIALS AND METHODS

5.1. Field features of experiments

In these three-year sets: 2015-2016, 2016-2017 and 2018-2019, growing seasons for a field trial of high milling and baking quality winter wheat (*Triticum aestivum* L.) varieties were set up under identical agronomic conditions using split-plot design (10 m^2/plot). The trials were established at the experimental fields of the Hungarian University of Agriculture and Life Sciences, Crop Production Institute, Hungary in two different sites. The 2015-2016 and 2016 - 2017 crop seasons at Nagygombos-Hungary was the experimental site of Hungarian University of Agriculture and Life Sciences, Crop Production Institute. This site in Nagygombos lies between latitude 47°40'53.00 "N and 47°41'90.00", longitude 19°40'30.00"E and 19°40'20.00"E, shown in Figure 11 and soil parameters of the experimental field on Table 3.

11. Figure The experimental field view by satellite at 2016-2017, Nagygombos, Hungary

Soil type of the trial site at Nagygombos was chernozem (calciustoll).

	Humus %	pH (H_2O)	K_A	Sand %	Silt %	Clay %	$CaCO_3$
Medium	2.65	7.30	45	49	25	26	1.86

3. Table Soil type of the experimental field at Hungarian University of Agriculture and Life Sciences, Crop Production Institute, Nagygombos, Hungary

- Organic matter content %: 2,65
- CaCO3 %: 1,86
- pH (KCl): 7,30
- KA: 45
- P2O5 (mg/kg): 643
- K2O (mg/kg): 293

The is the Gödöllő-Hungary experimental site of the Hungarian University of Agriculture and Life Sciences, Crop Production Institute, used for 2018–2019 and 2019–2020 crop seasons. The experimental site in Gödöllő lies between latitude 47°59'39.88''N and 47°59'60.54''N, longitude 19°37'13.26'' and 19°36'82.81'', shown in Figure 12.

12. Figure The experimental field view by satellite at 2019-2020, Gödöllő, Hungary

The soil type of the experimental field was sand-based brown forest soil (Chromic Luvisol). The textural classification of the soil was sandy loam with parameters shown in Table 4. The agronomic characteristic of the soil was neutral sandy soil with variable clay content. The soil structure was susceptible to compaction issues. The water retention characteristics were poor due to the high sand content. The soil was exposed to the impacts of drought.

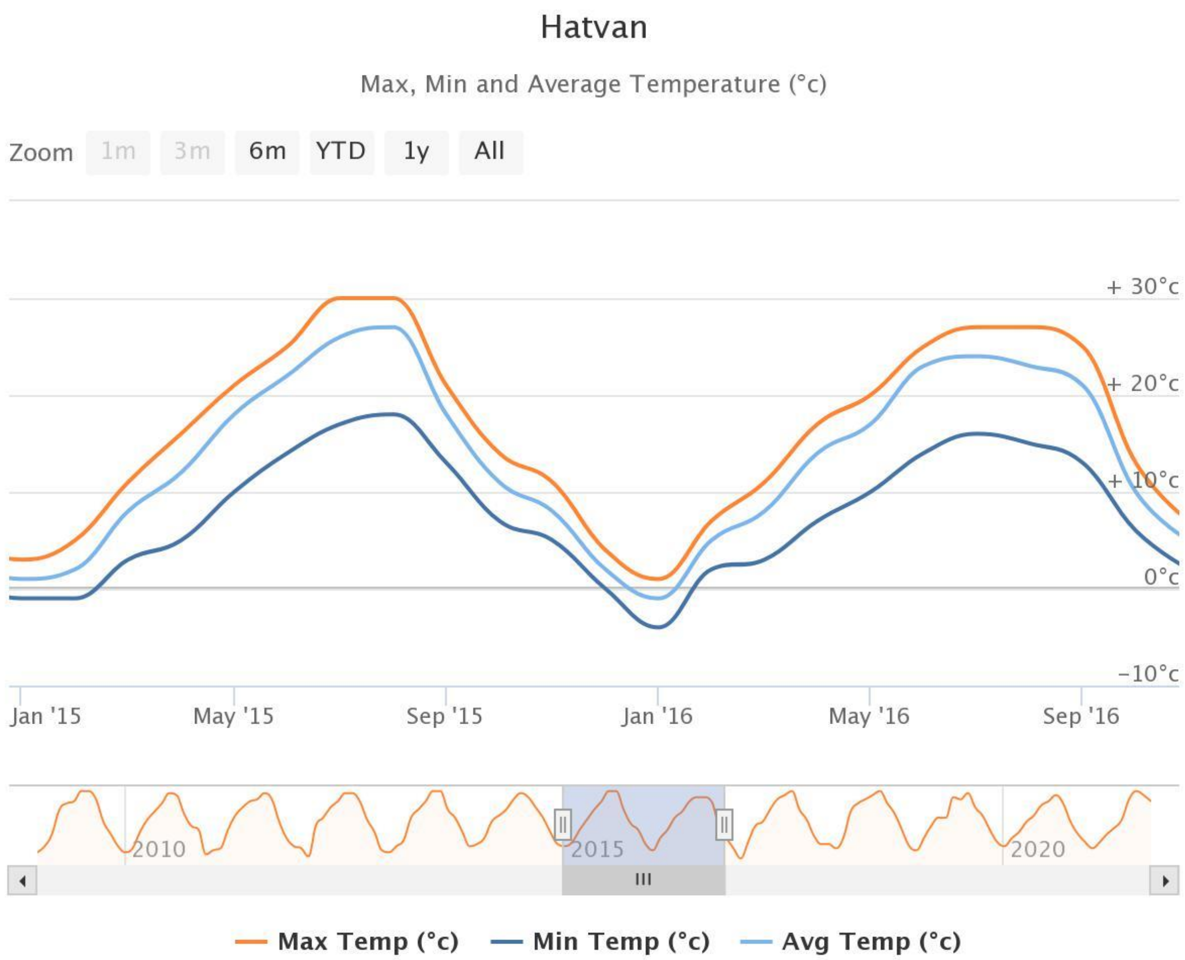
	Humus %	pH (H2O)	KA	Sand %	Silt %	Clay %	CaCO3
Medium	1.32	7.08	40	49	25	26	0

4. Table Soil type of the experimental field at Hungarian University of Agriculture and Life Sciences, Crop Production Institute, Gödöllő, Hungary

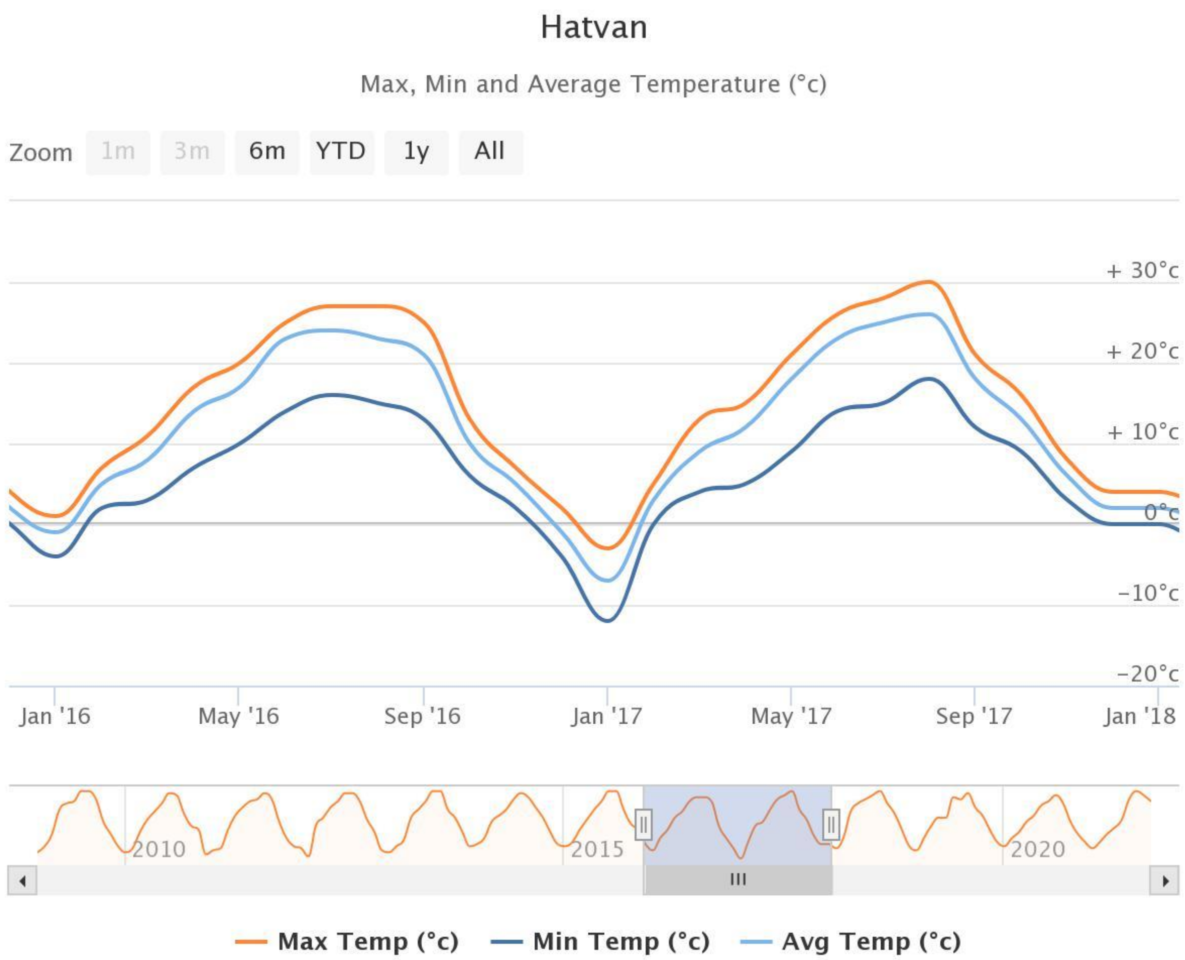
5.2. Meteorological properities of the experimental fields

5.2.1 Hatvan-Nagygombos meteorological properities

Figure 13 and Figure 14 provide information about the weather temperature, and Figure 15 and Figure 16 show rainfall amounts and rainy days of experimental site #1.

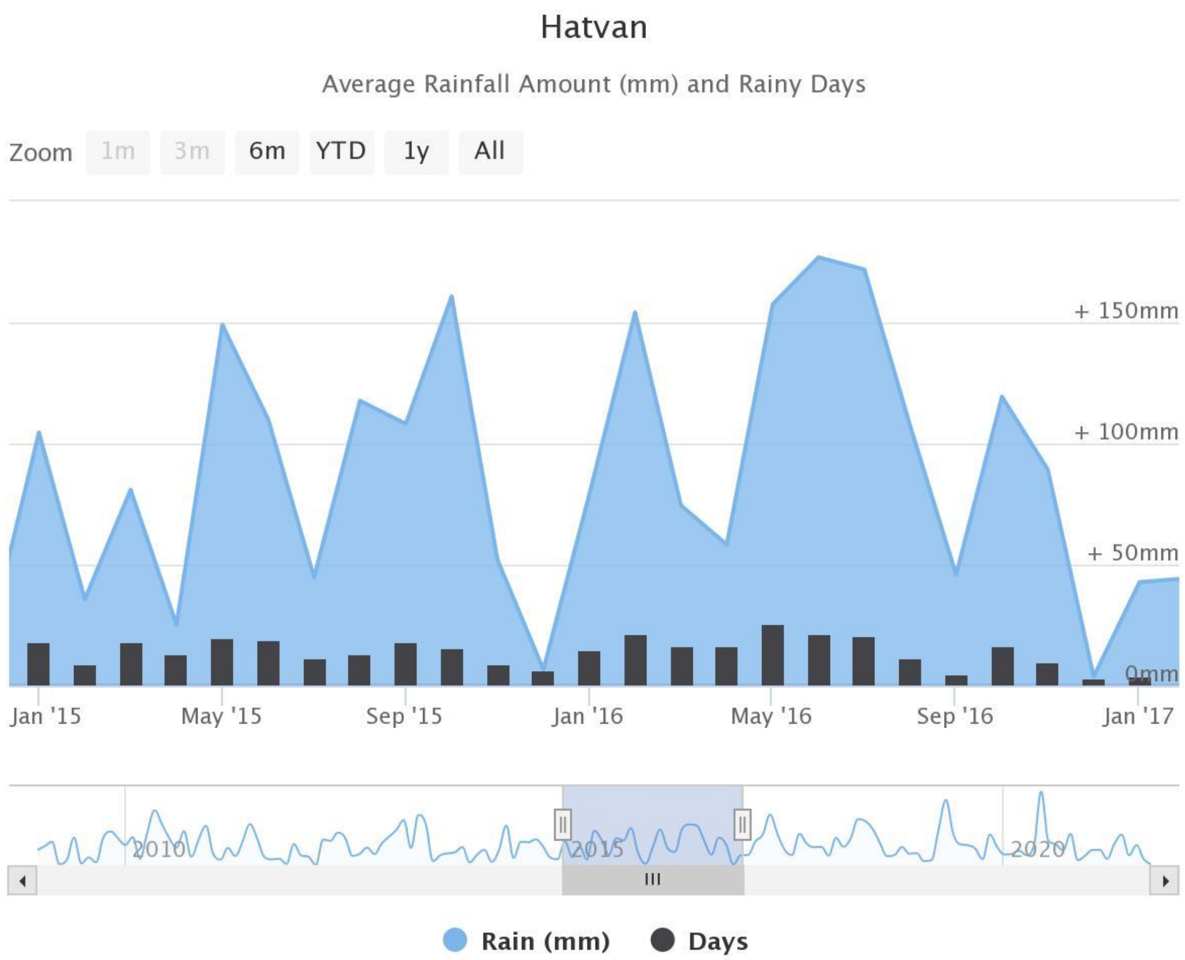


13. Figure Max, Min and Average Weather Temperature 2015-2016 (Nagygombos, Hungary). worldweatheronline.com

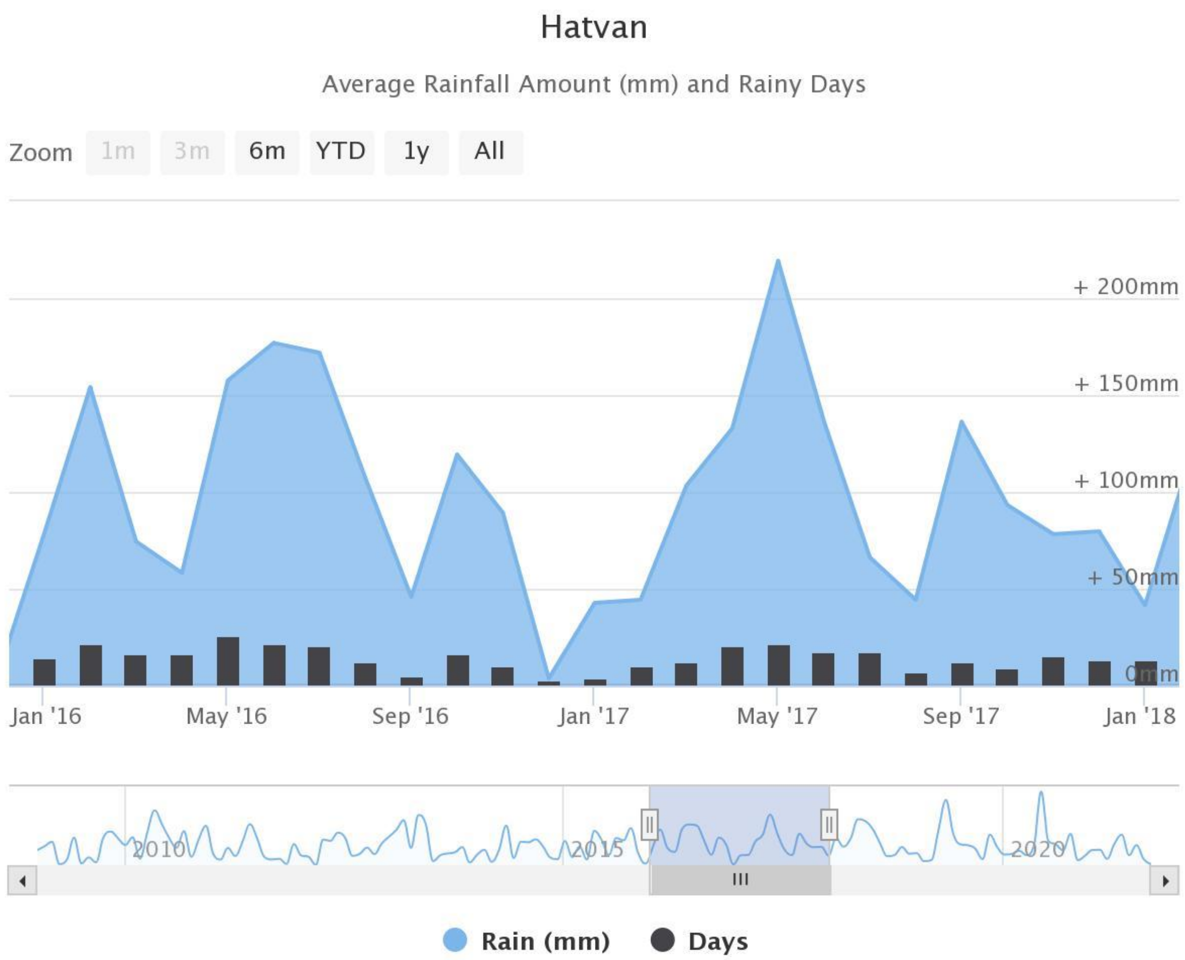


14. Figure Max, Min and Average Weather Temperature 2016-2017 (Nagygombos, Hungary). worldweatheronline.com

The experimental field #1's weather data showed differences between trial years: in 2016 summer the average temperature recorded approximately 3°C lower than the 2015 and 2017 weather average temperatures; however, in 2016 winter also was 6 °C colder than the 2015 and 2017 winter average.



15. Figure Rainfall and Rain Days 2015-2016 (Nagygombos, Hungary). worldweatheronline.com

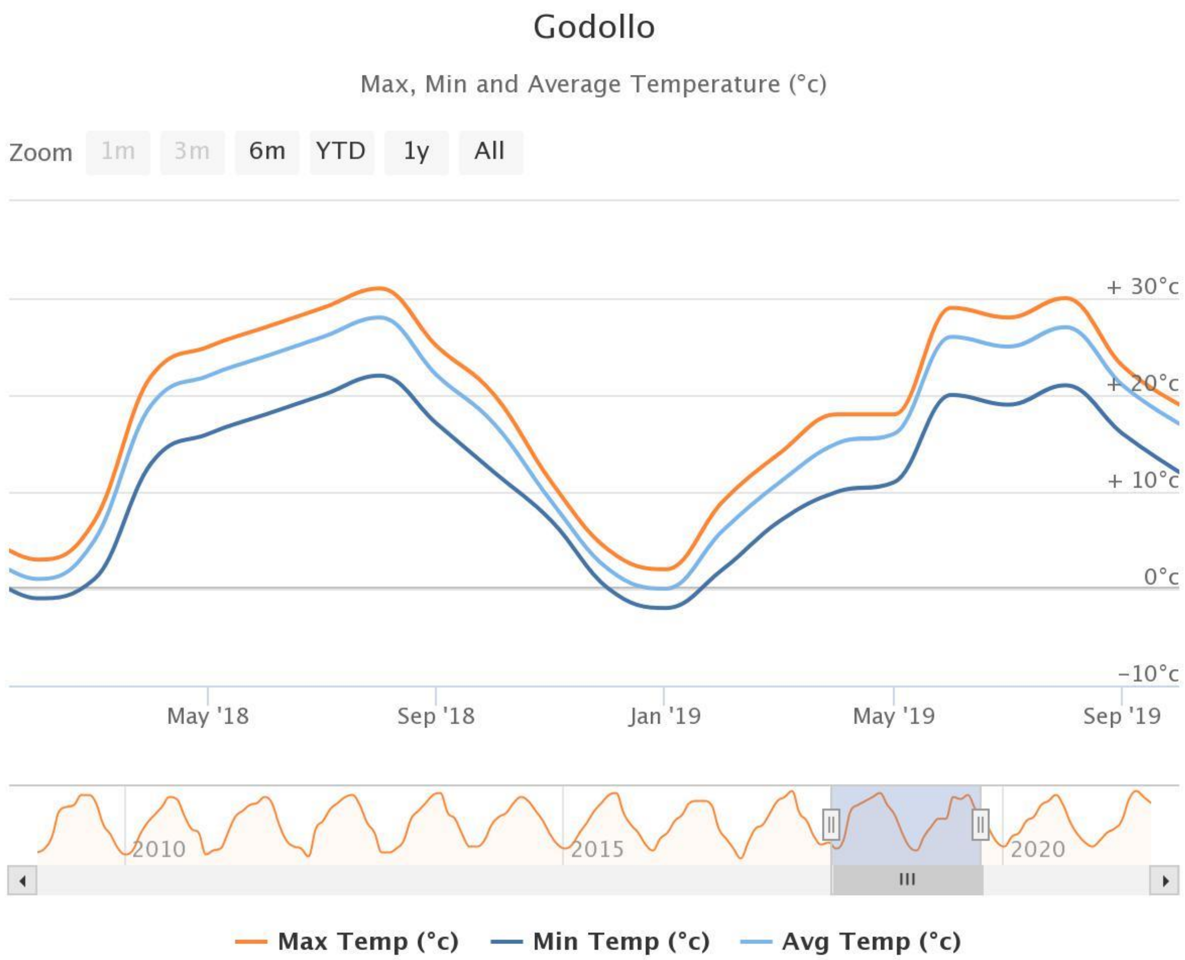


16. Figure Rainfall and Rain Days 2016-2017 (Nagygombos, Hungary). worldweatheronline.com

Recorded rainfall amounts show that experimental site #1 had 994,54 mm rainfall in 2015, 1.236,68 mm in 2016, and 1.176,47 mm. in 2015 -- which was drier than 2016 and 2017 crop years.

