The Crude Protein Content of Maize with Interseeding Cover Crop Technology

A kukorica nyersfehérje-tartalma a kukorica sorközeibe vetett takarónövényes technológiával

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Abstract: Maize is one of the plants with the largest sowing area in Hungary. Due to climate change, growing corn is becoming more and more risky. One of the mitigation options for climate exposure is the cultivation of cover crops. How different protective plants affect the protein content of maize. We set up our cover crop experiments in Szeged, chernozem soil. We tested a small-plot cover crop maize experiment in four replicates, in random block arrangement. The experiment aims to examine the protect plants planted between two rows when the maize is 6-8 leaves old. The experiment includes 20 cover crops and a control treatment. The crude protein content (%) of the maize was determined during the period of full ripening with a Foss Infratec1241 NIR grain analyzer. We used IBM SPSS Statistics 29 software, We analyzed the effect of cover crops on the crude protein content (%) of corn by means of One-Way ANOVA. In the first year the highest protein content of maize was obtained with the use of oil radish and white mustard cover crops ($p < 0{,}05$ significance level). A crude protein difference of nearly 1.5% was observed with the use of different protect plants.

Keywords: *cover crops; protein content of maize; protect plants; maize; interseeding cover crops*

Összefoglalás: A kukorica hazánkban az egyik legnagyobb termőterülettel rendelkező növény. A klímaváltozás miatt egyre kockázatosabbá válik a kapás kultúrák termesztése. A termesztéstechnológiák újragondolására, az egyre szárazabbá váló klímához való adaptációra van szükség a hazai kukoricatermesztésben. A klímakitettség egyik mérséklési lehetősége a takarónövényes termesztés. Agrotechnikai kísérleteinkben olyan a kérdésekre keressük a választ, hogy Szegedhez hasonló csapadékban szegény agroökológiai környezetben, milyen takarónövényeket lehet használni, illetve a különböző védőnövények hogyan hatnak a kukorica fehérjetartalmára. Takarónövényes kísérleteinket Szegeden állítottuk be, típusos mészlepedékes csernozjom talajon. Szántóföldi kisparcellás takarónövényes kukorica kísérletet négy ismétlésben, véletlen blokk elrendezésben, nettó 10,5m^2/parcella méretben vizsgáltuk. A kísérlet a kukorica 6-8 leveles állapotában a sorok közé vetett takarónövények (interseeding cover crops) vizsgálatát célozza. Ebben az esetben a kukorica és a takarónövények együtt fejlődnek egészen a kukorica betakarításáig, amikor a védőnövények továbbra is a talajon maradnak, és tovább fejlődnek. A takarónövények egy része télen kifagy a megmaradó növényeket pedig a kukorica vetése előtt 6 héttel termináljuk. Ezután egy regenerálódási idő következik a talaj számára, hogy felkészüljön a főnövény vetésére. A kísérlet 20 takarónövényt és egy kontroll kezelést tartalmaz. A kukorica betakarítását a teljesérés időszakában parcellakombájnnal végeztük és egyedileg jelölt papírzacskóba 500-600 g mintát vettünk minőségvizsgálat céljából. Foss Infratec1241 NIR gabonaanalizátorral meghatároztuk a szemeskukorica nyersfehérje-tartalmát (%). A kapott eredmények kiértékeléséhez IBM SPSS Statisztika 29. szoftvert és Microsoft Office Excel 2019 Professional Plus programokat használtunk. One-Way ANOVA segítségével elemeztük a takarónövények hatását a kukorica nyersfehérje-tartalmára (%). A kukorica interseeding cover crops-os kísérlet első évében a kukoricánál a legmagasabb fehérjetartalmat a Brassicaceae ssp. családba tartozó olajretek (Raphanus sativus L. convar. oleiferus) és fehér mustár (Sinapsis alba L.) takarónövények használata mellett mértünk ($p < 0,05$ szignifikancia szinten). A legalacsonyabb fehérjetartalom két pillangós esetében volt kimutatható, ezek a szegletes lednek (Lathyrus sativus L.), és a lucerna (Medicago sativa L.) voltak. Közel 1,5%-os nyersfehérje-különbség mutatkozott a különböző takarónövények használata mellett.