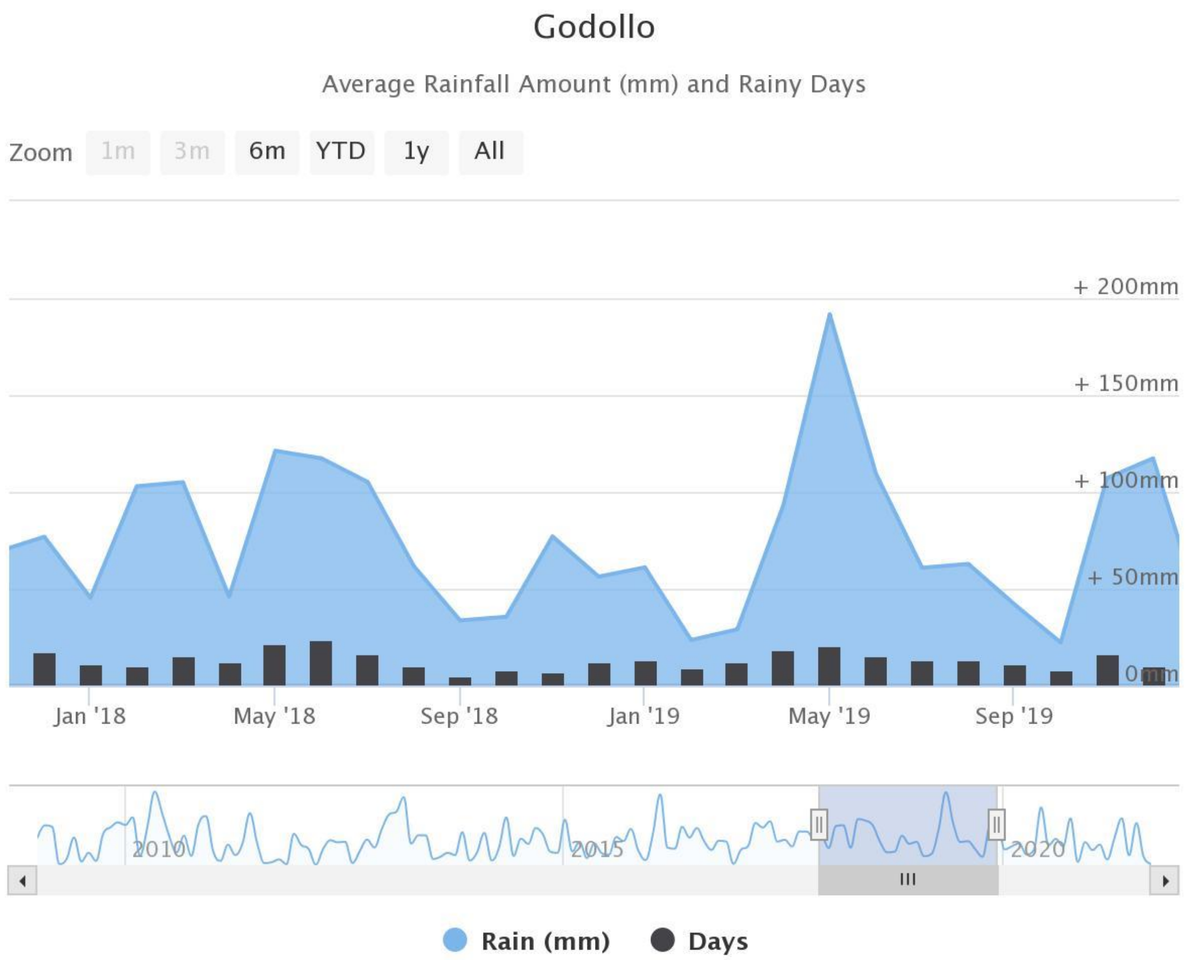
5.2.2. Gödöllő meteorological properties

Figure 17 provides information about the weather temperature, and Figure 18 shows the rainfall amount and rainy days of experimental site #2.



17. Figure Max, Min and Average Weather Temperature 2018-2019 (Gödöllő, Hungary). worldweatheronline.com

Summer and winter in site #2 was approximately 2°C warmer compared to site #1 on average.



18. Figure Rainfall and Rain Days 2018-2019 (Gödöllő, Hungary). worldweatheronline.com

Site #2 received 906,64 mm rainfall in 2018 and 920 mm in 2019

5.3. Studied winter wheat varieties

The present study examined the performance of five high baking quality winter wheat varieties:

2015-2016 and 2016-2017 crop seasons in Nagygombos - Hungary

-Alföld

-Mv Karéj

-Mv Nádor

-Mv Toldi

-Mv Toborzó

2018–2019 in Gödöllő - Hungary

-Alföld

-Mv Karéj

Variety	Alföld	Mv Karéj	Mv Nádor	Mv Toldi	Mv Toborzó
Ripening time	Early	Medium	Medium	Early	Early
Kernel type	Hard	Hard	Hard	Hard	Hard
Height (cm)	75-95	80-90	60-80	80-90	80-90
Yield (t/ha/)	5,5-7,0	7,0-8,0	7,5-9,5	6,0-7,5	6,0-7,5
TKW (gr)	39-44	45-50	45-50	40-45	48-54
Resistance (1-9)	8	7	9	8	7
Test weight (kg hl^{-1})	78-82	82-85	77-82	78-82	79-82
Protein %	14-17	11-13	12-14	13-15,5	13-15
Gluten %	34-40	29-32	28-32	30-36	32-36

5. Table Martonvásári Fajtakatalógus 2020

5.4. Treatments

The three-year experiment was set up in split-plot design with nine plot replications regarding each experimental factor such as variety and N application (time and dose) in each investigated year. The plots were sown and harvested with plot machines. Apart from N topdressing, all other agronomic treatments as well as sowing and harvesting were identically applied to all plots to study the impact of N treatments independently. N fertilizer topdressing was applied in single or split doses. N was applied in the form of ammonium nitrate (NH_4NO_3); the amounts indicate the N content in this paper, not the molecule. The applied fertilizer was granular ammonium nitrate with 34% content of the active ingredient. N was investigated in 6 different variants: 4 levels single and 2 levels split-dose treatments. Single application: 0, 80, 120, and

160 kg ha^{-1} N, split-dose application: 80+40 kg ha^{-1} and 120+40 kg ha^{-1} in two applications. Single applications were done at the tillering stage, while split-dose treatment was applied at the stage of tillering and heading. There was no N application in autumn in any of the crop years.

5.5. Investigations

Grain yields of the winter wheat varieties were sampled and measured from each harvested plot. The protein, test weight, thousand grain weight, and baking quality parameters were measured from harvested wheat grain. Analyses were done at the research laboratory of the Hungarian University of Agriculture and Life Sciences, Crop Production Institute.

Dickey-john® Instalab® 600 Analyser, Near-infrared (NIR) spectroscopic equipment Mininfra Scan-T Plus 2.02 version (Arana, 2016) were used to measure gluten, protein, and Zeleny sedimentation values of whole grains. Falling Number was also studied to determine amylase enzyme activity in the flour. The Hagberg Falling Number (HFN) Perten Type:1400 system, which meets the requirements of the AACC (American Association of Cereal Chemists) No.56-81.04, ICC (International Cereal Chemists) No. 107/1 (2010), and PN EN ISO 3093:2010 standards, was used to determine the Falling Number. The OS 1 type equipment by the ISO 7971-3:2019 standard was used to measure test weight. Thousand grain weight and test weight were measured with the KERN EMS and the Sartorius MA-30 precision scales. Farinograph (Valorigraph) instrument had been used to describe baking quality of the dough.

5.6. Statistical analyses

For the statistical evaluation of the results, we used the Explore and ANOVA modules of the IBM SPSS V.23 software. For data analysis, part Independent Sample T Test, ANOVA, and Pearson Correlation Analysis were used to test the hypotheses of the study. The effect of the different treatments on seed germination was analyzed using one-way ANOVA at a 0,05 level of significance. Values are given as the mean ± standard deviation of four measurements. LSD (least significant difference) tests were used to determine the significant difference among the data. The statistical significance level was p<0,05. That enabled us to determine the differences between the studied doses -- whether or not the obtained results had significant variations.

6. RESULTS

6.1. Test Weight Results

Table 6-7 and 8 as well as Figure 24-27 (Appendix 1) provide information on nitrogen application effects on test weight of the tested winter wheat varieties with the impact of undivided/split dose of N supply on two experimental sites during three years. The results obtained from experiment site #1 during first two years of the experiment shown on Table 6, test weight (kg hl^{-1}) values slightly decreased in some of the tested varieties by the increasing level of undivided N application, but the changes found were not significant. In addition, a positive effect of split-dose treatment had been detected, except in case of Mv Nádor 80+40 kg ha^{-1} to 120 kg ha^{-1} N application. The highest result had been recorded for the Alföld 80 kg ha^{-1} single dose application with 81.5 kg hl^{-1} at 2016-2017th experimental year and the lowest for MV Toborzó 80 kg ha^{-1} single dose application with 70.95 kg hl^{-1} at 2016-2017th experimental year. However, split dose N application did not present significant changes among the tested winter wheat varieties, similar results were reported by Pollhamer (1981) and Horváth and co-workers (2014).

Test weight (kg hl^{-1})					
N topdressing	Alföld	MV Nádor	MV Karéj	MV Toborzó	MV Toldi
0+	79.15	75.79	75.57	76.47	77.97
80+	79.17	74.95	75.68	76.19	77.29
80+40	78.86	75.13	77.03	76.49	77.50
120+	78.54	75.13	75.39	76.37	76.81
120+40	79.20	75.36	75.84	76.59	76.83
160+	78.26	74.90	75.57	76.26	76.79

6. Table Impact of N topdressing applications on wheat grain test weight. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

The results obtained from experiment site #2 in the experiment shown on Table 7, were that the test weight (kg hl^{-1}) values slightly decreased in some of the tested varieties via the increasing level of undivided N application, but the changes found were not significant. In addition, a positive effect of split dose treatment was detected. The highest result recorded was for the

Alföld 120 kg ha^{-1} single dose application and MV Karéj 80 kg ha^{-1} single dose application with 74.55 kg hl^{-1} at 2018-2019th experimental year, and the lowest was for MV Karéj 40 kg ha^{-1} single dose application as 67.80 kg hl^{-1} at 2018-2019th experimental year.

Test weight (kg hl^{-1})		
N topdressing	**Alföld**	**MV Karéj**
0+	70,73	69,32
80+	72,88	71,10
80+40	73,12	71,55
120+	73,35	71,62
120+40	72,45	69,75
160+	70,80	69,23

7. Table Impact of N topdressing applications on wheat grain test weight. 2018–2019 (Gödöllő, Hungary)

Regarding the study employed during three crop years in two different experimental fields showed that maximum test weight was recorded in both sites was in the Alföld variety with single dose application of the Nitrogen fertilizer. Minimum test weights varied on different sites with different varieties, and the minimum test weights were recorded on single dose applications of Nitrogen fertilizer. Alföld and MV Karéj had higher numbers at Site 1 than Site 2: Alföld 9.19% and MV Karéj 7.70% were the higher values on site 1. Test weight showed significant differences between site, genotype and year; however, level and type of the treatment did not show significant effect from the one-way ANOVA statistical analysis shown on Table 36-54.

The significant level of the difference based on year, site, genotypes and treatment in means of test weight measured in the sample of all genotypes was examined through ANOVA and outcomes were reflected in Table 8.

Test Weight (hl)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	90	76.80	1.75	84.353	2-213	.000	1, 2 > 3
	2017	90	76.52	2.57				
	2019	36	71.33	2.52				
Site	Hatvan	180	76.66	2.20	12.971	214	.000	1 > 2

	Gödöllő	36	71.33	2.52				
	Alföld	54	76.63	3.39				
	Karéj	54	73.91	3.42				
Genotypes	Nador	36	75.21	1.00	10.596	4-211	.000	1 > 2 > 3
	Toborzo	36	76.39	2.09				
	Toldi	36	77.19	2.36				
	0 kg/ha	36	75.83	3.32				
	80 kg/ha	36	75.88	3.00				
	80+40 kg/ha	36	76.03	2.82				
Treatment	120 kg/ha	36	75.79	2.69	.242	5-210	.943	
	120+40 kg/ha	36	75.79	3.07				
	160 kg/ha	36	75.30	3.23				

8. Table Comparison of the Means of Test Weight Parameters Measured in the Sample of All Genotypes Based on Categorical Variables, 2016, 2017 Hatvan and 2019 Gödöllő crop years.

As seen in Table 8, according to the outcomes it is found out that there is no significant difference in statistical level in test weight based on treatment (F(5-210) = .242, p > .05), however, there is a significant difference in statistical level in test weight based on year (F(2-213) = 84.353, p < .001), site (t(214) = 12.971, p < .001) and genotypes (F(4-211) = 10.596, p < .001) in the sample of all genotypes. Accordingly, the mean values of test weight in 2016 and 2017 tend to be higher than in 2019; Hatvan tends to be higher than in Gödöllő. In addition; Alföld and Karej tend to be higher than in Nador; Alföld tends to be higher than in Karej.

6.2. Thousand Kernel Weight Values

Table 9-10-11 as well as Figure 28-31 (Appendix 1) provide information on nitrogen application effects on thousand kernel weight varieties of the tested winter wheat, with the additional impact of an undivided/split-dose of N supply. The results obtained from experiment at site #1 during first two years of the experiment shown on Table 9, the thousand kernel weight value decreased slightly in most of the cases for the increasing undivided/split level of N applications: however, increasing number of N treatments had better effect in the comparison of 80+40 kg ha^{-1} to 120 kg ha^{-1} and 120+40 kg ha^{-1} to 160 kg ha^{-1}, except for Mv Toborzó comparison of 120+40 kg ha^{-1} to 160 kg ha^{-1}. Mv Nádor and Mv Toldi showed significant differences via a one-way ANOVA test of thousand kernel weight. Similar results were reported by Szentpétery and co-workers (2005) and Horváth and co-workers (2014). The highest thousand grain weight was recorded on the untreated (0 kg kg ha^{-1} N) MV Toborzó plot with 51,90 g/thousand kernel weight, and the lowest was detected on an Alföld plot treated with undivided 160 kg ha^{-1} N application resulting 31.40 g/thousand kernel weight.

Thousand kernel weight (g/1000 kernel)					
N topdressing	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	39.73	44.78	46.70	45.05	45.81
80	38.73	43.16	45.58	42.64	44.20
80+40	38.63	42.79	45.82	42.42	45.07
120	38.56	42.10	45.40	41.44	43.77
120+40	38.83	42.21	45.36	42.40	44.40
160	38.02	41.09	43.78	42.60	42.88

9. Table Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

The results obtained from experiment on site #2 during the 2018-2019 experiment shown on Table 10, the thousand kernel weight value increased up to 120 kg/ha^{-1} N undivided, and split application accordingly with a rising level of Nitrogen amount. However, after 80+40 kg/ha^{-1} and 120 kg/ha^{-1} N applications, increasing level of the N supply had a slightly negative effect on the thousand kernel weight at the 120+40 kg/ha^{-1} and 160 kg/ha^{-1} N applications compared to the 80+40 kg/ha^{-1} and 120 kg/ha^{-1}. The highest thousand grain weight was recorded on the 80 kg kg ha^{-1} N MV Karéj plot with 45.08 g/thousand kernel weight, and the lowest was detected on an Alföld plot treated with undivided 80 kg ha^{-1} N application, resulting in 38.00 g/thousand kernel weight.

Thousand kernel weight (g/1000 kernel)		
N topdressing	**Alföld**	**MV Karéj**
0	38,75	40,99

80	39,43	42,22
80+40	40,07	42,45
120	40,53	44,24
120+40	40,37	42,21
160	40,07	41,46

10. Table Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2018-2019 (Gödöllő, Hungary) 1

Comparing the two sites, Alföld had 2.89% higher numbers at site #2 than site #1, and the MV Karéj had 7.52% higher numbers at site #1 than site #2, however, in general comparison the sites did not have significant differences between each other. Thousand kernel weight showed a significant effect on year and genotype, but no correlation was found with a different dose and type of N applications, as tracked on Table 36-54.

The significance level of the difference, based on year, site, genotypes, and treatment in terms of thousand kernel weight measured in the sample of all genotypes, was examined through ANOVA and outcomes were reflected in Table 11.

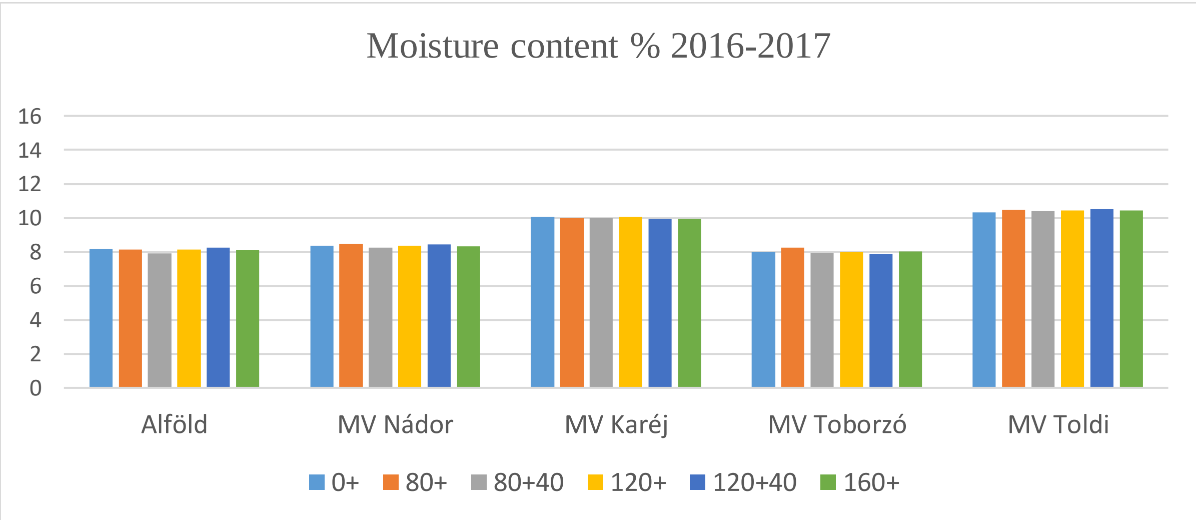
Thousand Kernel Weight (g)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	90	44.53	2.26	30.280	2-213	.000	1 > 2, 3
	2017	90	41.14	4.15				
	2019	36	41.07	2.07				
Site	Hatvan	180	42.84	3.74	2.752	214	.006	1 > 2
	Gödöllő	36	41.07	2.07				
Genotypes	Alföld	54	39.12	2.60	28.322	4-211	.000	2 > 3 > 1
	Karéj	54	44.51	2.45				
	Nádor	36	42.69	2.15				
	Toborzó	36	42.76	4.73				
	Toldi	36	44.35	2.19				
Treatment	0 kg/ha	36	43.66	3.50	1.154	5-210	.333	
	80 kg/ha	36	42.52	3.43				
	80+40 kg/ha	36	42.67	3.64				
	120 kg/ha	36	42.28	3.58				
	120+40 kg/ha	36	42.41	3.59				
	160 kg/ha	36	41.71	3.67				

11. Table Comparison of the Means of Thousand Kernel Weight Parameters Measured in the Sample of All Genotypes Based on Categorical Variables, 2016,2017 Hatvan and 2019 Gödöllő crop years.

As seen in Table 11, the outcomes reveal that there is no significant difference in statistical level in thousand kernel weight based on treatment ($F(5-210) = 1.154$, $p > .05$), however, there is a significant difference in statistical level in thousand kernel weight based on year ($F(2-213) = 30.280$, $p < .001$) and site ($t(214) = 2.752$, $p < .01$), genotypes ($F(4-211) = 28.322$, $p < .001$) in the sample of all genotypes. Accordingly, the mean values of thousand kernel weight in 2016 tend to be higher than in 2017 and 2019; Hatvan tends to be higher than Gödöllő; Karéj tends to be higher than Nádor, which tends to be lower than Alföld.

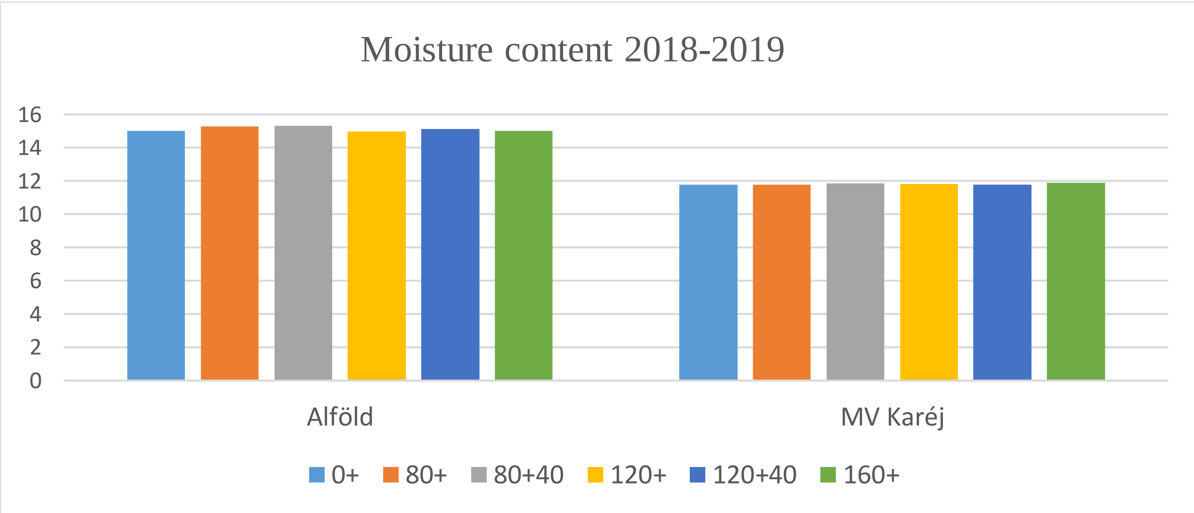
6.3. The grain moisture

Figures 19-20 and Table 12 as well as Table 31-32-32 and Figure 32 (Appendix 1) give information on N application effects on grain moisture content in the studied winter wheat varieties. Figure 19 Shows the experimental site #1's results for 2015-2016 and 2016-2017 crop seasons: the moisture content values slightly increased in some of the tested varieties by increasing the level of divided N application, but the changes found were not significant. However, the highest value was recorded on the untreated plot of MV Toldi with 17.70%, and the lowest result on the MV Nádor 80+40 kg/ha^{-1} N applied plot with 5.30% humidity.



19. Figure Impact of N topdressing applications on moisture content of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

Figure 20 shows the experimental site #2's results for the 2018-2019 crop season. Grain moisture content values changes found were not significant, however, and the highest value was recorded on 120+40 kg/ ha^{-1} N applied plot of MV Karéj with 12.70% and the lowest result on Alföld 80 kg/ ha^{-1} N applied plot with 9.00% humidity content.



20. Figure Impact of N topdressing applications on moisture content of wheat varieties. 2018-2019 (Gödöllő, Hungary)

Comparing the two sites, site #2 had higher grain moisture content for both varieties, Alföld had 86.33% and MV Karéj 18.30% more moisture content at site #2 than site #1; however, results showed significant differences between year, site, and genotype via the one-way ANOVA test of moisture content. But that moisture content ($F_{(5.102)}$ = .253, $p > .05$) did not have significant effect due to different dose and application type of N applications, as is shown on Table 36-54.

The significance level of the difference based on year, site, genotypes and treatment in terms of moisture content measured in the sample of all genotypes was examined through ANOVA and outcomes were reflected in Table 12.

Moisture Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	90	8.19	1.66	59.097	2-213	.000	3 > 2 > 1
	2017	90	9.77	0.61				
	2019	36	10.57	1.32				
Site	Hatvan	180	8.98	1.48	-6.009	214	.000	2 > 1
	Gödöllő	36	10.57	1.32				
Genotypes	Alföld	54	8.56	1.50	46.976	4-211	.000	2 > 1

	Karéj	54	10.55	1.02				
	Nádor	36	8.37	1.52				
	Toborzó	36	8.01	0.79				
	Toldi	36	10.42	0.23				
Treatment	0 kg/ha	36	9.18	1.52	.063	5-210	.997	
	80 kg/ha	36	9.26	1.46				
	80+40 kg/ha	36	9.16	1.62				
	120 kg/ha	36	9.24	1.58				
	120+40 kg/ha	36	9.33	1.64				
	160 kg/ha	36	9.30	1.67				

12. Table Comparison of the Means of Moisture Content Parameters Measured in the Sample of All Genotypes Based on Categorical Variables, 2016 and 2017 Hatvan and 2019 Gödöllő crop years.

As seen in Table 12, the outcomes reveal that there is no significant difference in statistical level in moisture content based on treatment (F(5-210) = .063, p > .05); however, there is a significant difference in statistical level in moisture content based on year (F(2-213) = 59.097, p < .001), site (t(214) = -6.009, p < .001) and genotypes (F(4-211) = 46.976, p < .001) in the sample of all genotypes. Accordingly, the mean values of moisture content in 2018-2019 tend to be higher than in 2016-2017, which tends to be higher than in 2015-2016; Gödöllő tends to be higher than Hatvan, and Karéj tends to be higher than Alföld.

6.4. The grain protein

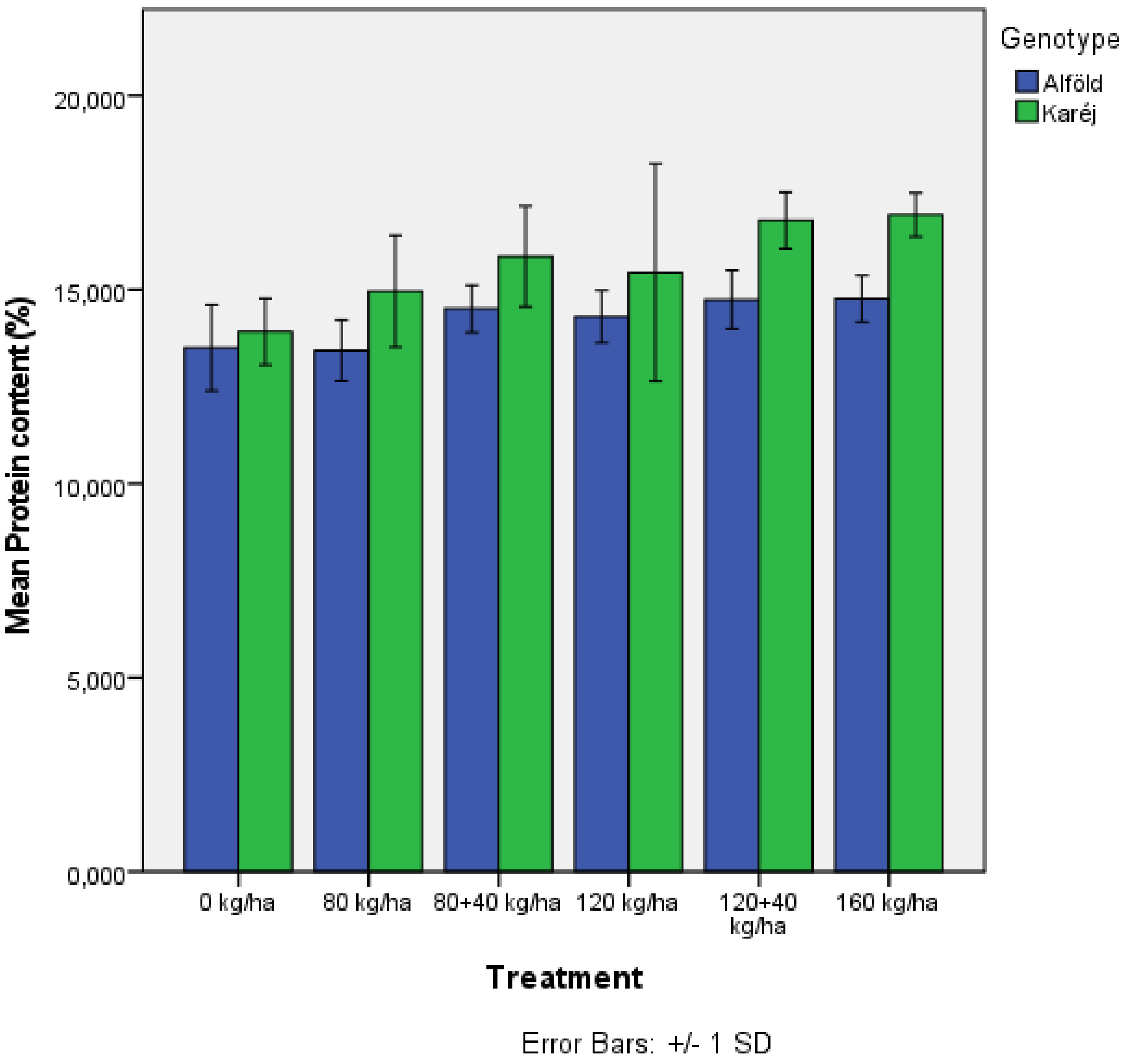
Table 13-20 and Figure 21-22 as well as Table 34-35 and Figure 33-34-35 (Appendix 1) show the grain protein values in site #1 in 2015-2016, 2016-2017 and site #2 in 2018-2019 crop years. Protein amounts changed from 6.86% to 17.33 %.

Protein content % 2015-2016 and 2016–2017					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	13,36	11,56	11,15	11,94	12,17
80	14,24	12,48	12,55	12,91	13,40
80+40	15,19	12,96	13,35	13,49	13,56
120	15,50	13,28	13,40	13,68	13,71
120+40	15,43	13,61	14,10	14,27	14,18
160	15,89	13,96	14,35	14,45	14,36

13. Table Impact of N topdressing applications on protein content of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

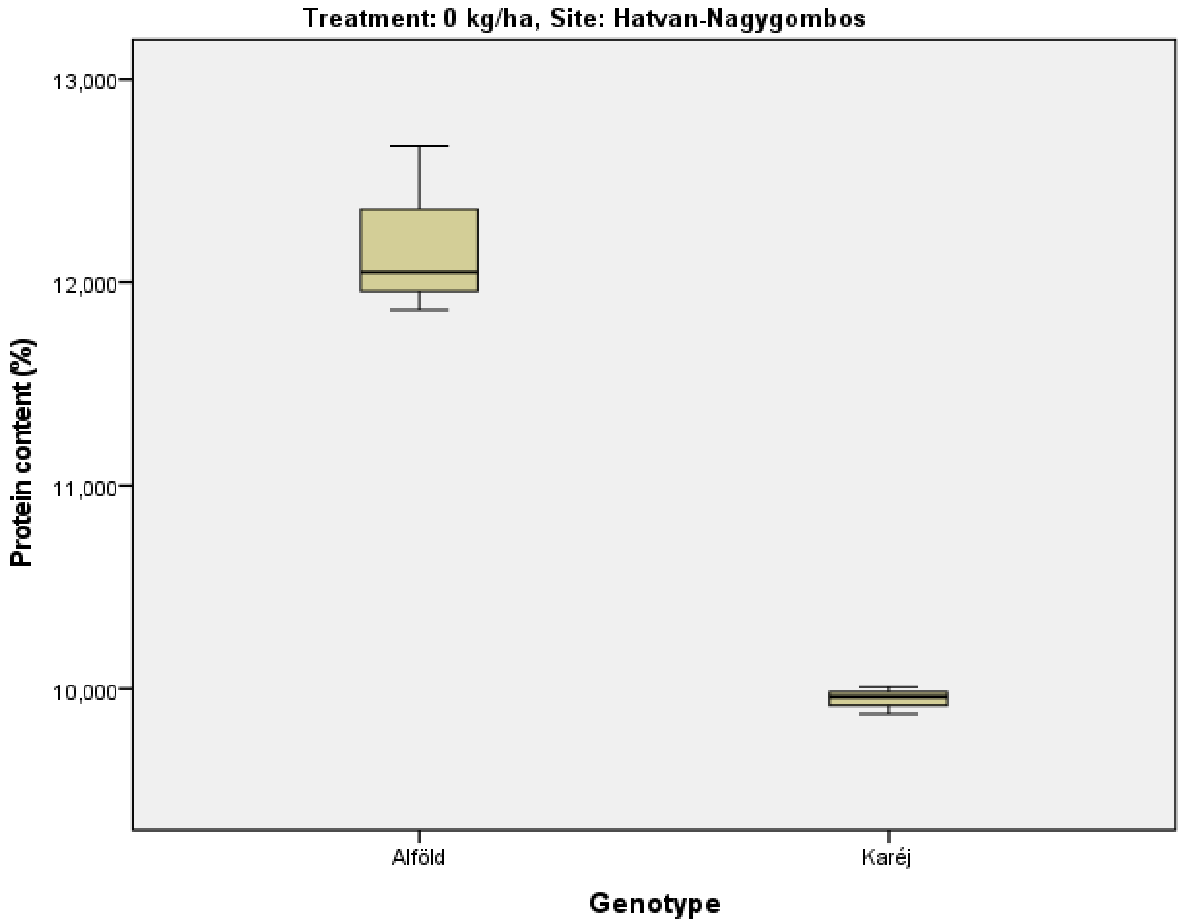
Protein content % 2018–2019		
N	**Alföld**	**MV Karéj**
0	13,60	13,80
80	13,00	15,20
80+40	13,40	15,90
120	13,30	15,50
120+40	14,10	17,20
160	13,80	16,90

14. Table Impact of N topdressing applications on protein content of wheat varieties. 2018–2019 (Gödöllő, Hungary)



21. Figure Impact of N topdressing applications on protein content of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary) and 2018-2019 (Gödöllő, Hungary) combined

Based on the results of the experiment, we can conclude that increasing levels of N topdressing had a significant effect on grain protein content in all studied winter wheat varieties, either in split or undivided dose applications. The results obtained are in harmony with Dubetz et al., (1979), Pollhamer (1981), Vida et al., (1996), Varga and Svecnjak (2006), Öztürk and Gökkuş (2008), and Pepó (2010) studies. There were varietal differences, too, as untreated plots had remarkable differences between varieties such as 2016-2017 crop seasons of untreated Alföld and MV Karéj's plots showing 32.63% differences shown on Figure 22 boxplot. A special increase in dose applications had a remarkable effect in the experimental year 2017. The highest 17.33% grain protein content was observed on the Alföld plot with split 120+40 kg ha^{-1} N application at site one 2015-2016 crop season and the lowest, 6.86 %, was obtained on Karéj untreated plot at site #1's 2016-2017 crop season. Split dose application did not have a significant effect compared to the same total amount of undivided application; however, sites had significant effect under identical agronomical treatments. Alföld had up to 10.30% differences between the two sites regarding grain protein content, and MV Karéj plots had 19.80% greater results in the general average of grain protein content of the tested MV Karéj plots. The MV Karéj have shown greater results on site #2 compared to site #1, except for the 80 and 120 kg ha^{-1} N single dose application according to One Way ANOVA statistics shown on Table 4.



22. Figure Impact of N topdressing applications on protein content of wheat varieties untreated plots. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

As seen in Table 36-54 the outcomes reveal that there is a significant difference in the statistical levels of grain protein content between trial years ($F_{(2.105)} = 8.829$, $p < .001$), site ($t_{(106)} = -2.885$, $p < .01$), genotype (t(87.225) = 2.094, $p < .05$) and the treatment ($F_{(5.102)} = 10.238$, $p < .001$).

The significance level of the difference based on year, site, genotypes, and treatment by means of protein content measured in the sample of all genotypes was examined through ANOVA and outcomes were reflected in Table 15.

Protein Content (%)		N	M	SD	F/t	df	p	Difference
Year	2016	90	14.12	1.12	25.938	2-213	.000	3 > 1 > 2
	2017	90	13.08	1.60				
	2019	36	14.93	1.48				
Site	Hatvan	180	13.60	1.47	-4.946	214	.000	2 > 1
	Gödöllő	36	14.93	1.48				
Genotypes	Alföld	54	14.63	1.17	8.426	4-211	.000	1 > 2 > 3
	Karéj	54	13.99	1.94				
	Nador	36	12.95	1.01				
	Toborzo	36	13.46	1.62				
	Toldi	36	13.60	1.13				
Treatment	0 kg/ha	36	12.24	1.57	18.050	5-210	.000	2, 3, 4, 5, 6 > 1; 4, 5, 6 > 2; 5, 6 > 3; 6 > 4
	80 kg/ha	36	13.33	1.22				
	80+40 kg/ha	36	13.93	1.43				
	120 kg/ha	36	14.07	1.28				
	120+40 kg/ha	36	14.56	1.23				
	160 kg/ha	36	14.80	1.08				

15. Table Comparison of the Means of Protein Content Parameters Measured in the Sample of All Genotypes Based on Categorical Variables, 2016,2017 Hatvan and 2019 Gödöllő crop years.

As seen in Table 15, outcomes revealed that there is a significant difference in statistical level in protein content based on year ($F(2\text{-}213) = 25.938$, $p < .001$), site ($t(214) = -4.946$, $p < .001$), genotypes ($F(4\text{-}211) = 8.426$, $p < .001$) and treatment ($F(5\text{-}210) = 18.050$, $p < .001$) in the sample of all genotypes. Accordingly, the mean values of protein content in 2018-2019 tend to be higher than in 2015-2016 tend to be higher than in 2016-2017; Gödöllő tends to be higher than in Hatvan; Alföld tends to be higher than in Karéj, which tends to be higher than in Nádor. 2, 3, 4, 5 and 6 tend to be higher than in 1; 4, 5 and 6 tend to be higher than in 2; 5 and 6 tend to be higher than in 3; and 6 tends to be higher than in 4.

The significance level of the difference, based on genotypes and treatment by means of protein content measured in the sample of all genotypes in 2015-2016, was examined through ANOVA and outcomes were reflected in Table 16.

Protein Content (%)	N	M	SD	F/t	df	p	Difference

Genotypes	Alföld	18	15.14	1.02	13.004	4-85	.000	1 > 2, 3, 5; 3, 4 > 2; 4 > 3, 5
	Karéj	18	13.93	1.06				
	Nádor	18	13.24	0.96				
	Toborzó	18	14.64	0.76				
	Toldi	18	13.64	0.62				
Treatment	0 kg/ha	15	12.92	0.83	11.433	5-84	.000	3, 4, 5, 6 > 1, 2; 5 > 4
	80 kg/ha	15	13.48	0.90				
	80+40 kg/ha	15	14.44	1.06				
	120 kg/ha	15	14.20	0.75				
	120+40 kg/ha	15	14.91	0.94				
	160 kg/ha	15	14.76	0.80				

16. Table Comparison of the Means of Protein Content Parameters Measured in the Sample of All Genotypes in 2016, Based on Categorical Variables, Hatvan site.

As seen in Table 16, according to the outcomes it is found out that there is a significant difference in statistical level in protein content based on genotypes ($F(4-85) = 13.004$, $p < .001$) and treatment ($F(5-84) = 11.433$, $p < .001$) in the sample of all genotypes in 2015-2016. Accordingly, the mean values of protein content in Alföld tend to be higher than in Karéj, Nádor and Toldi, Nádor and Toborzó tend to be higher than in Karéj, Toborzó tends to be higher than in Nádor and Toldi; 3, 4, 5 and 6 tend to be higher than in 1 and 2; and 5 tends to be higher than in 4.

The significance level of the difference, based on genotypes and treatment in terms of protein content measured in the sample of Alföld and Karéj genotypes in Gödöllő in 2018-2019, was examined through Independent Samples t-Test and outcomes were reflected in Table 17.

Protein Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Genotypes	Alföld	18	14.21	0.86	-3.285	34	.002	2 > 1
	Karéj	18	15.65	1.64				
Treatment	0 kg/ha	6	13.71	0.92	2.370	5-30	.063	
	80 kg/ha	6	14.20	1.34				
	80+40 kg/ha	6	15.18	1.17				
	120 kg/ha	6	14.88	1.93				
	120+40 kg/ha	6	15.77	1.30				
	160 kg/ha	6	15.85	1.29				

17. Table Comparison of the Means of Protein Content Parameters Measured in the Sample of Alföld and Karéj Genotypes in Gödöllő in 2019, Based on Categorical Variables, Gödöllő site.

As seen in Table 17, the outcomes revealed that there is no significant difference in statistical level in protein content based on treatment ($F(5-30) = 2.370$, $p > .05$), however, there is a significant difference in statistical level in protein content based on genotypes (t(34) = -3.285, p < .01) in the sample of Alföld and Karéj genotypes in Gödöllő in 2018-2019. Accordingly, the mean values of protein content in Karéj tend to be higher than in Alföld.

The significance level of the difference, based on year, site and treatment in terms of protein content measured in the sample of Karéj genotype, was examined through ANOVA and outcomes were reflected in Table 18.

Protein Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	18	13.93	1.06	23.524	2-51	.000	3 > 1 > 2
	2017	18	12.39	1.51				
	2019	18	15.65	1.64				
Site	Hatvan	36	13.16	1.50	-5.561	52	.000	2 > 1
	Gödöllő	18	15.65	1.64				
Treatment	0 kg/ha	9	12.09	1.91	4.060	5-48	.004	3, 4, 5, 6 > 1; 5, 6 > 2
	80 kg/ha	9	13.35	1.66				
	80+40 kg/ha	9	14.17	1.80				
	120 kg/ha	9	14.10	1.84				
	120+40 kg/ha	9	15.01	1.58				
	160 kg/ha	9	15.21	1.43				

18. Table Comparison of the Means of Protein Content Parameters Measured in the Sample of Karej Genotype Based on Categorical Variables

As seen in Table 18, outcomes revealed that there is a significant difference in statistical level in protein content based on year (F(2-51) = 23.524, p < .001), site (t(52) = -5.561, p < .001) and treatment (F(5-48) = 4.060, p < .01) in the sample of Karéj genotype. Accordingly, the mean values of protein content in 2018-2019 is higher than 2015-2016, and 2015-2016 is higher than 2016-2017; Gödöllő tends to be higher than in Hatvan; 3, 4, 5 and 6 tend to be higher than in 1; and 5 and 6 tend to be higher than in 2.

6.5. The gluten content

Gluten content %					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	27,41	24,98	21,20	25,11	24,31
80	31,84	27,89	25,75	28,01	28,18
80+40	34,48	29,71	28,40	30,34	28,81

120	35,16	30,33	28,65	31,27	28,06
120+40	35,28	30,58	30,35	31,99	30,44
160	36,37	32,36	31,65	33,31	31,45

19. Table Impact of N topdressing applications on gluten content of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary)

Gluten content %		
N	**Alföld**	**MV Karéj**
0	25,50	28,60
80	23,80	32,70
80+40	23,50	34,90
120	24,30	34,20
120+40	26,50	39,40
160	25,80	38,10

20. Table Impact of N topdressing applications on gluten content of wheat varieties. 2018–2019 (Gödöllő, Hungary) 1

Grain gluten amounts changed from 10.00 % to 41.10 %. The highest value was observed on the MV Karéj plot with split 120+40 kg ha^{-1} N application as 41.10% and the lowest, 10.00 %, had been obtained on MV Karéj untreated plot. Grain gluten content was significantly affected by increasing doses of N applications as well with increased split dose applications. Similar examples have been reported by several authors (Győri, 2006; Kismányoky and Tóth, 2010; Rakszegi et al., 2016). Table 19-20-21-22-23-24 as well as Figure 36-40 (Appendix 1) show strong effect of N application on grain gluten content regardless of crop year, variety, or split/undivided application. Alföld had up to 34.22% differences between two sites in terms of grain gluten content, and MV Karéj plots had 25.23% higher results in the general average of protein content of the tested MV Karéj plots between two experimental sites. In addition, split dose application did not have significant effect on grain gluten content compared to the same amount of undivided application.

The significance level of the difference based on year, site, genotypes and treatment, in terms of gluten content measured in the sample of all genotypes, was examined through ANOVA and outcomes were reflected in Table 21.

Gluten Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	90	30.73	3.66	24.209	2-213	.000	3 > 1 > 2
	2017	90	28.85	4.65				

	2019	36	34.52	3.90				
Site	Hatvan	180	29.79	4.28	-6.141	214	.000	2 > 1
	Gödöllő	36	34.52	3.90				
Genotypes	Alföld	54	34.12	3.42	14.093	4-211	.000	1 > 2, 3
	Karéj	54	29.62	5.23				
	Nádor	36	29.30	3.01				
	Toborzó	36	30.01	4.43				
	Toldi	36	28.55	3.62				
Treatment	0 kg/ha	36	25.70	5.06	21.138	5-210	.000	2, 3, 4, 5, 6 > 1; 3, 4, 5, 6 > 2; 5, 6 > 3; 6 > 4
	80 kg/ha	36	29.00	3.38				
	80+40 kg/ha	36	31.01	3.62				
	120 kg/ha	36	31.26	3.40				
	120+40 kg/ha	36	32.78	3.84				
	160 kg/ha	36	33.72	2.93				

21. Table Comparison of the Means of Gluten Content Parameters Measured in the Sample of All Genotypes Based on Categorical Variables

As seen in Table 21, outcomes revealed that there is a significant difference in statistical level in gluten content based on year ($F(2\text{-}213) = 24.209$, $p < .001$), site ($t(214) = -6.141$, $p < .001$), genotypes ($F(4\text{-}211) = 14.093$, $p < .001$) and treatment ($F(5\text{-}210) = 21.138$, $p < .001$) in the sample of all genotypes. Accordingly, the mean values of gluten content in 2018-2019 tend to be higher than in 2015-2016, which tend to be higher than in 2017. Gödöllő tends to be higher than Hatvan; Alföld tends to be higher than in Karéj and Nádor; 2, 3, 4, 5 and 6 tend to be higher than in 1; 3, 4, 5 and 6 tend to be higher than in 2; 5 and 6 tend to be higher than in 3, and 6 tends to be higher than in 4.

The significance level of the difference based on genotypes and treatment, in terms of gluten content measured in the sample of all genotypes in 2016, was examined through ANOVA and outcomes were reflected in Table 22.