Kulcsszavak: *takarónövény; kukorica nyersfehérje-tartalom; védőnövény; kukorica; kukorica fehérje*

1. Introduction

The crude protein content of maize grains is usually between 9-12%. Crude protein values measured by different authors show a deviation between 6-15% (Nagy, 2021). The amount of protein in the endosperm of the corn grain is 8%, and 18,4 % in the germ. Prolamins or zeins account for nearly half of the protein in maize grains, glutens account for 35%, albumins account for 7%, and globulins account for 5% (Nuss et Tanumihardjo, 2011). The essential amino acid content of maize is deficient, the reason for this beeing the low content of lysine and tryptophan in zein proteins. Maize is also an important food plant in human nutrition. It is grown wordwide and plays a key role in global food security (Gayral et al., 2016). In developed countries, it is common to eat cornflakes for breakfast or to eat tortillas (Serna-Saldivar , 2016). Foods made from cornmeal can provide celiac sufferers with a gluten-free alternative (Zevallos et Herencia, 2016). In developing countries, it is crucial in their nutrition, because one of the basic foods is corn. Nowadays maize consumption is mainly in India and South Africa countries (Badu et Fakorede, (2017). Indian corn is also important in Hungary from the point of view of feeding animals, since corn accounts for nearly 40% of domestic protein requirements. Although the protein content of the corn is not outstanding, because it is one of the lowest among domestic abrac feeds, but since there is a serious tradition of growing maize in our country, it is the raw material available in the largest quantity (Tanács ,2005, Radics,2012). The protein content of corn is determined by the variety chosen. In 1952, Worth and his colleagues at the Illinois Experiment Station created „High protein corn",which had a protein content of nearly 20% (Gáspár, 1970). The fact that there is a negative correlation between maize yield and protein content is still a challange in improvement. The protein content is determined by the ecological factor. What is the habitat, and what is the crop year. The protein content is typically lower in rainy years, higher in years with poor rainfall (Széll et Dévényiné, 2009). The protein content is determined by agricultural technique used. Béla Győrffy already proved in his nutrient supply experiments in Martonvásár that the protein content of maize increases with increasing nitrogen doses (Győrffy,1958). His experiments on plant density confirmed that the protein content of maize decreases with an increase in the number of plants (Győrffy, 1959). The use of cover crops can modify the protein content of corn through several factors. As observed by Blanco et al. (2022) that cover crops reduced compaction and improved water infiltration, moderated evapotranspiration and affected the amount of water available to the cash-crop. Cover crops can bring up nutrients from different depths with their root system. Because of their root acids, they determine the solubility and absorption of various nutrients.(Wagg et al, 2014).The decomposition of cover crops and the subsequent release of nitrogen are highly dependent on soil water content and temperature Nitrogen uptake by cover crops can range from 10 to 45 kg nitrogen in a given area (Jüan et al, 2019).

2. Materials and Methods

Cover crop experiments were set up in Szeged, next to the Maty water reservoir and Olympic Center of Szeged on chernozem soil in 2023 (Figure. 1). On the agroclimatological map of Hungary, the experimantal area falls in the warmest and driest area. The purpose of the experiment is to examine what kind of cover crops can be used in the agroecological parts of Hungary with poor rainfall.