Gluten Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Genotypes	Alföld	18	34.24	3.15	17.043	4-85	.000	1 > 2, 3, 5; 4 > 2; 4 > 3; 3, 4 > 5
	Karéj	18	28.71	3.29				
	Nádor	18	30.23	2.78				
	Toborzó	18	32.71	2.50				
	Toldi	18	27.75	2.04				
Treatment	0 kg/ha	15	26.60	2.78	11.632	5-84	.000	3, 4, 5, 6 > 1, 2
	80 kg/ha	15	28.75	3.01				

	80+40 kg/ha	15	31.99	3.14				
	120 kg/ha	15	31.16	2.57				
	120+40 kg/ha	15	32.94	3.04				
	160 kg/ha	15	32.94	2.80				

22. Table Comparison of the Means of Gluten Content Parameters Measured in the Sample of All Genotypes in 2016 Based on Categorical Variables

As seen in Table 22, outcomes revealed that there is a significant difference in statistical level in gluten content based on genotypes ($F(4-85) = 17.043$, $p < .001$) and treatment ($F(5-84) = 11.632$, $p < .001$) in the sample of all genotypes in 2016. Accordingly, the mean values of gluten content in Alföld tend to be higher than in Karéj, Nádor and Toldi, Toborzó tends to be higher than in Karéj, Toborzó tends to be higher than in Nádor, and Nádor and Toborzó tend to be higher than in Toldi. 3, 4, 5 and 6 tend to be higher than in 1 and 2.

The significance level of the difference based on year and treatment, in terms of gluten content measured in the sample of Toldi genotype, was examined through Independent Samples t-Test and outcomes were reflected in Table 23.

Gluten Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	18	27.75	2.04	-1.345	34	.188	
	2017	18	29.36	4.64				
Treatment	0 kg/ha	6	24.32	3.67	3.928	5-30	.007	3, 5, 6 > 1
	80 kg/ha	6	28.21	3.26				
	80+40 kg/ha	6	28.83	2.54				
	120 kg/ha	6	28.08	3.27				
	120+40 kg/ha	6	30.45	2.54				
	160 kg/ha	6	31.44	2.80				

23. Table Comparison of the Means of Gluten Content Parameters Measured in the Sample of Toldi Genotype Based on Categorical Variables

As seen in Table 23, outcomes revealed that there is no significant difference in statistical level in gluten content based on year ($t(34) = -1.345$, $p > .05$), however, there is a significant difference in statistical level in gluten content based on treatment ($F(5-30) = 3.928$, $p < .01$) in the sample of Toldi genotype. Accordingly, the mean values of gluten content in 3, 5 and 6 tend to be higher than in 1.

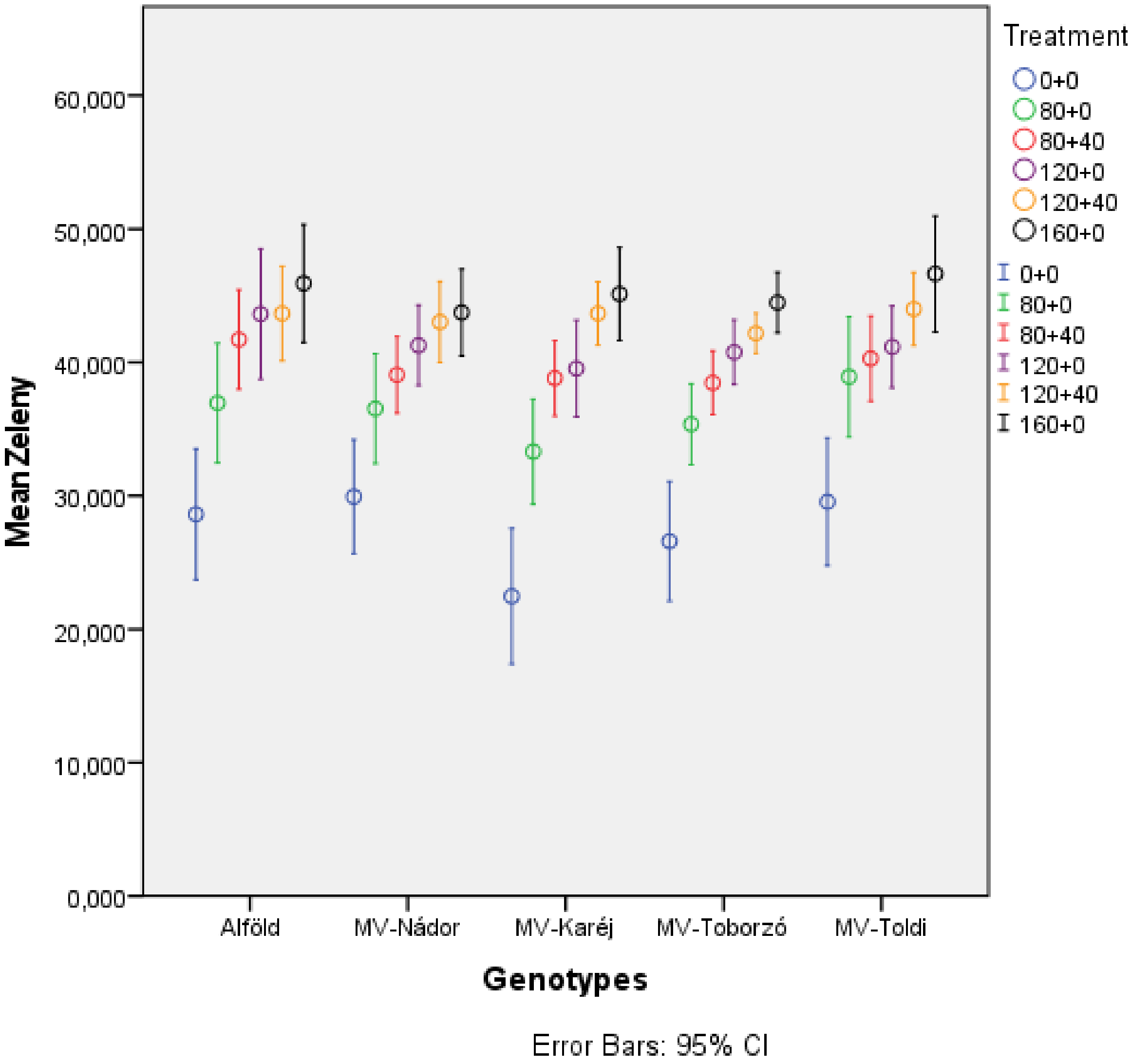
The significance level of the difference based on genotypes and treatment, in terms of gluten content measured in the sample of Alföld and Karéj genotypes in Gödöllő in 2018-2019, was examined through Independent Samples t-Test and outcomes were reflected in Table 24.

Gluten Content (%)		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Genotypes	Alföld	18	35.53	2.37	1.589	34	.121	
	Karéj	18	33.51	4.85				
Treatment	0 kg/ha	6	31.25	5.57	3.884	5-30	.008	5, 6 > 1, 2, 3; 5 > 4
	80 kg/ha	6	32.27	3.22				
	80+40 kg/ha	6	34.34	1.90				
	120 kg/ha	6	34.12	3.29				
	120+40 kg/ha	6	37.95	2.11				
	160 kg/ha	6	37.18	2.07				

24. Table Comparison of the Means of Gluten Content Parameters Measured in the Sample of Alföld and Karéj Genotypes in Gödöllő in 2019 Based on Categorical Variables

As seen in Table 24, according to the outcomes it is found out that there is no significant difference in statistical level in gluten content based on genotypes ($t(34) = 1.589$, $p > .05$); however, there is a significant difference in statistical level in gluten content based on treatment ($F(5\text{-}30) = 3.884$, $p < .01$) in the sample of Alföld and Karéj genotypes in Gödöllő in 2018-2019. Accordingly, the mean values of gluten content in 5 and 6 tend to be higher than in 1, 2 and 3; 5 tends to be higher than in 4.

6.6 The Zeleny number (ml)



23. Figure Impact of N topdressing applications on Zeleny Nr. of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary) 1

Zeleny Nr/mL					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	28,64	29,93	23,60	26,60	29,56
80	36,95	36,54	33,30	35,39	35,13
80+40	41,71	39,06	38,80	38,45	35,69
120	43,64	41,29	39,55	40,79	36,44
120+40	43,64	43,01	43,70	42,17	38,28
160	45,90	43,75	45,10	44,50	41,14

25. Table Impact of N topdressing applications on Zeleny Nr. of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary) 2

Zeleny Nr/mL		
N	**Alföld**	**MV Karéj**
0	38,50	41,10
80	37,60	50,80
80+40	35,60	55,40
120	35,90	51,90
120+40	42,70	60,70
160	41,30	58,90

26. Table Impact of N topdressing applications on Zeleny Nr. of wheat varieties. 2015-2016 and 2018–2019 (Gödöllő, Hungary)

The significance level of the difference based on year in terms of parameters was examined through ANOVA and outcomes were reflected in Figure 23 and Table 26-30 as well as Table 36-54 (Appendix 1)

As seen in Table 36-54, outcomes revealed that there is a significant difference in statistical level in Zeleny number ($F_{(2.105)} = 18.886$, $p < .001$) based on year, ($t(103.445) = 3.234$, $p < .01$) based on site and ($F_{(5.102)} = 13.148$, $p < .001$) based on treatment. However, no significance ($t_{(106)} = 1.635$, $p > .05$) based on genotypes.

The significance level of the difference based on year, site, genotypes and treatment, in terms of Zeleny number measured in the sample of all genotypes, was examined through ANOVA and outcomes were reflected in Table 27.

Zeleny Number		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Year	2016	90	35.05	6.04	31.764	2-213	.000	2, 3 > 1
	2017	90	42.68	8.80				
	2019	36	45.88	10.12				
Site	Hatvan	180	38.87	8.44	-4.391	214	.000	2 > 1
	Gödöllő	36	45.88	10.12				
Genotypes	Alföld	54	39.59	8.59	1.672	4-211	.158	
	Karéj	54	42.55	11.45				
	Nádor	36	38.93	7.62				
	Toborzó	36	37.98	7.41				

	Toldi	36	40.10	8.39				
Treatment	0 kg/ha	36	29.59	8.82	23.141	5-210	.000	2, 3, 4, 5, 6 > 1; 4, 5, 6 > 2; 5, 6 > 3; 6 > 4
	80 kg/ha	36	37.56	7.49				
	80+40 kg/ha	36	40.65	6.78				
	120 kg/ha	36	41.71	6.91				
	120+40 kg/ha	36	44.71	6.58				
	160 kg/ha	36	46.00	7.58				

27. Table Comparison of the Means of Zeleny Nr. Parameters Measured in the Sample of All Genotypes Based on Categorical Variables

As seen in Table 27, outcomes revealed that there is no significant difference in the statistical level in Zeleny number based on genotypes (F(4-211) = 1.672, p > .05); however, there is a significant difference in statistical level in Zeleny number based on year (F(2-213) = 31.764, p < .001), site (t(214) = -4.391, p < .001) and treatment (F(5-210) = 23.141, p < .001) in the sample of all genotypes. Accordingly, the mean values of Zeleny number in 2016-2017 and 2018-2019 tend to be higher than in 2015-2016; Gödöllő tends to be higher than in Hatvan; 2, 3, 4, 5 and 6 tend to be higher than in 1; 4, 5 and 6 tend to be higher than in 2; 5 and 6 tend to be higher than in 3; and 6 tends to be higher than in 4.

The significance level of the difference based on genotypes and treatment, in terms of Zeleny number measured in the sample of Alföld and Karéj genotypes in Gödöllő in 2018-2019, was examined through Independent Samples t-Test and outcomes were reflected in Table 28.

Zeleny Number		**N**	**M**	**SD**	**F/t**	**df**	**p**	**Difference**
Genotypes	Alföld	18	38.61	6.26	-6.188	34	.000	2 > 1
	Karéj	18	53.14	7.75				
Treatment	0 kg/ha	6	39.78	8.35	1.148	5-30	.357	
	80 kg/ha	6	44.23	8.03				
	80+40 kg/ha	6	45.52	11.59				
	120 kg/ha	6	43.88	9.99				
	120+40 kg/ha	6	51.72	10.56				
	160 kg/ha	6	50.12	11.06				

28. Table Comparison of the Means of Zeleny Nr. Parameters Measured in the Sample of Alföld and Karéj Genotypes in Gödöllő in 2019 Based on Categorical Variables

As seen in Table 28, outcomes revealed that there is no significant difference in statistical level in Zeleny number based on treatment (F(5-30) = 1.148, p > .05), however, there is a significant difference in statistical level in Zeleny number based on genotypes (t(34) = -6.188, p < .001) in the sample of Alföld and Karej genotypes in Gödöllő in 2018-2019. Accordingly, the mean values of zeleny number in Karéj tend to be higher than in Alföld.

The significance level of the difference based on genotypes and treatment, in terms of Zeleny number measured in the sample of Alföld and Karéj genotypes in 2015-2016, was examined through Independent Samples t-Test and outcomes were reflected in Table 29.

Zeleny Number		N	M	SD	F/t	df	p	Difference
Genotypes	Alföld	18	33.24	6.54	-.754	34	.456	2 > 1
	Karéj	18	34.99	7.40				
Treatment	0 kg/ha	6	22.97	3.05	18.143	5-30	.000	2, 3, 4, 5, 6 > 1; 3, 4, 5, 6 > 2; 5 > 4
	80 kg/ha	6	30.02	4.54				
	80+40 kg/ha	6	37.01	4.94				
	120 kg/ha	6	35.54	2.89				
	120+40 kg/ha	6	40.06	3.49				
	160 kg/ha	6	39.08	3.01				

29. Table Comparison of the Means of Zeleny Nr. Parameters Measured in the Sample of Alföld and Karéj Genotypes in 2016 Based on Categorical Variables

As seen in Table 29, outcomes revealed that there is no significant difference in statistical level in Zeleny number based on genotypes (t(34) = -.754, p > .05); however, there is a significant difference in statistical level in Zeleny number based on treatment (F(5-30) = 18.143, p < .001) in the sample of Alföld and Karéj genotypes in 2016. Accordingly, the mean values of Zeleny number in Karéj tend to be higher than in Alföld; 2, 3, 4, 5 and 6 tend to be higher than in 1; 3, 4, 5 and 6 tend to be higher than in 2; and 5 tends to be higher than in 4.

The significance level of the difference based on year, site and treatment, in terms of Zeleny number measured in the sample of Karéj genotype, was examined through ANOVA and outcomes were reflected in Table 30.

Zeleny Number		N	M	SD	F/t	df	p	Difference
Year	2016	18	34.99	7.40	21.924	2-51	.000	3 > 1, 2
	2017	18	39.51	10.25				
	2019	18	53.14	7.75				
Site	Hatvan	36	37.25	9.10	-6.338	52	.000	2 > 1

	Gödöllő	18	53.14	7.75				
Treatment	0 kg/ha	9	29.05	11.20	5.969	5-48	.000	3, 4, 5, 6 > 1; 5, 6 > 2
	80 kg/ha	9	39.16	10.25				
	80+40 kg/ha	9	44.36	9.23				
	120 kg/ha	9	43.65	7.79				
	120+40 kg/ha	9	49.36	9.09				
	160 kg/ha	9	49.72	8.75				

30. Table Comparison of the Means of Zeleny Nr. Parameters Measured in the Sample of Karéj Genotype Based on Categorical Variables

As seen in Table 30, outcomes revealed that there is significant difference in statistical level in Zeleny number based on year (F(2-51) = 21.924, p < .001), site (t(52) = -6.338, p < .001) and treatment (F(5-48) = 5.969, p < .001) in the sample of Karéj genotype. Accordingly, the mean values of Zeleny number in 2019 tend to be higher than in 2015-2016 and 2016-2017; Gödöllő tends to be higher than in Hatvan; 3, 4, 5 and 6 tend to be higher than in 1; and 5 and 6 tend to be higher than in 2.

7. CONCLUSION AND RECOMMENDATIONS

- Test weight measurements showed no significant differences by different dose and divided amounts of nitrogen fertilizer applications. However, year, site and genotype showed significant differences on test weight results of tested winter wheat species. Alföld and Karéj species had greater results both on sites and years.

- Thousand kernel weight measurements showed no significant differences by different dose and divided amount of nitrogen fertilizer applications. However, year, site and genotype showed significant differences on thousand kernel weight results of tested winter wheat species. Hatvan site had greater results compared to Gödöllő.

- The grain moisture measurements showed no significant differences by different dose and divided amounts of nitrogen fertilizer applications. However, year, site and genotype showed significant differences on grain moisture results of tested winter wheat species. Alföld and Karéj species had greater results both on sites and years. The Gödöllő site had greater results compared to Hatvan.

- The grain protein measurements showed significant effect on all studied years, sites, genotypes and treatment parameters. 2018-2019 was the leading year and the Gödöllő site had higher figures than Hatvan. The Alföld variety showed the best performance while Karéj was the second good performer among the five studied winter wheat varieties. Apart from this, the general results wherein all the years, sites and varieties were measured, showed the increased level of Nitrogen fertilizer supply caused an increase in the grain protein content (where no species, year sites separated). However, division of the given amounts of the nitrogen fertilizer did not have significant effect on tested winter wheat varieties. On the other hand, those at the Hatvan site's 2015-2016-year trials regarding all varieties and 2018-2019-year 80+40 kg/ha divided application, compared to 120 kg/ha un-divided applications, as well as the Karéj's

80+40 kg/ha compared to 120 kg/ha applications, showed that while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to same amounts un-divided applications. Therefore, 80+40 kg/ha N application is recommended.

- The grain gluten measurements showed significant effect on all studied year, site, genotype and treatment parameters. 2018-2019 was the leading crop year as well as the Gödöllő site had greater figures than Hatvan. Alföld variety showed the best performance among the five studied winter wheat varieties. Apart from this, the general results wherein all the years, sites and varieties that were measured, showed that the increased level of Nitrogen fertilizer supply caused an increase in the grain protein content. However, division of the given amounts of the nitrogen fertilizer did not have a significant effect on tested winter wheat varieties. On the other hand, those at the Hatvan site’s 2015-2016- crop year trials and Toldi varieties, and Hatvan’s site trials results of 80+40 kg/ha divided application compared to 120 kg/ha un-divided applications, showed that while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to the same amounts in undivided applications.

- The Zeleny number measurements showed significant effect on all studied years, sites, genotypes and treatment parameters. 2018-2019 was the leading year, and the Gödöllő site had higher figures than Hatvan. The Karéj variety showed the best performance among the five studied winter wheat varieties. Apart from that, the general results wherein all the years, sites and varieties that were measured, showed that the increased level of Nitrogen fertilizer supply caused an increase to the Zeleny number; however, division of the given amounts of the nitrogen fertilizer did not have significant effect on the tested winter wheat varieties. On the other hand, those in the Hatvan site 2015-2016-year trials, the Gödöllő site 2018-2019-year trials’ results, and the Karéj varieties measurement of 80+40 kg/ha divided application compared to 120 kg/ha un-divided applications, and the 120+40 kg/ha divided applications compared to 160 kg/ha un-divided applications showed that, while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to the same amounts in un-divided applications.

8. NEW SCIENTIFIC RESULTS

1- Measurements of this experiment proved that increasing amounts of Nitrogen fertilizer application raised the protein content of the tested winter varieties; however, 80+40 kg/ha Nitrogen fertilization was even more remarkable and recommended.
2- The Gödöllő site and Alföld variety showed the best results comparing the sites and the tested winter wheat varieties, in regard to the grain gluten content. While the grain gluten content increased with higher amounts of Nitrogen fertilizer applications, increasing the level of the Nitrogen application did not affect the result significantly.
3- By analyzing the Zeleny number of the chosen winter wheat varieties, results showed that the Karéj variety was significantly affected by split-dose application of Nitrogen fertilizer; however, all the varieties of Zeleny numbers rose with the increasing amount of N application.
4- All the tested winter wheat varieties showed significant differences, comparing all the measurement parameters (Zeleny number, Grain protein content, Grain gluten content, Test weight, Thousand kernel weight and Grain moisture) by site, genotype, and year.

9. SUMMARY

The Earth's rising population growth is contributing to increasing hunger, as well as creating insufficient and unbalanced nutrition, all of which continue to be major problems for human survival. Although different opinions are put forward for the solution, the most notable consensus among experts has been to engineer an increase in plant and animal products. Wheat, the most widely grown plant species in the world, is a plant of high strategic importance due to the fact that it has been grown since the earliest times; its agricultural process is easier than other plants; the product is more adaptable to transportation and storage conditions; and its inherent high nutrition solves one of the most pressing economic problems. Wheat is also one of the most predominant cereal grains in Hungary and Turkey, and it retains high economic value. The goal of wheat production is two-fold: to provide both quantity and quality. The aim of this study is to find the quality changes on tested winter wheat varieties with the application of Nitrogen fertilizer. As

Nitrogen fertilization has a considerably high economic and environmental effect on wheat farming and wheat quality, we therefore should find the most appropriate formula for supplying fertilizer to get the best results to be able to improve the quality of the winter wheat products, as well as consider the economic and environmental side effects of the this kind of farming approach.

Baking quality of wheat flour is determined by grain protein concentration (GPC) and its composition. It's also highly influenced by environmental factors, such as nitrogen (N) fertilization management (Xue et al., 2019). Increasing the level of protein content will raise the baking quality (Gabriel, et al., 2017; Wrigley and Batey, 2003). It's generally accepted that fertilization increases soil microbial biomass in agricultural soils on the short and long term (Nguyen et al., 2018), however, application of solely continuous N fertilizer can decrease soil microbial biomass (Wallenstein et al., 2006; Treseder, 2008). Numerous studies stipulate that overdose application, rather than the appropriate amount of nitrogen fertilizer application, had no significant positive effect on wheat quality parameters (Abedi et al., 2011; Cui et al., 2010; Chen et al., 2004; Lloveras et al., 2001) and even dropped the yield performances (Jolánkai, 1985). Nitrogen use efficiency is closely related to fertilization, the genetic and morphological characteristics of the plant, as well as the climate and soil characteristics.

Results showed that test weight, thousand kernel weight and grain moisture outcomes showed that there is no significant difference with applied dose and divided amount of nitrogen fertilizer applications. However, year, site and genotype showed significant differences.

The grain protein measurements showed significant effect on all studied years, sites, genotypes and treatment parameters. 2018-2019 was the leading year and the Gödöllő site had higher figures than Hatvan. The Alföld variety showed the best performance while Karéj was the second good performer among the five studied winter wheat varieties. Apart from this, the general results wherein all the years, sites and varieties were measured, showed the increased level of Nitrogen fertilizer supply caused an increase in the grain protein content (where no species, year sites separated). However, division of the given amounts of the nitrogen fertilizer did not have significant effect on tested winter wheat varieties. On the other hand, those at the Hatvan site's 2015-2016-year trials regarding all varieties and 2018-2019-year 80+40 kg/ha divided application, compared to 120 kg/ha un-divided applications, as well as the Karéj's 80+40 kg/ha compared to 120 kg/ha applications, showed that while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to same amounts un-divided applications. Therefore, 80+40 kg/ha N application is recommended.

- The grain gluten measurements showed significant effect on all studied year, site, genotype and treatment parameters. 2018-2019 was the leading crop year as well as the Gödöllő site had greater figures than Hatvan. Alföld variety showed the best performance among the five studied winter wheat varieties. Apart from this, the general results wherein all the years, sites and varieties that were measured, showed that the increased level of Nitrogen fertilizer supply caused an increase in the grain protein content. However, division of the given amounts of the nitrogen fertilizer did not have a significant effect on tested winter wheat varieties. On the other hand, those at the Hatvan site's 2015-2016- crop year trials and Toldi varieties, and Hatvan's site trials results of 80+40 kg/ha divided application compared to 120 kg/ha un-divided applications, showed that while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to the same amounts in undivided applications.

- The Zeleny number measurements showed significant effect on all studied years, sites, genotypes and treatment parameters. 2018-2019 was the leading year, and the Gödöllő site had higher figures than Hatvan. The Karéj variety showed the best performance among the five studied winter wheat varieties. Apart from that, the general results wherein all the years, sites and varieties that were measured, showed that the increased level of Nitrogen fertilizer supply caused an increase to the Zeleny number; however, division of the given amounts of the nitrogen fertilizer did not have significant effect on the tested winter wheat varieties. On the other hand, those in the Hatvan site 2015-2016-year trials, the Gödöllő site 2018-2019-year trials' results, and the Karéj varieties measurement of 80+40 kg/ha divided application compared to 120 kg/ha un-divided applications, and the 120+40 kg/ha divided applications compared to 160 kg/ha un-divided applications showed that, while increasing doses of the nitrogen fertilizer supply shows significant effect, divided doses of the nitrogen fertilizer showed greater effect compared to the same amounts in un-divided applications.

10. THE PUBLICATIONS OF THE AUTHOR IN THE RESEARCH FIELD

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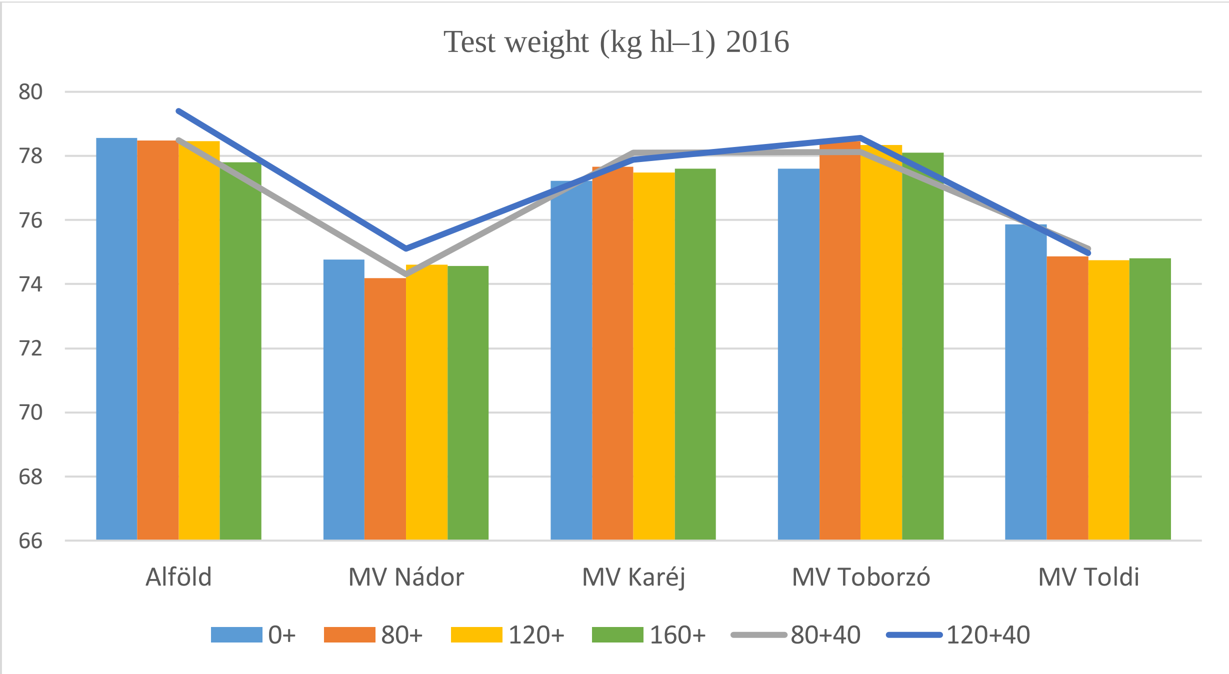
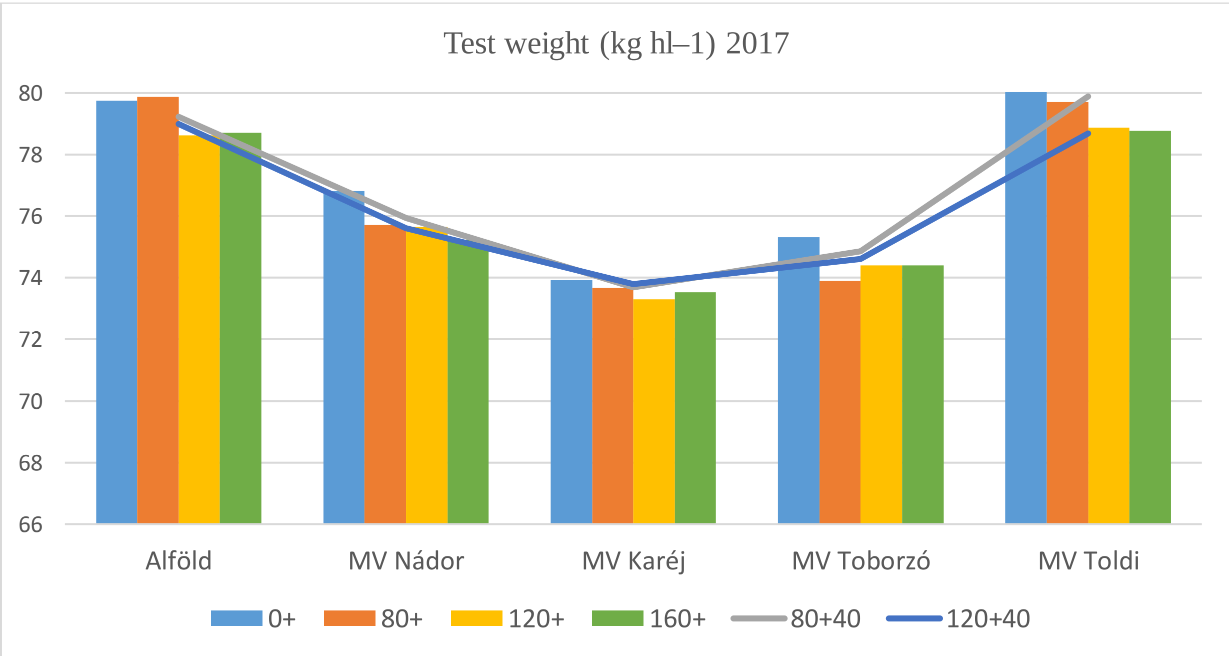
- I express deep and sincere gratitude to members of my family; without their blessing and inspiration, this study would not have been possible.

13. APPENDIX 1 – TABLES AND FIGURES

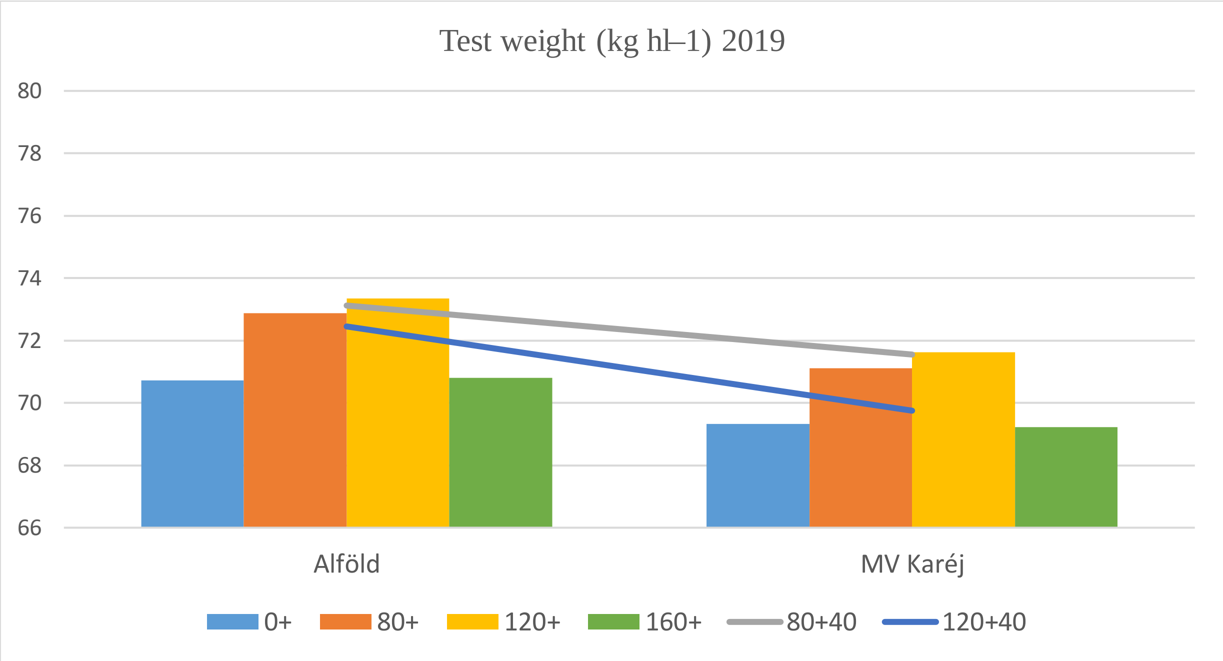
12.1. Test Weight



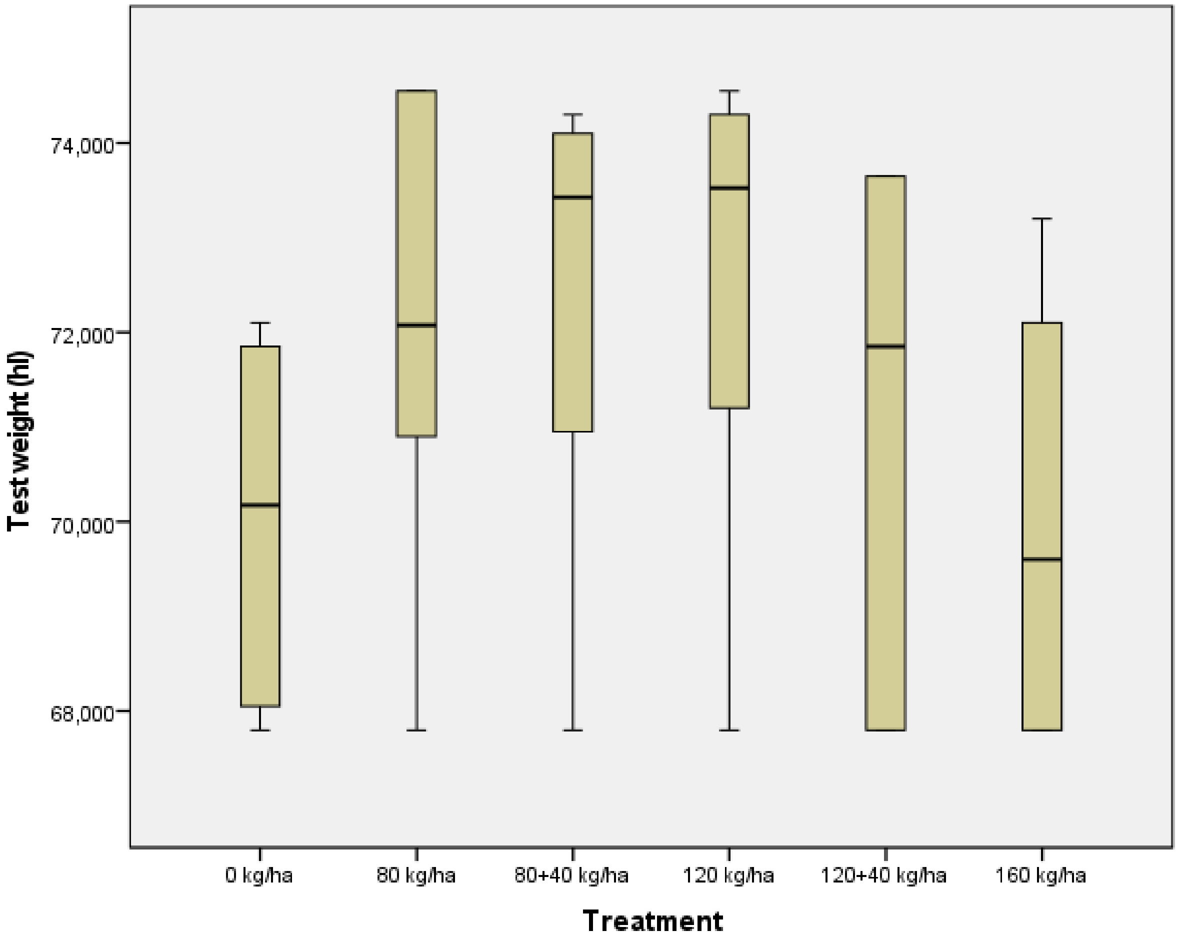
24. Figure Impact of N topdressing applications on wheat grain test weight. 2015-2016 (Nagygombos, Hungary)



25. Figure Impact of N topdressing applications on wheat grain test weight. 2016-2017 (Nagygombos, Hungary)

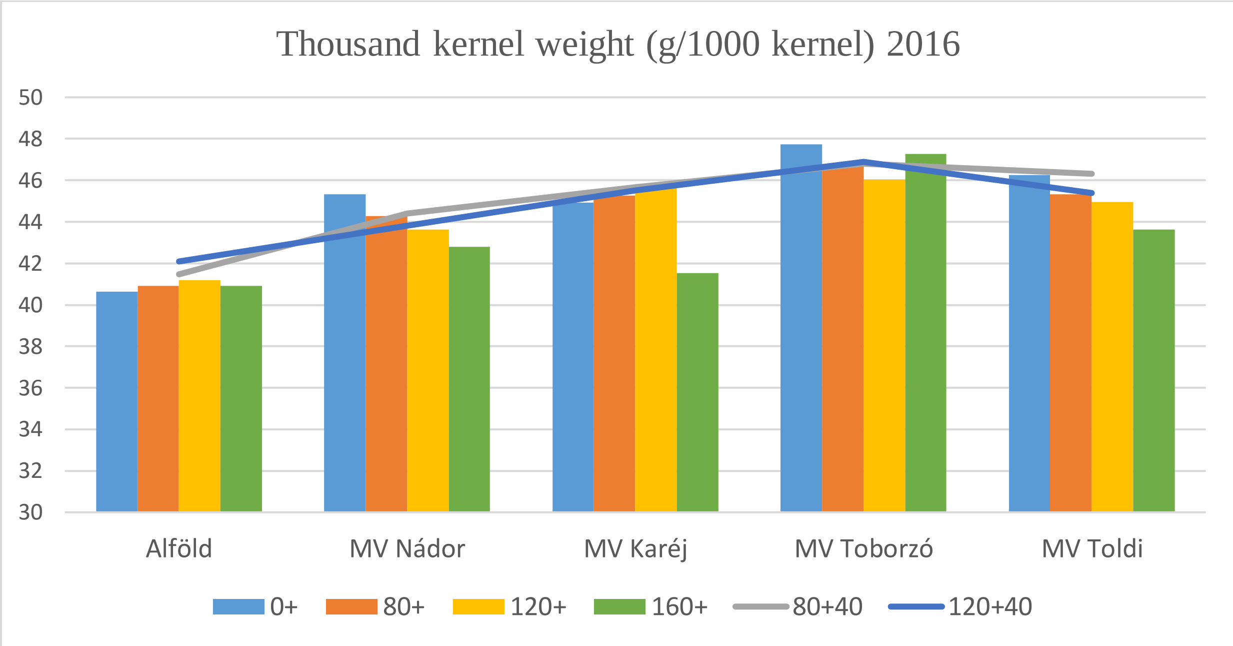


26. Figure Impact of N topdressing applications on wheat grain test weight. 2018-2019 (Gödöllő, Hungary) 2

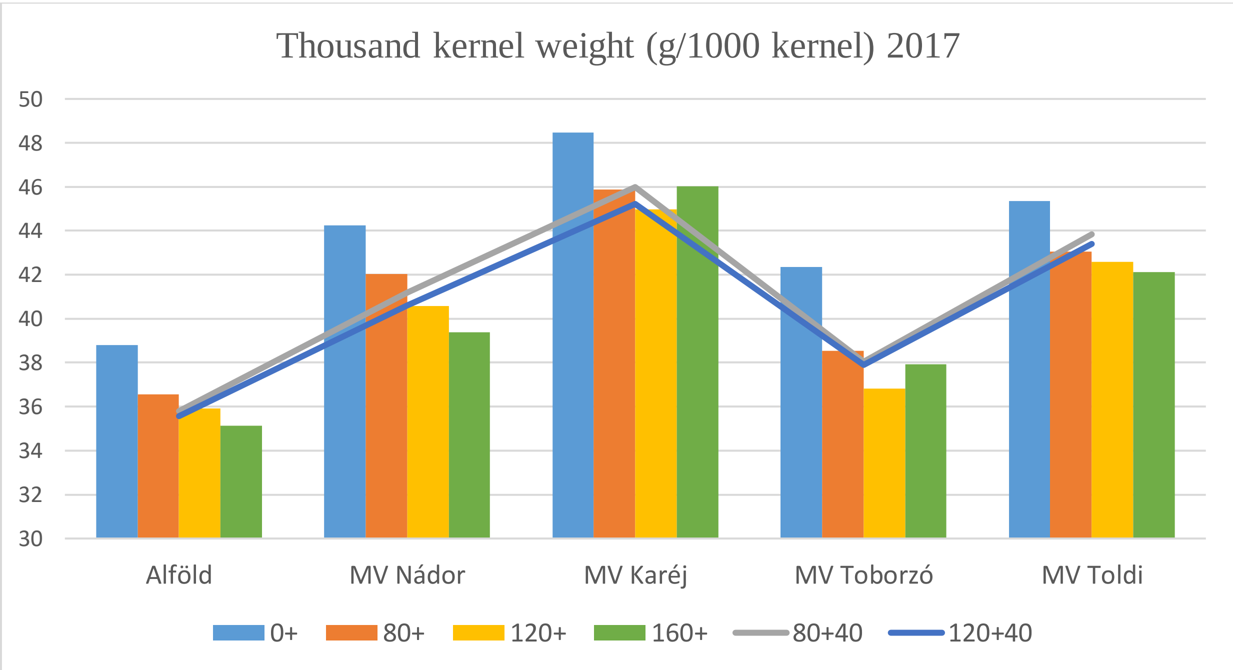


27. Figure Impact of N topdressing applications on wheat grain test weight. 2018–2019 (Gödöllő, Hungary) Box Plot Alföld and MV Karéj

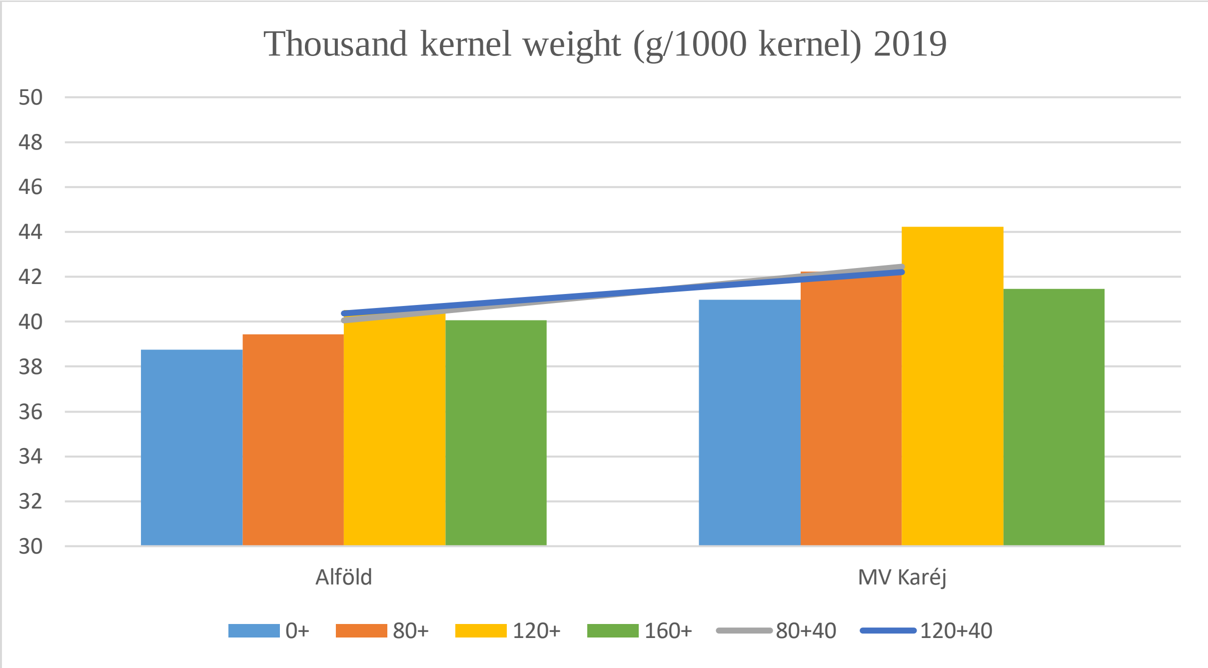
12.2. Thousand Kernel Weight



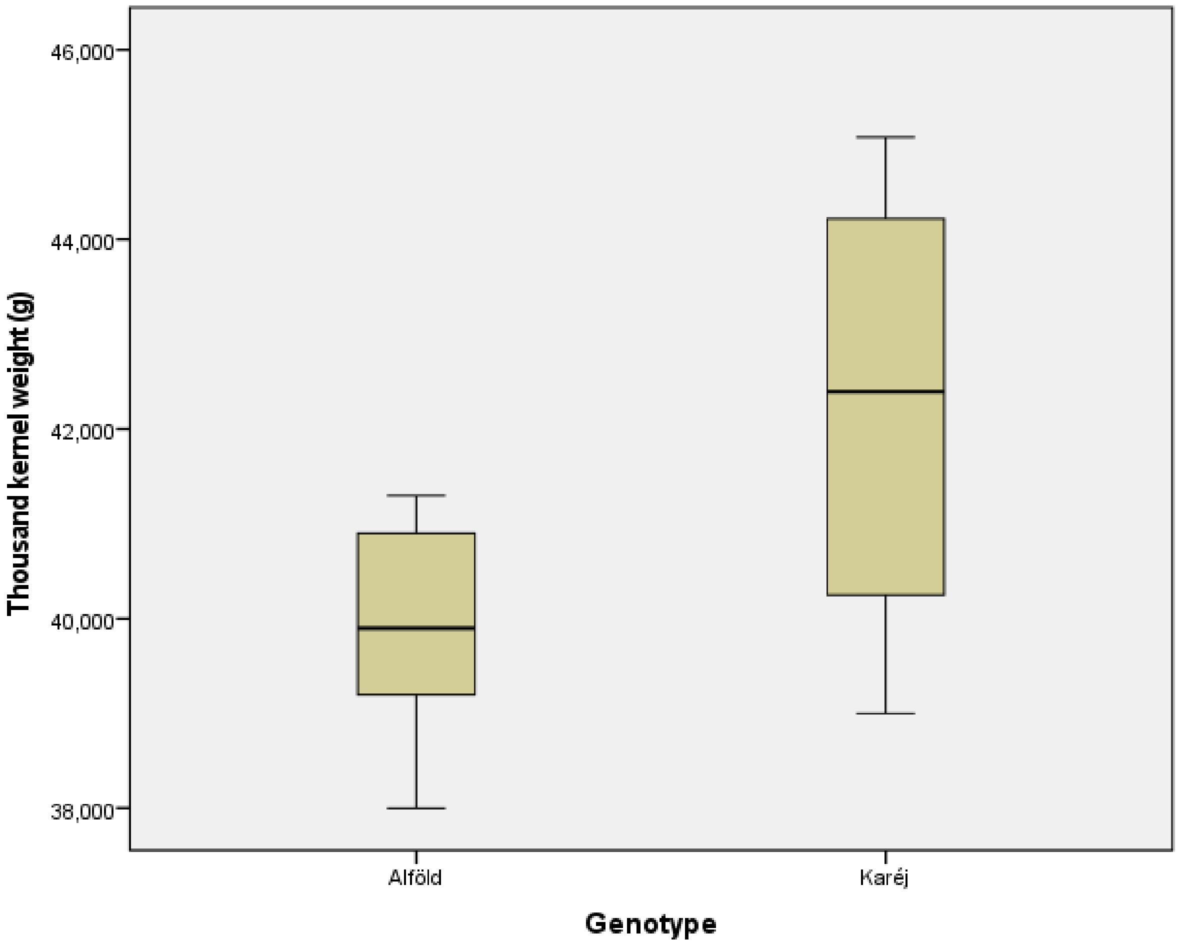
28. Figure Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2015-2016 (Nagygombos, Hungary)