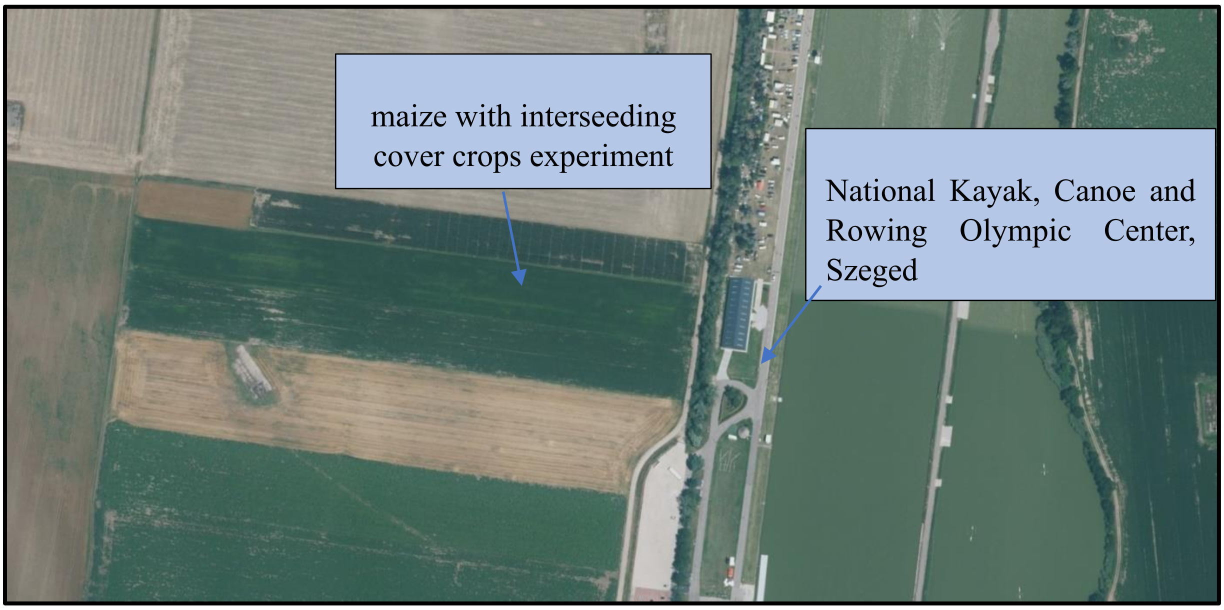

Figure 1. *The location of the experiment*

In the experiment, the cover crops are not mixed, so it is possible to name exactly the species that can be grown in this region. The plots have a gross area of 24 m^2 (net area 10,5 m^2 /plot), each treatment is examined in 4 repetitions in a random block arrangement.

Table 1. The cover crops included in the experiment

treatment	name
1.	Alfalfa (Medicago sativa L.)
2.	Red clover (*Trifolium pratense L.)*
3.	Crimson clover (*Trifolim incarnatum L.)*
4.	Sainfoin (*Onobrychis viciifolia Scop)*
5.	Kidney vetch (*Anthyllis vulneralia L.)*
6.	Birdsfoot trefoil *(Lotus corniculatus L)*
7.	Persian clover (*Trifolium resupinatum L.)*
8.	White sweet clover (*Melilotus albus Desr.*)
9.	Italian ryegrass (*Lolium multiflorum Lam. ssp. italicum A. Br)*
10.	Tillage radish (*Raphanus sativus L. var. longipinnatus)*
11.	Field pea (*Pisum sativum arvense L.Asch*)
12.	Cowpea (Vigna *sinensis* L.)
13.	Pea vine *(Lathyrus sativus L.)*
14.	Turnip *(Brassica rapa convar rapa L.)*
15.	Common vetch (*Vicia sativa L*.)
16.	White mustard (*Sinapsis alba L.)*
17.	Fodder radish (*Raphanus sativus L. convar. oleiferus Pers*)
18.	Buckwheat (*Fagopyrum esculentum Mönch*)
19.	Marrow-stem kale (*Brassica oleracea L. var. medullosa*)
20.	Fenugreek (*Trigonella foenum-graecum L.*)
21.	Control

The experiment is when the corn has got 6-8 leaf we sow cover crops into the rows whitch name is interseeding cover crops (Table 1). In this case, the cash-crop and cover crops grow together until the maize is harvested, when the cover crops remain in the field and continue to grow (Figure 2). Some of the cover crops die (freeze) in the winter, and we terminate the remaining plants 6 weeks before sowing the corn. Then there is a regeneration period for the soil to prepare for sowing the cash-crop. In addition to the cover crop treatments, there is also a control treatment without cover crop and with uncovered soil.

Figure 2. *Maize with interseeding cover crops in the growing season and before harvesting*

Our maize hybrid was an early FAO 330 hybrid. The recommended number of plants, which is 75000 plants/ha was reduced to 55000 plants/ ha due to interseeding technology. The sowing depth was 6 cm. Cover crops were sown in 3 rows between the two rows of maize with a Wintersteiger Plotman plot seeder. The corn was harvested during the full ripening period with a parcel combine and 500-600 g samples were taken in individually marked paper bags for quality testing. We determined the crude protein content (%) of grain maize with Foss Infratec1241 NIR grain analyzer. We used IBM Spss Statistics 29 software and Microsoft Office Excel 2019 Professional Plus programs for the data analysis of different cover crops affect protein content of maize. Using One-Way ANOVA, we analyzed the effect of cover crops on the basis of the measured corn grain protein content (%).

3. Results/ Results and Discussion

In the first year (in 2023) of the maize interseeding cover crops experiment, the highest protein content of maize was *Brassicaceae* ssp.were measured with the use of oil radish (*Raphanus sativus L. convar. oleiferus)* and white mustard (*Sinapsis alba L.*) cover crops ($p < 0,05$ significance level) after performing the LSD post hoc test. Interestingly, the lowest protein content was detected in the case of two legumes, these were the pea vine *(Lathyrus sativus L.)* and alfalfa *(Medicago sativa L.)* based on Figure 3. A crude protein difference of nearly 1,5 % was observed with the use of different cover crops. In Figure 3, we can observe that, compared to the control, we see higher protein contents in the grain yield of corn in the case of cover crops, the majority of wich are not nitrogen collecting plants. Such as buckwheat, Italian ryegrass or even the three best-performing cover crops, all of wich are from the brassiaceae family (marrow-stem kale, fodder radish and white mustard). In comparison to the control, the lowest protein contents were measured in maize in nitrogen collecting plants (pea vine, alfalfa, cowpea, sainfoin, crimson clover, red clover, white sweet clover, common vetch, persian clover) and in the case of two root crops (fodder radish and tillage radish).