29. Figure Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2016-2017 (Nagygombos, Hungary)



30. Figure Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2018-2019 (Gödöllő, Hungary) 2



31. Figure Impact of N topdressing applications on thousand kernel weight of wheat varieties. 2018-2019 (Gödöllő, Hungary) 3

12.3. The Grain Moisture

Moisture content % 2015-2016					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	6,50	6,90	9,80	7,30	10,40
80	6,50	7,10	9,70	7,70	10,60
80+40	6,30	6,60	9,70	7,20	10,60
120	6,50	6,90	9,90	7,20	10,50
120+40	6,70	7,00	9,70	7,10	10,60
160	6,50	6,90	9,80	7,30	10,40

31. Table Impact of N topdressing applications on moisture content of wheat varieties. 2015-2016 (Nagygombos, Hungary)

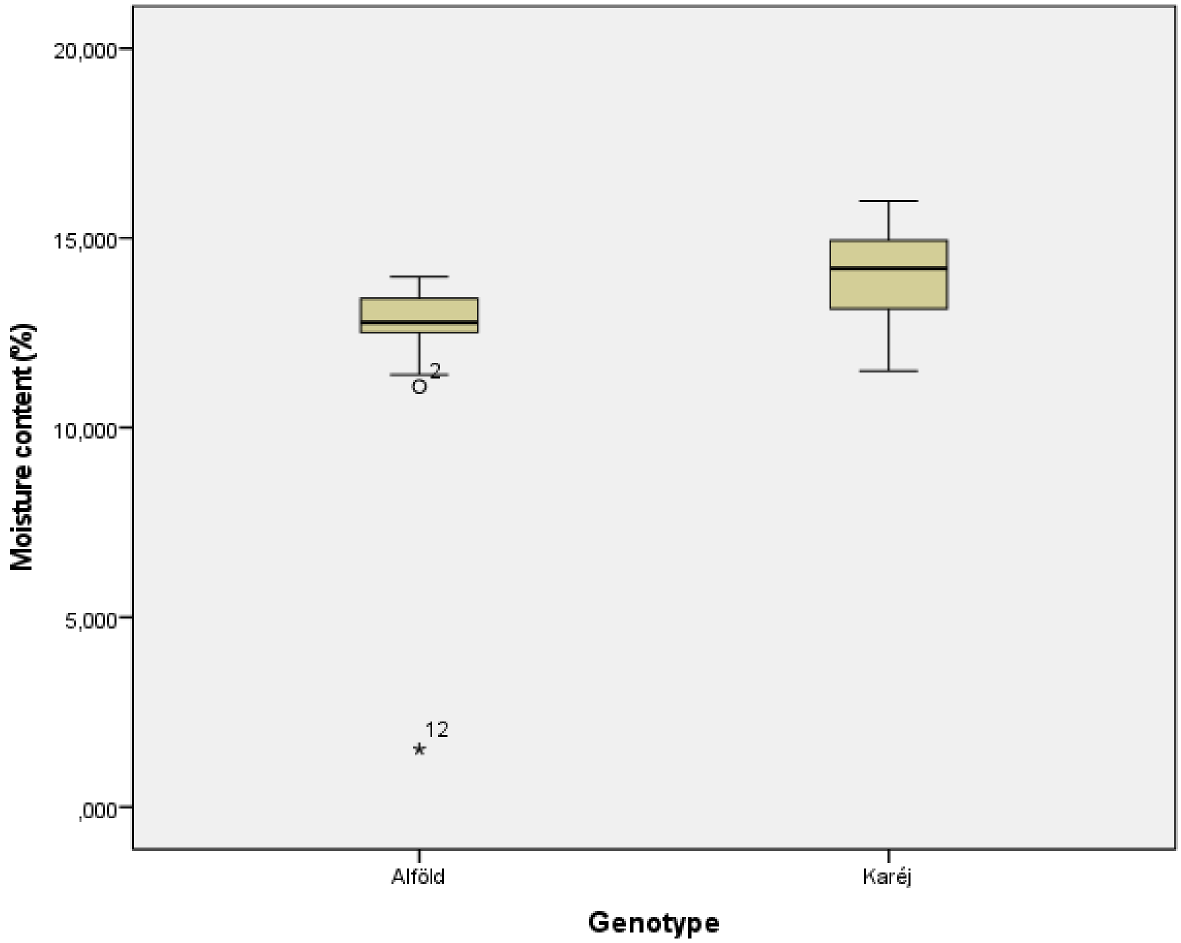
Moisture content % 2016-2017					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	9,87	9,83	10,30	8,65	10,22
80	9,73	9,84	10,30	8,80	10,32
80+40	9,50	9,88	10,30	8,70	10,23
120	9,75	9,83	10,20	8,75	10,36
120+40	9,80	9,85	10,20	8,69	10,40
160	9,73	9,79	10,10	8,78	10,44

32. Table Impact of N topdressing applications on moisture content of wheat varieties. 2016-2017 (Nagygombos, Hungary)

Moisture content % 2018-2019		
N	**Alföld**	**MV Karéj**
0	15,03	11,77
80	15,30	11,80
80+40	15,33	11,87
120	14,97	11,83
120+40	15,13	11,80

160	15,03	11,90

33. Table Impact of N topdressing applications on moisture content of wheat varieties. 2018-2019 (Gödöllő, Hungary) 2



32. Figure Impact of N topdressing applications on moisture content of wheat varieties. 2018-2019 (Gödöllő, Hungary) 3

12.4. Protein Content

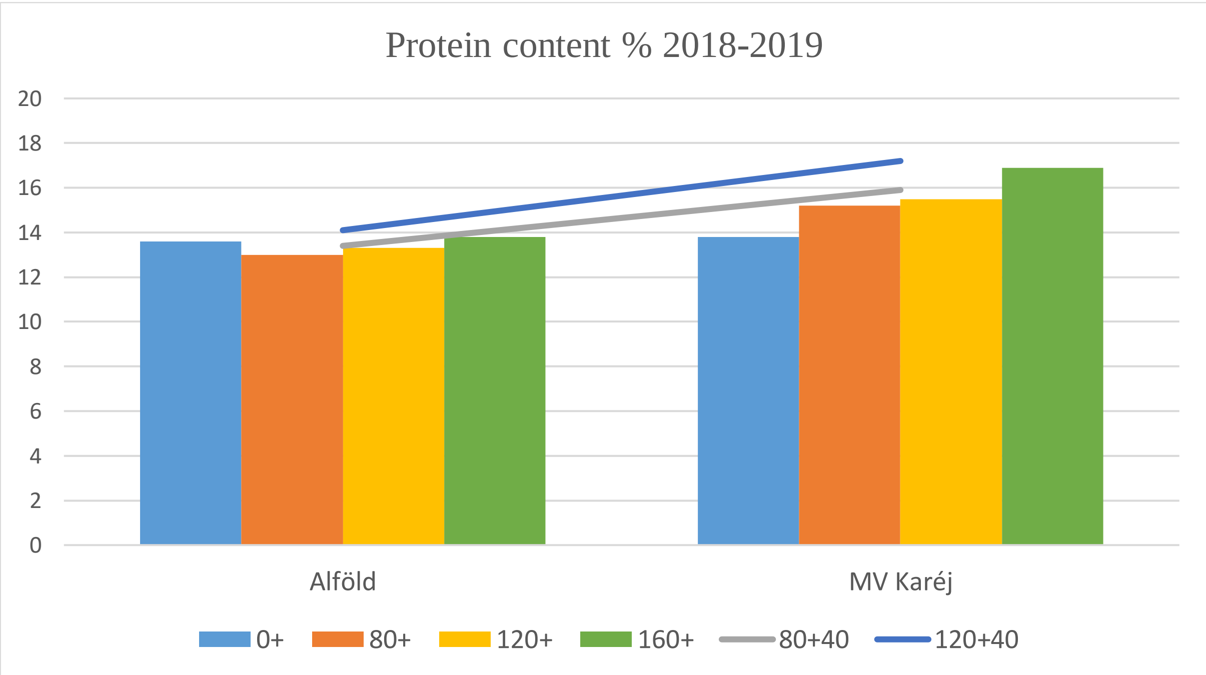
Protein content % 2015-2016					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	13,60	12,00	12,40	13,80	12,70
80	14,50	12,60	13,30	13,80	13,30
80+40	15,70	13,60	14,40	14,90	13,90
120	15,30	13,50	13,90	14,60	13,80

120+40	16,00	13,90	14,90	15,50	14,30
160	15,80	14,20	14,60	15,30	14,00

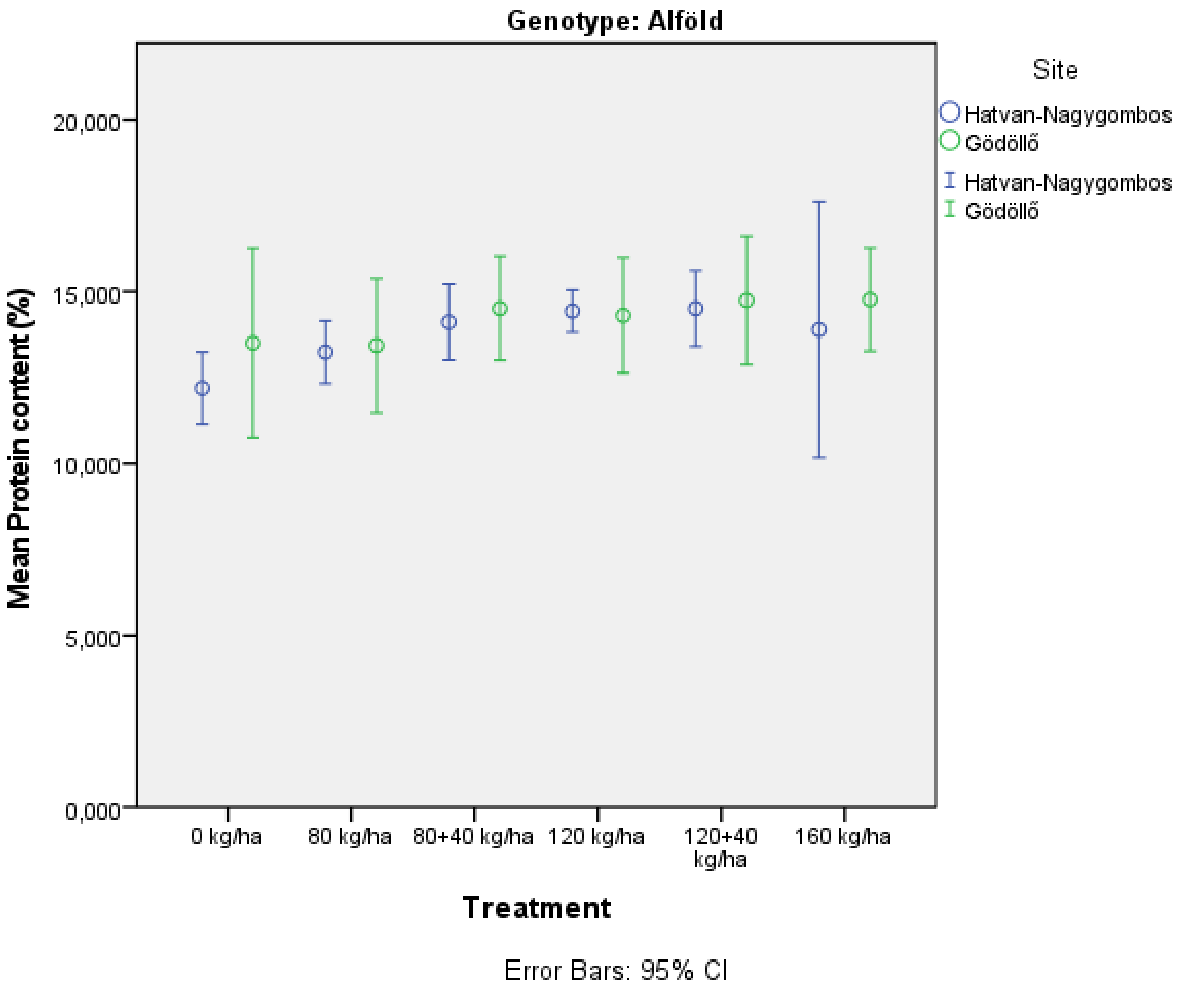
34. Table Impact of N topdressing applications on protein content of wheat varieties. 2015-2016 (Nagygombos, Hungary)

Protein content % 2016-2017					
N	**Alföld**	**MV Nádor**	**MV Karéj**	**MV Toborzó**	**MV Toldi**
0	13,13	11,12	9,90	10,09	11,65
80	13,98	12,36	11,80	12,03	13,50
80+40	14,68	12,33	12,30	12,09	13,22
12	15,70	13,07	12,90	12,77	13,62
120+40	14,87	13,32	13,30	13,04	14,06
160	15,99	13,73	14,10	13,60	14,73

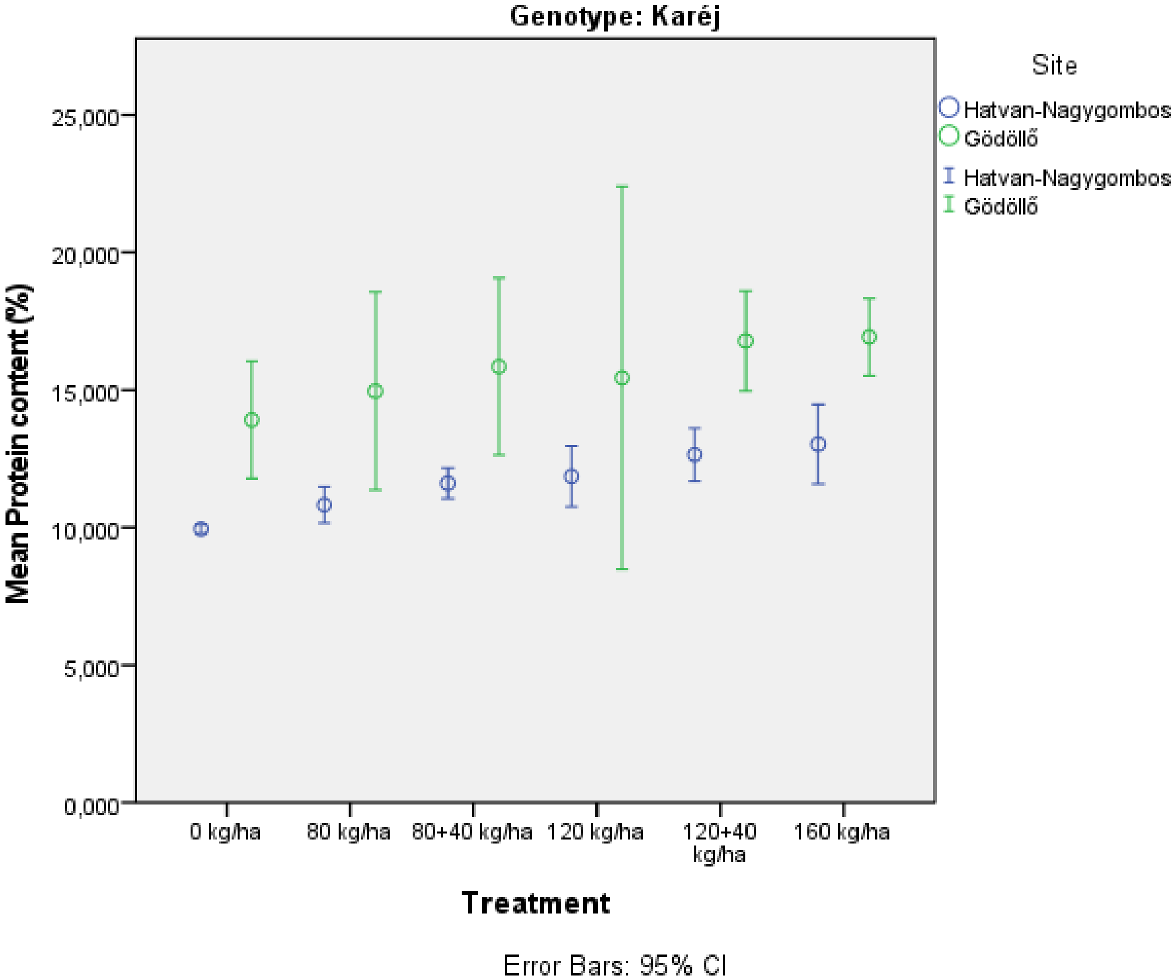
35. Table Impact of N topdressing applications on protein content of wheat varieties. 2016-2017 (Nagygombos, Hungary)



33. Figure Impact of N topdressing applications on protein content of wheat varieties. 2018–2019 (Gödöllő, Hungary) 2

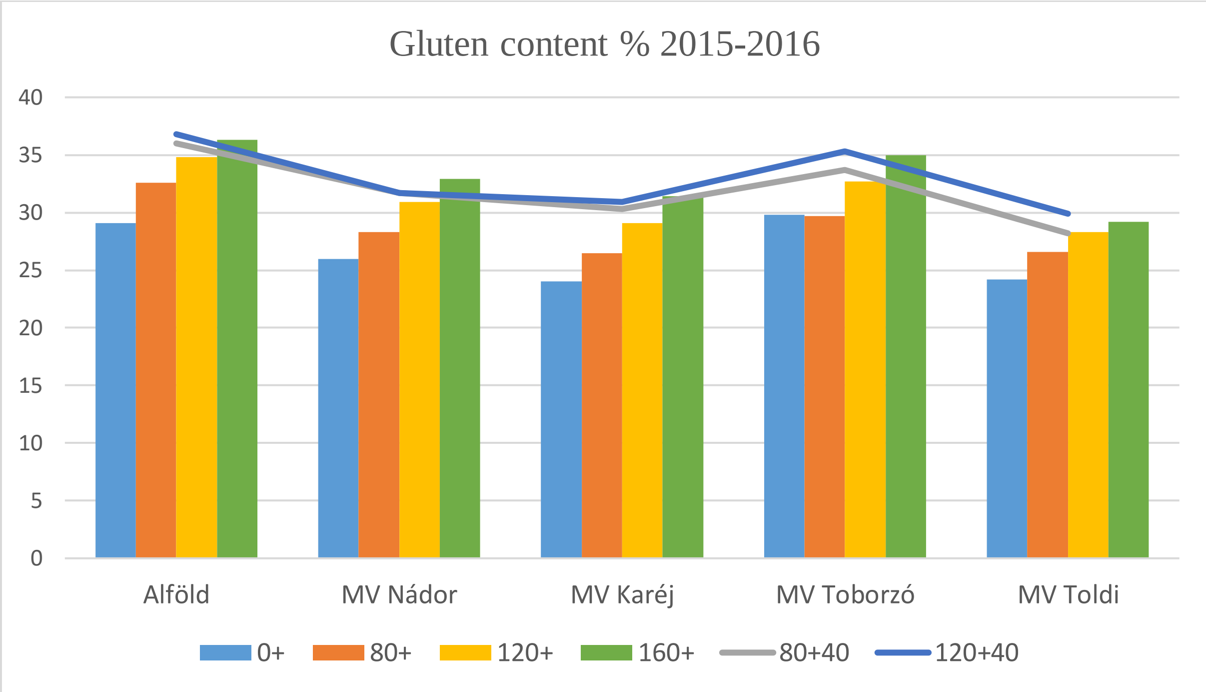


34. Figure Impact of N topdressing applications on protein content in Alföld. 2015-2016 and 2016–2017 (Nagygombos, Hungary) and 2018-2019 (Gödöllő, Hungary) combined.

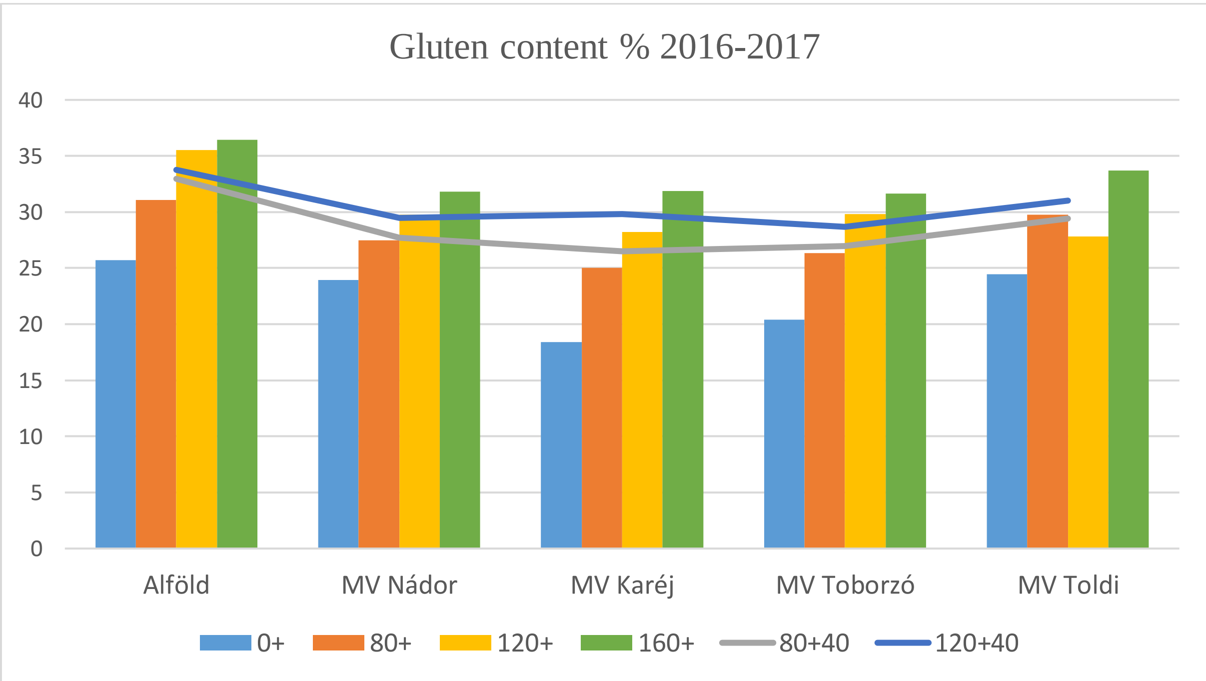


35. Figure Impact of N topdressing applications on protein content of MV Karéj. 2015-2016 and 2016–2017 (Nagygombos, Hungary) and 2018-2019 (Gödöllő, Hungary) combined.

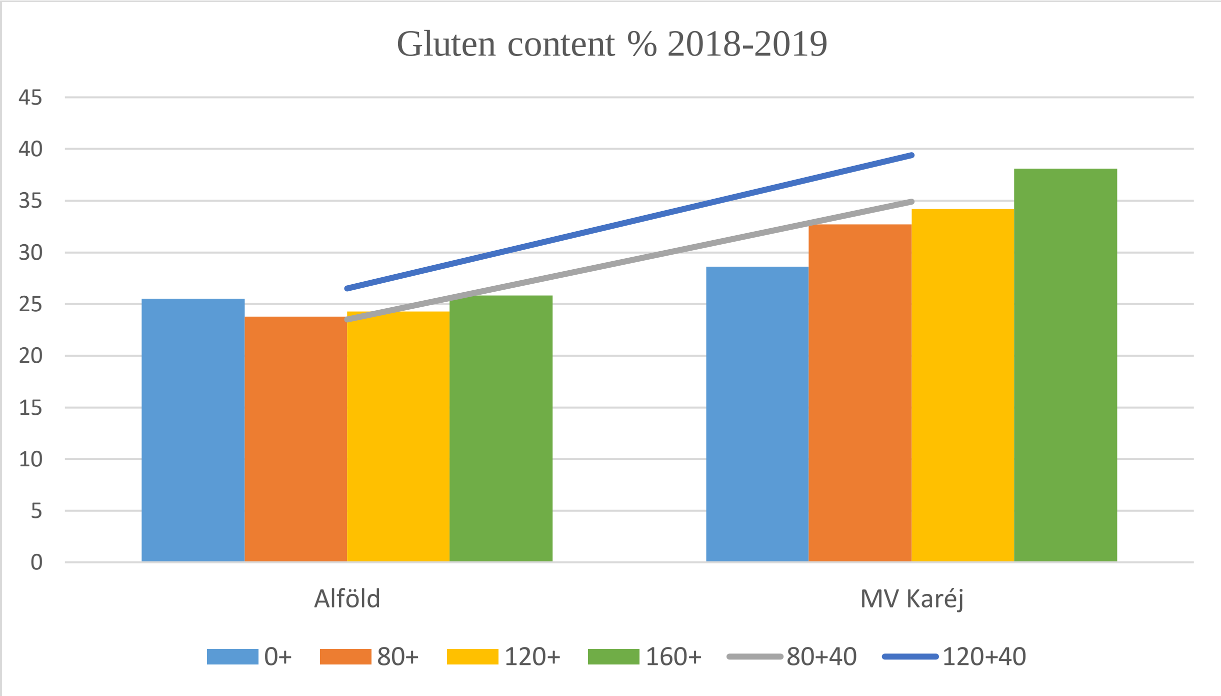
12.5. Gluten Content



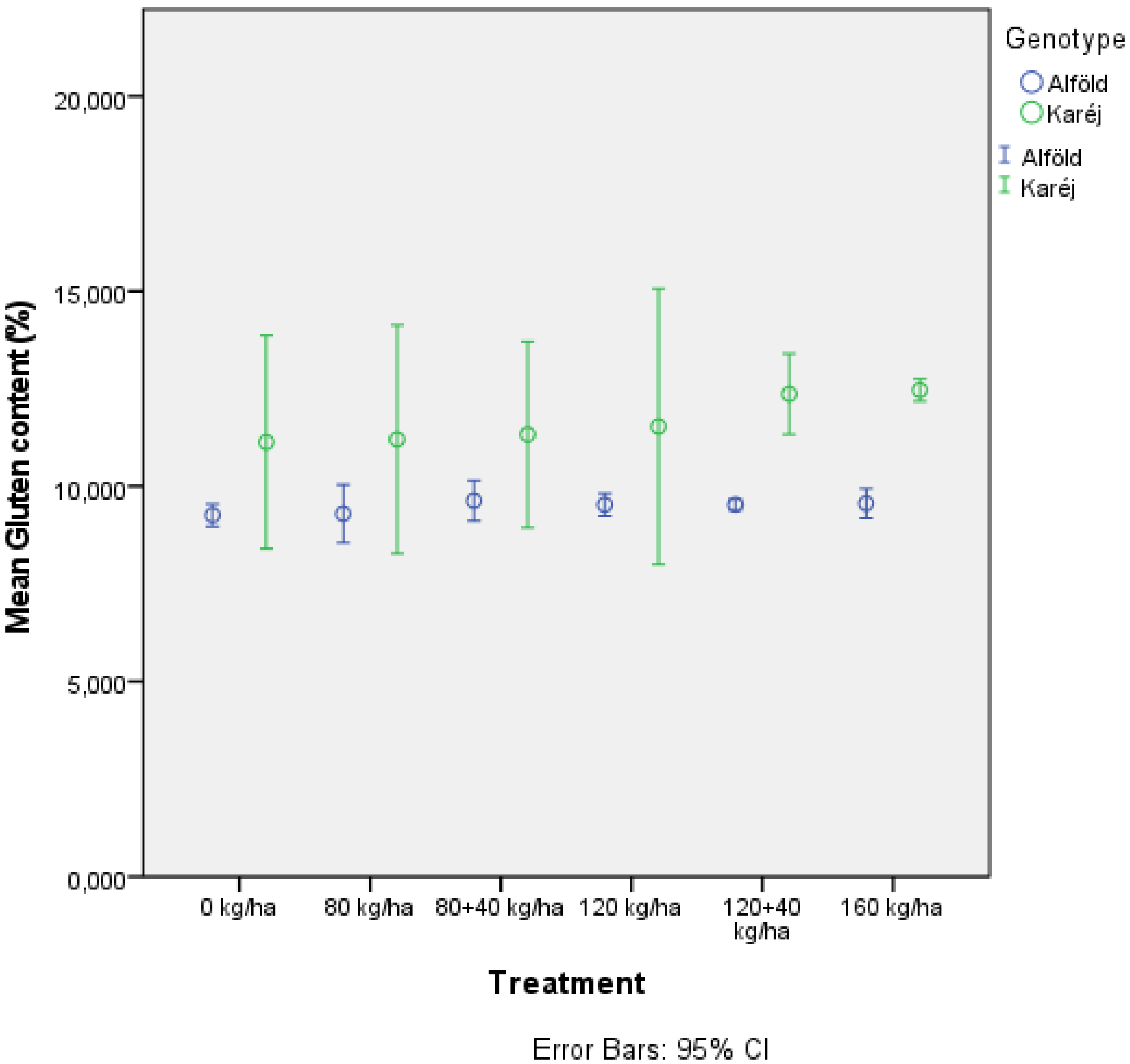
36. Figure Impact of N topdressing applications on gluten content of wheat varieties. 2015-2016 (Nagygombos, Hungary)



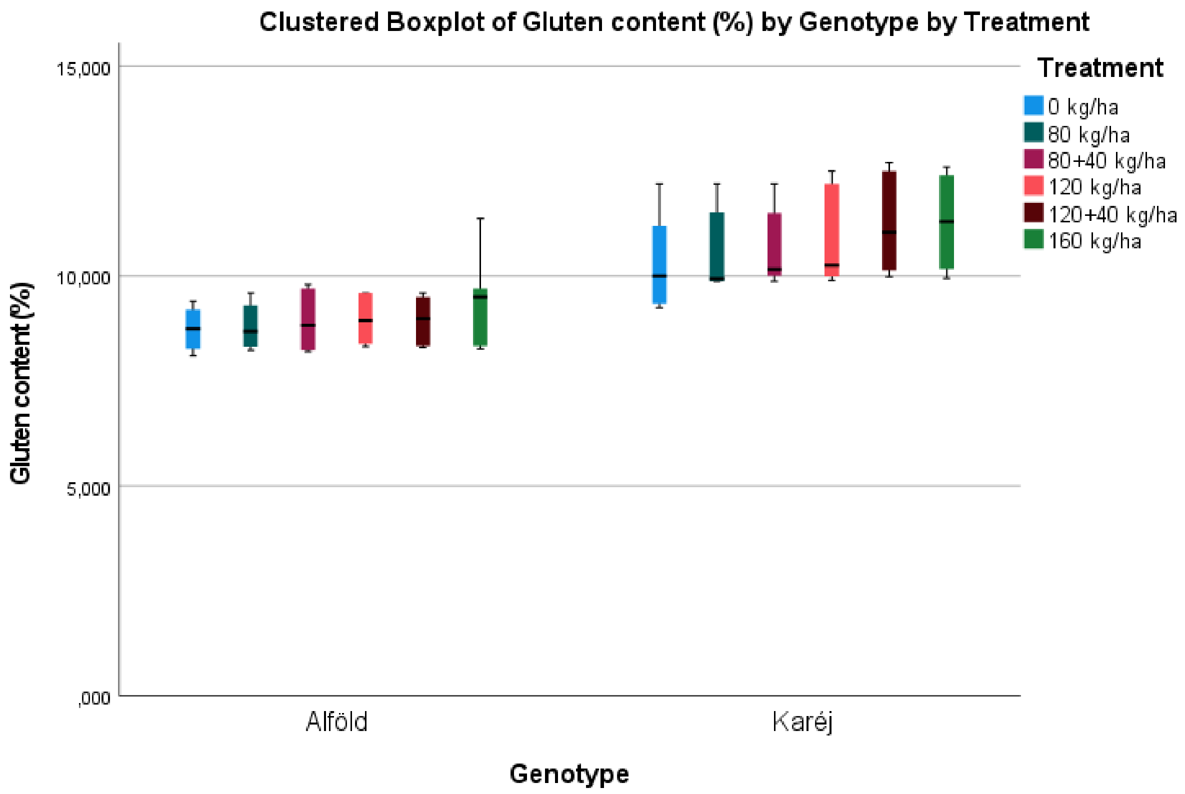
37. Figure Impact of N topdressing applications on gluten content of wheat varieties. 2016-2017 (Nagygombos, Hungary)



38. Figure Impact of N topdressing applications on gluten content of wheat varieties. 2018-2019 (Gödöllő, Hungary) 2



39. Figure Impact of N topdressing applications on gluten content of wheat varieties. 2018–2019 (Gödöllő, Hungary) 3



40. Figure Impact of N topdressing applications on gluten content of wheat varieties. 2015-2016 and 2016–2017 (Nagygombos, Hungary) and 2018-2019 (Gödöllő, Hungary) combined.

12.6. Anova-Spss outputs

12.6.1. Examination of Parameters According to Categorical Variables in Different Years

		N	M	SD	F	df	p
Test Weight (hl)	2016	36	78.07	0.67	86.509	2.105	.000
	2017	36	76.42	2.94			
	2019	36	71.33	2.52			
Thousand Kernel Weight (g)	2016	36	43.18	2.33	3.910	2.105	.023
	2017	36	41.20	5.39			
	2019	36	41.07	2.07			
Falling Number	2016	36	365.47	56.47	42.200	2.105	.000
	2017	36	528.32	116.18			
	2019	36	396.30	49.66			
Protein Content (%)	2016	36	14.53	1.19	8.829	2.105	.000
	2017	36	13.47	1.82			
	2019	36	14.93	1.48			
Moisture Content (%)	2016	36	8.12	1.67	83.241	2.105	.000
	2017	36	9.97	0.35			
	2019	36	13.13	2.33			
Gluten Content (%)	2016	36	31.47	4.24	297.147	2.105	.000
	2017	36	29.61	5.38			
	2019	36	10.57	1.32			
Zeleny Number	2016	36	34.11	6.94	18.886	2.105	.000
	2017	36	43.22	9.38			
	2019	36	34.52	3.90			

36. Table Impact of undivided/split N topdressing applications on wheat grain based on years, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.2. Examination of Parameters According to Categorical Variables in Different Sites-Hatvan

12.6.2.1. Comparison of the Means of Parameters Measured in Hatvan-Nagygombos Based on Year

		N	M	SD	t	df	p
Test Weight (hl)	2016	36	78.07	0.67	3.280	38.601	.002
	2017	36	76.42	2.94			
Thousand Kernel Weight (g)	2016	36	43.18	2.33	2.026	47.655	.048
	2017	36	41.20	5.39			

Falling Number	2016	36	365.47	56.47	-7.564	50.660	.000
	2017	36	528.32	116.18			
Protein Content (%)	2016	36	14.53	1.19	2.919	60.304	.005
	2017	36	13.47	1.82			
Moisture Content (%)	2016	36	8.12	1.67	-6.508	38.017	.000
	2017	36	9.97	0.35			
Gluten Content (%)	2016	36	31.47	4.24	1.635	70	.107
	2017	36	29.61	5.38			
Zeleny Number	2016	36	34.11	6.94	-4.682	70	.000
	2017	36	43.22	9.38			

37. Table Impact of undivided/split N topdressing applications on wheat grain based on Hatvan-Nagygombos site, 2015-2016 and 2016-2017 crop seasons, Spss-One Way Anova

12.6.2.2. Comparison of the Means of Parameters Measured in Hatvan-Nagygombos Based on Genotype

		N	M	SD	t	df	p
Test Weight (hl)	Alföld	36	78.83	0.83	8.278	45.180	.000
	Karéj	36	75.66	2.15			
Thousand Kernel Weight (g)	Alföld	36	38.75	3.03	-11.836	55.378	.000
	Karéj	36	45.63	1.72			
Falling Number	Alföld	36	521.01	119.56	6.447	55.885	.000
	Karéj	36	372.79	68.79			
Protein Content (%)	Alföld	36	14.85	1.26	5.159	70	.000
	Karéj	36	13.16	1.50			
Moisture Content (%)	Alföld	36	8.11	1.66	-6.618	38.268	.000
	Karéj	36	9.98	0.36			
Gluten Content (%)	Alföld	36	33.41	3.66	6.117	70	.000
	Karéj	36	27.67	4.28			
Zeleny Number	Alföld	36	40.08	9.58	1.286	70	.203
	Karéj	36	37.25	9.10			

38. Table Impact of undivided/split N topdressing applications on wheat grain based on Hatvan-Nagygombos site by Genotype, 2015-2016 and 2016-2017 crop seasons, Spss-One Way Anova

12.6.2.3. Comparison of the Means of Parameters Measured in Hatvan-Nagygombos Based on Treatment

		N	M	SD	F	df	p
Test Weight (hl)	0 kg/ha	12	77.36	2.35	.124	5.66	.986
	80 kg/ha	12	77.43	2.45			
	80+40 kg/ha	12	77.38	2.31			

	120 kg/ha	12	76.97	2.33			
	120+40 kg/ha	12	77.43	2.35			
	160 kg/ha	12	76.91	2.29			
Thousand Kernel Weight (g)	0 kg/ha	12	43.22	4.23	.208	5.66	.958
	80 kg/ha	12	42.16	4.12			
	80+40 kg/ha	12	42.23	4.43			
	120 kg/ha	12	41.98	4.34			
	120+40 kg/ha	12	42.09	4.50			
	160 kg/ha	12	41.45	4.55			
Falling Number	0 kg/ha	12	389.38	86.66	.813	5.66	.545
	80 kg/ha	12	437.33	110.76			
	80+40 kg/ha	12	446.99	123.54			
	120 kg/ha	12	463.99	133.08			
	120+40 kg/ha	12	462.00	127.34			
	160 kg/ha	12	481.69	148.08			
Protein Content (%)	0 kg/ha	12	12.03	1.61	9.227	5.66	.000
	80 kg/ha	12	13.39	1.23			
	80+40 kg/ha	12	14.26	1.49			
	120 kg/ha	12	14.45	1.22			
	120+40 kg/ha	12	14.78	1.11			
	160 kg/ha	12	15.11	0.95			
Moisture Content (%)	0 kg/ha	12	9.12	1.63	.023	5.66	1.000
	80 kg/ha	12	9.06	1.56			
	80+40 kg/ha	12	8.93	1.64			
	120 kg/ha	12	9.08	1.58			
	120+40 kg/ha	12	9.08	1.49			
	160 kg/ha	12	9.01	1.55			
Gluten Content (%)	0 kg/ha	12	24.28	4.71	10.307	5.66	.000
	80 kg/ha	12	28.79	3.89			
	80+40 kg/ha	12	31.43	4.19			
	120 kg/ha	12	31.89	3.64			
	120+40 kg/ha	12	32.84	3.28			
	160 kg/ha	12	34.02	2.83			
Zeleny Number	0 kg/ha	12	25.83	7.65	13.155	5.66	.000
	80 kg/ha	12	35.14	7.03			
	80+40 kg/ha	12	40.27	6.09			
	120 kg/ha	12	41.58	7.79			
	120+40 kg/ha	12	43.66	4.83			
	160 kg/ha	12	45.53	7.49			

39. Table Impact of undivided/split N topdressing applications on wheat grain, based on Hatvan-Nagygombos site by Treatments, 2015-2016 and 2016-2017 crop seasons, Spss-One Way Anova

12.6.3. Examination of Parameters According to Categorical Variables in Different Sites-Gödöllő

12.6.3.1. Comparison of the Means of Parameters Measured in Gödöllő Based on Genotypes

		N	M	SD	t	df	p
Test Weight (hl)	Alföld	18	72.22	1.90	2.259	30.046	.031
	Karéj	18	70.43	2.78			
Thousand Kernel Weight (g)	Alföld	18	39.87	1.09	-4.213	25.211	.000
	Karéj	18	42.26	2.15			
Falling Number	Alföld	18	424.37	42.50	4.080	34	.000
	Karéj	18	368.22	40.03			
Protein Content (%)	Alföld	18	14.21	0.86	-3.285	25.677	.003
	Karéj	18	15.65	1.64			
Moisture Content (%)	Alföld	18	12.21	2.78	-2.549	34	.015
	Karéj	18	14.05	1.27			
Gluten Content (%)	Alföld	18	9.47	0.21	-9.210	18.451	.000
	Karéj	18	11.67	0.99			
Zeleny Number	Alföld	18	35.53	2.37	1.589	24.662	.125
	Karéj	18	33.51	4.85			

40. Table Impact of undivided/split N topdressing applications on wheat grain based on Gödöllő site by Genotype, 2018-2019 crop seasons, Spss-One Way Anova

12.6.3.2. Comparison of the Means of Parameters Measured in Gödöllő Based on Treatment

		N	M	SD	F	df	p
Test Weight (hl)	0 kg/ha	6	70.03	1.98	1.220	5.30	.324
	80 kg/ha	6	71.99	2.62			
	80+40 kg/ha	6	72.33	2.53			
	120 kg/ha	6	72.48	2.59			
	120+40 kg/ha	6	71.10	2.81			
	160 kg/ha	6	70.02	2.26			
Thousand Kernel Weight (g)	0 kg/ha	6	39.87	1.84	.946	5.30	.466
	80 kg/ha	6	40.83	2.35			
	80+40 kg/ha	6	41.26	2.49			
	120 kg/ha	6	42.39	2.12			
	120+40 kg/ha	6	41.29	1.82			
	160 kg/ha	6	40.77	1.75			
Falling Number	0 kg/ha	6	369.67	44.91	1.252	5.30	.310
	80 kg/ha	6	373.67	21.93			
	80+40 kg/ha	6	414.44	57.19			

	120 kg/ha	6	416.39	51.77			
	120+40 kg/ha	6	417.11	70.28			
	160 kg/ha	6	386.50	29.91			
Protein Content (%)	0 kg/ha	6	13.71	0.92	2.370	5.30	.063
	80 kg/ha	6	14.20	1.34			
	80+40 kg/ha	6	15.18	1.17			
	120 kg/ha	6	14.88	1.93			
	120+40 kg/ha	6	15.77	1.30			
	160 kg/ha	6	15.85	1.29			
Moisture Content (%)	0 kg/ha	6	12.19	0.84	1.165	5.30	.349
	80 kg/ha	6	12.72	1.02			
	80+40 kg/ha	6	13.58	0.90			
	120 kg/ha	6	11.89	5.17			
	120+40 kg/ha	6	14.32	1.26			
	160 kg/ha	6	14.09	0.92			
Gluten Content (%)	0 kg/ha	6	10.20	1.24	.370	5.30	.865
	80 kg/ha	6	10.25	1.30			
	80+40 kg/ha	6	10.48	1.12			
	120 kg/ha	6	10.53	1.42			
	120+40 kg/ha	6	10.95	1.57			
	160 kg/ha	6	11.02	1.59			
Zeleny Number	0 kg/ha	6	31.25	5.57	3.884	5.30	.008
	80 kg/ha	6	32.27	3.22			
	80+40 kg/ha	6	34.34	1.90			
	120 kg/ha	6	34.12	3.29			
	120+40 kg/ha	6	37.95	2.11			
	160 kg/ha	6	37.18	2.07			