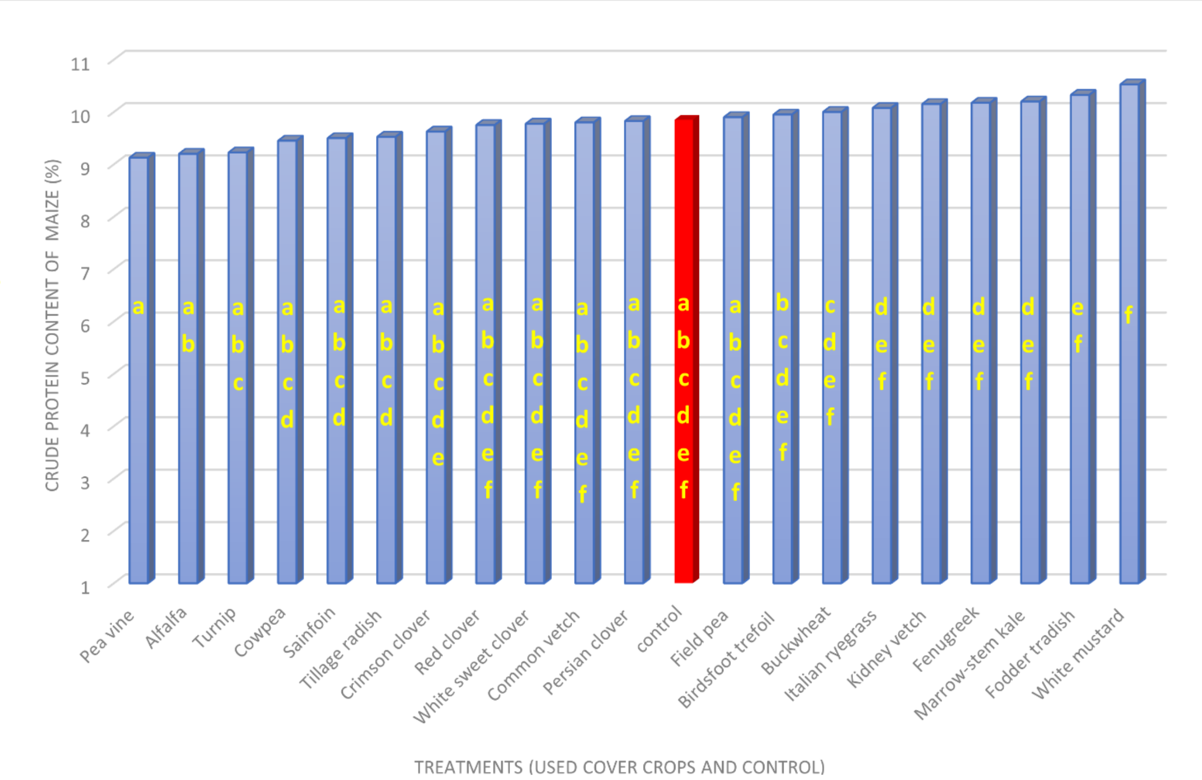

Figure 3. *The effect of cover crops on the crude protein content of maize*

Different lowercase letters indicate significant difference (p $<$ *0,05) between treatments*

4. Discussion

Based on our one-year experiment with cover crops sowed into the corn rows, it can be concluded that the different cover crops modified the crude protein content(%) of the maize. In the first year (contrary to expectations), we found that it was not nitrogen collecting plants, but fodder radish (*Raphanus sativus L. convar. oleiferus Pers.*) and white mustard (*Sinapsis alba L.)*that gave a large green mass between the rows of corn that yielded the highest crude protein content (%) of the corn grain. Based on our observations, we would like to note that the best-performing cover crops quickly formed a large green area, covered the soil and endured even drier periods. How the cover crops affect the protein content of maize after terminalization requires further investigation. Based on literature data, we would expect that after the decomposition of nitrigen collecting plants, more absorbable nitrogen remains for the maize, and from the second year of the experiment, the legumes can contribute more to the crude protein content of the maize.

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