41. Table Impact of undivided/split N topdressing applications on wheat grain based on Gödöllő site by Treatment, 2018-2019 crop seasons, Spss-One Way Anova

12.6.4. Examination of Parameters According to Categorical Variables in Different Genotypes

12.6.4.1. Comparison of the Means of Parameters Measured for Alföld Genotype Based on Year

		N	M	SD	F	df	p
Test Weight (hl)	2016	18	78.47	0.44	166.885	2.51	.000
	2017	18	79.19	0.97			
	2019	18	72.22	1.90			
Thousand Kernel Weight (g)	2016	18	41.20	0.81	46.646	2.51	.000
	2017	18	36.30	2.36			
	2019	18	39.87	1.09			

Falling Number	2016	18	418.46	18.03	82.101	2.51	.000
	2017	18	623.56	82.67			
	2019	18	424.37	42.50			
Protein Content (%)	2016	18	15.14	1.02	3.065	2.51	.055
	2017	18	14.56	1.43			
	2019	18	14.21	0.86			
Moisture Content (%)	2016	18	6.49	0.20	56.663	2.51	.000
	2017	18	9.73	0.27			
	2019	18	12.21	2.78			
Gluten Content (%)	2016	18	34.24	3.15	395.263	2.51	.000
	2017	18	32.58	4.03			
	2019	18	9.47	0.21			
Zeleny Number	2016	18	33.24	6.54	30.463	2.51	.000
	2017	18	46.93	6.85			
	2019	18	35.53	2.37			

42. Table Impact of undivided/split N topdressing applications on wheat grain based on Alföld genotype by years, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.4.2. Comparison of the Means of Parameters Measured for Alföld Genotype Based on Site

		N	M	SD	t	df	p
Test Weight (hl)	Hatvan	36	78.83	0.83	14.089	20.283	.000
	Gödöllő	18	72.22	1.90			
Thousand Kernel Weight (g)	Hatvan	36	38.75	3.03	-1.976	48.718	.054
	Gödöllő	18	39.87	1.09			
Falling Number	Hatvan	36	521.01	119.56	4.333	48.541	.000
	Gödöllő	18	424.37	42.50			
Protein Content (%)	Hatvan	36	14.85	1.26	1.917	52	.061
	Gödöllő	18	14.21	0.86			
Moisture Content (%)	Hatvan	36	8.11	1.66	-6.786	52	.000
	Gödöllő	18	12.21	2.78			
Gluten Content (%)	Hatvan	36	33.41	3.66	39.102	35.438	.000
	Gödöllő	18	9.47	0.21			
Zeleny Number	Hatvan	36	40.08	9.58	2.693	42.747	.010
	Gödöllő	18	35.53	2.37			

43. Table Impact of undivided/split N topdressing applications on wheat grain based on Alföld genotype by Site, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.4.3. Comparison of the Means of Parameters Measured for Alföld Genotype Based on Treatment

		N	M	SD	F	df	p
Test Weight (hl)	0 kg/ha	9	76.34	4.35	.171	5.48	.972
	80 kg/ha	9	77.08	3.36			
	80+40 kg/ha	9	76.94	3.05			
	120 kg/ha	9	76.81	2.81			
	120+40 kg/ha	9	76.83	3.42			
	160 kg/ha	9	75.77	3.98			
Thousand Kernel Weight (g)	0 kg/ha	9	39.40	1.89	.082	5.48	.995
	80 kg/ha	9	38.96	2.28			
	80+40 kg/ha	9	39.11	2.82			
	120 kg/ha	9	39.21	2.86			
	120+40 kg/ha	9	39.34	3.27			
	160 kg/ha	9	38.70	2.95			
Falling Number	0 kg/ha	9	431.35	72.43	.765	5.48	.580
	80 kg/ha	9	468.65	103.24			
	80+40 kg/ha	9	503.40	103.38			
	120 kg/ha	9	514.01	115.96			
	120+40 kg/ha	9	506.40	111.29			
	160 kg/ha	9	508.98	148.43			
Protein Content (%)	0 kg/ha	9	13.08	1.15	10.543	5.48	.000
	80 kg/ha	9	13.96	0.75			
	80+40 kg/ha	9	14.96	0.87			
	120 kg/ha	9	15.09	0.71			
	120+40 kg/ha	9	15.20	0.86			
	160 kg/ha	9	15.50	0.69			
Moisture Content (%)	0 kg/ha	9	9.44	2.48	.268	5.48	.928
	80 kg/ha	9	9.48	2.48			
	80+40 kg/ha	9	9.62	2.98			
	120 kg/ha	9	8.52	3.69			
	120+40 kg/ha	9	9.93	2.92			
	160 kg/ha	9	9.86	3.00			
Gluten Content (%)	0 kg/ha	9	21.36	9.39	.308	5.48	.906
	80 kg/ha	9	24.32	11.37			
	80+40 kg/ha	9	26.19	12.58			
	120 kg/ha	9	26.60	12.81			
	120+40 kg/ha	9	26.70	13.04			
	160 kg/ha	9	27.42	13.41			
Zeleny Number	0 kg/ha	9	30.88	7.47	3.195	5.48	.014
	80 kg/ha	9	35.90	6.72			
	80+40 kg/ha	9	39.58	6.69			
	120 kg/ha	9	40.57	9.09			
	120+40 kg/ha	9	41.70	5.73			
	160 kg/ha	9	42.77	8.53			

44. Table Impact of undivided/split N topdressing applications on wheat grain based on Alföld genotype by Treatment, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.4.4. Comparison of the Means of Parameters Measured for Karéj Genotype Based on Year

		N	M	SD	F	df	p
Test Weight (hl)	2016	18	77.67	0.61	81.669	2.51	.000
	2017	18	73.65	0.76			
	2019	18	70.43	2.78			
Thousand Kernel Weight (g)	2016	18	45.16	1.49	21.077	2.51	.000
	2017	18	46.09	1.85			
	2019	18	42.26	2.15			
Falling Number	2016	18	312.49	17.15	53.958	2.51	.000
	2017	18	433.09	41.82			
	2019	18	368.22	40.03			
Protein Content (%)	2016	18	13.93	1.06	23.524	2.51	.000
	2017	18	12.39	1.51			
	2019	18	15.65	1.64			
Moisture Content (%)	2016	18	9.75	0.32	171.195	2.51	.000
	2017	18	10.22	0.22			
	2019	18	14.05	1.27			
Gluten Content (%)	2016	18	28.71	3.29	128.146	2.51	.000
	2017	18	26.63	4.96			
	2019	18	11.67	0.99			
Zeleny Number	2016	18	34.99	7.40	2.879	2.51	.065
	2017	18	39.51	10.25			
	2019	18	33.51	4.85			

45. Table Impact of undivided/split N topdressing applications on wheat grain based on Karéj genotype by Year, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.4.5. Comparison of the Means of Parameters Measured for Karéj Genotype Based on Site

		N	M	SD	t	df	p
Test Weight (hl)	Hatvan	36	75.66	2.15	7.000	27.452	.000
	Gödöllő	18	70.43	2.78			
Thousand Kernel Weight (g)	Hatvan	36	45.63	1.72	5.788	28.231	.000
	Gödöllő	18	42.26	2.15			
Falling Number	Hatvan	36	372.79	68.79	.307	50.641	.760
	Gödöllő	18	368.22	40.03			

Protein Content (%)	Hatvan	36	13.16	1.50	-5.561	52	.000
	Gödöllő	18	15.65	1.64			
Moisture Content (%)	Hatvan	36	9.98	0.36	-13.349	18.380	.000
	Gödöllő	18	14.05	1.27			
Gluten Content (%)	Hatvan	36	27.67	4.28	21.316	41.942	.000
	Gödöllő	18	11.67	0.99			
Zeleny Number	Hatvan	36	37.25	9.10	1.971	51.711	.054
	Gödöllő	18	33.51	4.85			

46. Table Impact of undivided/split N topdressing applications on wheat grain based on Karéj genotype by Site, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

12.6.4.6. Comparison of the Means of Parameters Measured for Karéj Genotype Based on Treatment

		N	M	SD	F	df	p
Test Weight (hl)	0 kg/ha	9	73.48	3.66	.112	5.48	.989
	80 kg/ha	9	74.15	3.35			
	80+40 kg/ha	9	74.45	3.35			
	120 kg/ha	9	74.13	3.13			
	120+40 kg/ha	9	73.81	3.97			
	160 kg/ha	9	73.45	3.92			
Thousand Kernel Weight (g)	0 kg/ha	9	44.80	3.52	.280	5.48	.922
	80 kg/ha	9	44.46	2.33			
	80+40 kg/ha	9	44.70	2.42			
	120 kg/ha	9	45.02	1.32			
	120+40 kg/ha	9	44.31	2.39			
	160 kg/ha	9	43.75	2.74			
Falling Number	0 kg/ha	9	334.27	35.14	1.103	5.48	.371
	80 kg/ha	9	363.57	48.24			
	80+40 kg/ha	9	368.89	51.92			
	120 kg/ha	9	382.23	62.81			
	120+40 kg/ha	9	387.68	77.96			
	160 kg/ha	9	390.95	73.29			
Protein Content (%)	0 kg/ha	9	12.09	1.91	4.060	5.48	.004
	80 kg/ha	9	13.35	1.66			
	80+40 kg/ha	9	14.17	1.80			
	120 kg/ha	9	14.10	1.84			
	120+40 kg/ha	9	15.01	1.58			
	160 kg/ha	9	15.21	1.43			
Moisture Content (%)	0 kg/ha	9	10.84	1.25	.206	5.48	.958
	80 kg/ha	9	11.08	1.76			
	80+40 kg/ha	9	11.33	2.13			
	120 kg/ha	9	11.51	2.33			
	120+40 kg/ha	9	11.72	2.72			
	160 kg/ha	9	11.55	2.47			

Gluten Content (%)	0 kg/ha	9	17.82	5.96	.909	5.48	.483
	80 kg/ha	9	20.90	7.60			
	80+40 kg/ha	9	22.71	8.91			
	120 kg/ha	9	22.93	8.70			
	120+40 kg/ha	9	24.39	9.10			
	160 kg/ha	9	25.28	9.73			
Zeleny Number	0 kg/ha	9	24.39	5.92	14.195	5.48	.000
	80 kg/ha	9	32.47	5.19			
	80+40 kg/ha	9	37.00	4.73			
	120 kg/ha	9	37.62	5.52			
	120+40 kg/ha	9	41.82	4.29			
	160 kg/ha	9	42.72	6.47			

47. Table Impact of undivided/split N topdressing applications on wheat grain based on Karéj genotype by Treatment, 2015-2016, 2016-2017 and 2018-2019 crop seasons, Spss-One Way Anova

	ANOVA by treatments						
			Sum of Squares	df	Mean Square	F	Sig.
Alföld	Test weight(hl)	Between Groups	11,987	5	2,397	2,193	,061
		Within Groups	111,484	102	1,093		
		Total	123,471	107			
	Thousand kernel weight(g)	Between Groups	27,954	5	5,591	,513	,766
		Within Groups	1110,874	102	10,891		
		Total	1138,829	107			
	Falling number	Between Groups	160764,750	5	32152,950	2,220	,058
		Within Groups	1477427,352	102	14484,582		
		Total	1638192,102	107			
	Protein	Between Groups	111,323	5	22,265	18,682	,000
		Within Groups	121,559	102	1,192		
		Total	232,882	107			
	Gluten	Between Groups	987,878	5	197,576	21,084	,000
		Within Groups	955,809	102	9,371		
		Total	1943,687	107			
	Zeleny	Between Groups	3659,712	5	731,942	9,528	,000
		Within Groups	7835,598	102	76,820		
		Total	11495,310	107			

MV-Nádor	Test weight(hl)	Between Groups	9,561	5	1,912	1,503	,195
		Within Groups	129,750	102	1,272		
		Total	139,312	107			
	Thousand kernel weight(g)	Between Groups	138,837	5	27,767	6,244	,000
		Within Groups	453,604	102	4,447		
		Total	592,440	107			
	Falling number	Between Groups	5606,264	5	1121,253	0,095	,993
		Within Groups	1206753,401	102	11830,916		
		Total	1212359,666	107			
	Protein	Between Groups	65,112	5	13,022	16,210	,000
		Within Groups	81,941	102	0,803		
		Total	147,052	107			
	Gluten	Between Groups	592,986	5	118,597	15,686	,000
		Within Groups	771,184	102	7,561		
		Total	1364,170	107			
	Zeleny	Between Groups	2374,650	5	474,930	9,763	,000
		Within Groups	4962,066	102	48,648		
		Total	7336,717	107			
MV-Karéj	Test weight(hl)	Between Groups	3,233	5	,647	,126	,986

		Within Groups	521,596	102	5,114		
		Total	524,829	107			
	Thousand kernel weight(g)	Between Groups	81,695	5	16,339	1,337	,255
		Within Groups	1246,449	102	12,220		
		Total	1328,144	107			
	Falling number	Between Groups	44637,317	5	8927,463	1,811	,117
		Within Groups	502698,593	102	4928,418		
		Total	547335,909	107			
	Protein	Between Groups	121,323	5	24,265	13,861	,000
		Within Groups	178,559	102	1,751		
		Total	299,883	107			
	Gluten	Between Groups	1279,148	5	255,830	19,902	,000
		Within Groups	1311,162	102	12,855		
		Total	2590,309	107			
	Zeleny	Between Groups	6202,355	5	1240,471	22,893	,000
		Within Groups	5526,898	102	54,185		
		Total	11729,253	107			
MV-Toborzó	Test weight(hl)	Between Groups	2,106	5	,421	,081	,995
		Within Groups	529,535	102	5,192		
		Total	531,641	107			

	Thousand kernel weight(g)	Between Groups	131,000	5	26,200	1,048	,394
		Within Groups	2551,082	102	25,011		
		Total	2682,082	107			
	Falling number	Between Groups	33203,598	5	6640,720	,493	,781
		Within Groups	1374205,673	102	13472,605		
		Total	1407409,271	107			
	Protein	Between Groups	75,826	5	15,165	6,574	,000
		Within Groups	235,308	102	2,307		
		Total	311,134	107			
	Gluten	Between Groups	797,881	5	159,576	9,944	,000
		Within Groups	1636,827	102	16,047		
		Total	2434,708	107			
	Zeleny	Between Groups	3676,516	5	735,303	22,665	,000
		Within Groups	3309,076	102	32,442		
		Total	6985,592	107			
MV-Toldi	Test weight (hl)	Between Groups	20,703	5	4,141	,702	,623
		Within Groups	601,572	102	5,898		
		Total	622,275	107			
		Between Groups	93,379	5	18,676	3,692	,004

	Thousand kernel weight(g)	Within Groups	515,915	102	5,058		
		Total	609,294	107			
	Falling number	Between Groups	26999,588	5	5399,918	,152	,979
		Within Groups	3624628,161	102	35535,570		
		Total	3651627,749	107			
	Protein	Between Groups	53,587	5	10,717	8,847	,000
		Within Groups	123,571	102	1,211		
		Total	177,159	107			
	Gluten	Between Groups	545,280	5	109,056	7,548	,000
		Within Groups	1473,787	102	14,449		
		Total	2019,068	107			
	Zeleny	Between Groups	3088,550	5	617,710	10,289	,000
		Within Groups	6123,849	102	60,038		
		Total	9212,399	107			

48. Table Impact of undivided/split N topdressing applications on wheat grain, 2015-2016 and 2016-2017 crop seasons, Spss-One Way Anova

	ANOVA[a]						
			Sum of Squares	df	Mean Square	F	Sig.
	Test weight (hl)	Between Groups	3,010	1	3,010	,729	,441
		Within Groups	16,523	4	4,131		

		Total	19,534	5			
	Thousand kernel weight (g)	Between Groups	7,504	1	7,504	3,195	,148
		Within Groups	9,394	4	2,349		
		Total	16,898	5			
	Falling number	Between Groups	9178,074	1	9178,074	40,445	,003
		Within Groups	907,704	4	226,926		
		Total	10085,778	5			
	Protein content (%)	Between Groups	,256	1	,256	,260	,637
		Within Groups	3,936	4	,984		
		Total	4,192	5			
	Moisture content (%)	Between Groups	,205	1	,205	,250	,643
		Within Groups	3,286	4	,821		
		Total	3,491	5			
	Gluten content (%)	Between Groups	5,227	1	5,227	8,522	,043
		Within Groups	2,453	4	,613		
		Total	7,680	5			
	Zeleny number	Between Groups	103,335	1	103,335	8,017	,047
		Within Groups	51,560	4	12,890		
		Total	154,895	5			

49. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 0kg/ha, Spss-One Way Anova

	ANOVA[a]					
Treat		Sum of Squares	df	Mean Square	F	Sig.

	Test weight (hl)	Between Groups	4,770	1	4,770	,644	,467
		Within Groups	29,627	4	7,407		
		Total	34,397	5			
	Thousand kernel weight (g)	Between Groups	11,676	1	11,676	2,926	,162
		Within Groups	15,962	4	3,990		
		Total	27,638	5			
	Falling number	Between Groups	711,407	1	711,407	1,680	,265
		Within Groups	1693,481	4	423,370		
		Total	2404,889	5			
	Protein content (%)	Between Groups	3,496	1	3,496	2,580	,183
		Within Groups	5,419	4	1,355		
		Total	8,915	5			
	Moisture content (%)	Between Groups	1,771	1	1,771	2,085	,222
		Within Groups	3,399	4	,850		
		Total	5,170	5			
	Gluten content (%)	Between Groups	5,434	1	5,434	7,328	,054
		Within Groups	2,966	4	,742		
		Total	8,400	5			
	Zeleny number	Between Groups	13,500	1	13,500	1,406	,301
		Within Groups	38,393	4	9,598		
		Total	51,893	5			

50. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 80kg/ha, Spss-One Way Anova

	ANOVA[a]

			Sum of Squares	df	Mean Square	F	Sig.
Treatment = 80+40 kg/ha	Test weight(hl)	Between Groups	3,682	1	3,682	,521	,510
		Within Groups	28,257	4	7,064		
		Total	31,938	5			
	Thousand kernel weight (g)	Between Groups	8,520	1	8,520	1,523	,285
		Within Groups	22,372	4	5,593		
		Total	30,892	5			
	Falling number	Between Groups	11208,963	1	11208,963	8,716	,042
		Within Groups	5144,296	4	1286,074		
		Total	16353,259	5			
	Protein content (%)	Between Groups	2,707	1	2,707	2,647	,179
		Within Groups	4,091	4	1,023		
		Total	6,798	5			
	Moisture content (%)	Between Groups	1,335	1	1,335	1,965	,234
		Within Groups	2,717	4	,679		
		Total	4,052	5			
	Gluten content (%)	Between Groups	4,335	1	4,335	8,969	,040
		Within Groups	1,933	4	,483		
		Total	6,268	5			
	Zeleny number	Between Groups	5,549	1	5,549	1,771	,254
		Within Groups	12,535	4	3,134		
		Total	18,084	5			

51. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 80+40 kg/ha, Spss-One Way Anova

	ANOVA[a]						
Treatment = 120 kg/ha			Sum of Squares	df	Mean Square	F	Sig.
	Test weight (hl)	Between Groups	4,507	1	4,507	,621	,475
		Within Groups	29,027	4	7,257		
		Total	33,533	5			
	Thousand kernel weight (g)	Between Groups	20,572	1	20,572	44,062	,003
		Within Groups	1,868	4	,467		
		Total	22,440	5			
	Falling number	Between Groups	7049,796	1	7049,796	4,440	,103
		Within Groups	6351,407	4	1587,852		
		Total	13401,204	5			
	Protein content (%)	Between Groups	1,938	1	1,938	,466	,532
		Within Groups	16,627	4	4,157		
		Total	18,565	5			
	Moisture content (%)	Between Groups	40,925	1	40,925	1,768	,254
		Within Groups	92,579	4	23,145		
		Total	133,504	5			
	Gluten content (%)	Between Groups	6,000	1	6,000	5,892	,072
		Within Groups	4,073	4	1,018		
		Total	10,073	5			
	Zeleny number	Between Groups	,735	1	,735	,055	,826
		Within Groups	53,433	4	13,358		
		Total	54,168	5			

52. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 120 kg/ha, Spss-One Way Anova

	ANOVA[a]						
Treatment = 120+40 kg/ha			Sum of Squares	df	Mean Square	F	Sig.
	Test weight(hl)	Between Groups	10,935	1	10,935	1,528	,284
		Within Groups	28,620	4	7,155		
		Total	39,555	5			
	Thousand kernel weight (g)	Between Groups	5,078	1	5,078	1,772	,254
		Within Groups	11,461	4	2,865		
		Total	16,539	5			
	Falling number	Between Groups	4231,185	1	4231,185	,827	,415
		Within Groups	20464,074	4	5116,019		
		Total	24695,259	5			
	Protein content (%)	Between Groups	6,242	1	6,242	11,355	,028
		Within Groups	2,199	4	,550		
		Total	8,441	5			
	Moisture content (%)	Between Groups	5,684	1	5,684	9,873	,035
		Within Groups	2,303	4	,576		
		Total	7,987	5			
	Gluten content (%)	Between Groups	12,042	1	12,042	136,321	<,001
		Within Groups	,353	4	,088		
		Total	12,395	5			
	Zeleny number	Between Groups	,202	1	,202	,037	,858
		Within Groups	22,093	4	5,523		
		Total	22,295	5			

53. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 120+40 kg/ha, Spss-One Way Anova

	ANOVA[a]						
Treatment = 160 kg/ha			Sum of Squares	df	Mean Square	F	Sig.
	Test weight (hl)	Between Groups	3,682	1	3,682	,671	,459
		Within Groups	21,947	4	5,487		
		Total	25,628	5			
	Thousand kernel weight (g)	Between Groups	2,926	1	2,926	,950	,385
		Within Groups	12,323	4	3,081		
		Total	15,249	5			
	Falling number	Between Groups	1242,241	1	1242,241	1,538	,283
		Within Groups	3230,370	4	807,593		
		Total	4472,611	5			
	Protein content (%)	Between Groups	6,998	1	6,998	20,445	,011
		Within Groups	1,369	4	,342		
		Total	8,368	5			
	Moisture content (%)	Between Groups	3,154	1	3,154	11,485	,028
		Within Groups	1,098	4	,275		
		Total	4,252	5			
	Gluten content (%)	Between Groups	12,615	1	12,615	688,091	<,001
		Within Groups	,073	4	,018		
		Total	12,688	5			

	Zeleny number	Between Groups	3,082	1	3,082	,672	,458
		Within Groups	18,347	4	4,587		
		Total	21,428	5			

54. Table Impact of undivided/split N topdressing applications on wheat grain, 2018-2019 crop seasons 160 kg/ha, Spss-One Way Anova