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Effects of Cultivar and Fertilization on Plant and Silage Crude Protein Contents in Maize

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Abstract: This research was conducted to determine the effects of organic and inorganic fertilizer treatments (organic, inorganic, ½ organic + ½ inorganic) on plant and silage crude protein contents of hybrid corn cultivars (PR 31Y43, OSSK-644 and Lacasta) in the years 2011 and 2012 under the ecological conditions of Eskipazar-Karabük. The fertilizer treatments were statistically significant on plant crude protein ratio and plant crude protein yield in both research years. The highest values were obtained from inorganic (10.5, 7.0 and 1.96, 1.67 respectively) and ½ organic + ½ inorganic (9.1, 6.7 and 1.53, 1.52 respectively) fertilizer treatments. The fertilization treatments x hybrid corn cultivars interactions were statistically significant on the plant and silage crude protein in the first research year. The highest plant crude protein was obtained from ½ organic + ½ inorganic x Lacasta interactions and from Lacasta, OSSK-644 and PR 31Y43 interactions of the inorganic fertilizer treatments (11.0, 10.7, 10.6 and 10.2 respectively). On the other hand, the highest silage crude protein was obtained from ½ organic + ½ inorganic x Lacasta and inorganic x Lacasta interactions (9.4 and 9.2 respectively). As a result of the research, high protein yields obtained from PR 31Y43 corn cultivar and inorganic, ½ organic + ½ inorganic fertilizer treatments. When we consider the sums paid for the export of inorganic fertilizers and the negative effects of these inorganic fertilizers on human and environmental health, we may see that ½ organic + ½ inorganic fertilizer treatments would be preferable in the silage corn growing.

Key Words: Crude protein, organic and inorganic fertilization, silage corn cultivars

Çeşit ve gübrelemenin silajlık mısırın bitki ve silaj ham protein içeriği üzerine etkileri

Özet: Karabük-Eskipazar ekolojik koşullarında 2011 ve 2012 yıllarında yürütülen bu araştırmada, farklı hibrit mısır çeşitlerinde (PR 31Y43, OSSK-644 ve Lacasta) organik ve inorganik gübre (organik, inorganik, ½ organik + ½ inorganik) uygulamalarının bitki ve silaj ham protein içerikleri üzerine etkileri araştırılmıştır. Gübreleme uygulamaları her iki araştırma yılında bitki ham protein oranı ve verimi üzerine istatistiki olarak etkili olmuştur. En yüksek değerler inorganik (10.5, 7.0 ve 1.96, 1.67 sırasıyla) ve ½ organik + ½ inorganik (9.1, 6.7 ve 1.53, 1.52 sırasıyla) gübre uygulamalarından elde edilmiştir. Gübre uygulamaları x çeşit interaksiyonları bitki ve silaj ham protein oranları üzerine ilk araştırma yılında istatistiki olarak etkili olmuştur. En yüksek bitki ham protein oranı değerleri ½ organik + ½ inorganik x Lacasta interaksiyonu ile inorganik gübre uygulamalarının Lacasta, OSSK-644 ve PR 31Y43 interaksiyonlarından elde edilmiştir (11.0, 10.7, 10.6 ve 10.2 sırasıyla). En yüksek silaj ham protein oranı ise ½ organik + ½ inorganik x Lacasta ve inorganik x Lacasta interaksiyonlarından elde edilmiştir (9.4 ve 9.2 sırasıyla). Araştırma sonucunda, en yüksek ham protein verimi PR 31Y43 çeşidi ve inorganik, ½ organik + ½ inorganik gübre uygulamalarından elde edilmiştir. İnorganik gübre ithalatına ödenilen döviz miktarı ile inorganik gübrelerin insan ve çevre sağlığı üzerine olumsuz etkileri düşünüldüğünde, ½ organik + ½ inorganik gübre uygulamalarının silajlık mısır yetiştiriciliğinde tavsiye edilebileceği görülmektedir.

Anahtar Kelimeler: Ham protein, organik ve inorganik gübreleme, silajlık mısır çeşitleri

1. Introduction

The adequate production of the animal proteins, which have an important role in human nutrition, can only be possible with adequate providing of high quality fodder for ruminants (Tukel and Hatipoglu 1997). The corn silage is accepted as a semi concentrated feed due to its high value of energy and its higher production potentioal compared to many ather forage crops. This high energy is the result of the fact that about 50% of the dry matter of this crop is consist of grains. This characteristic makes the corn silage superior than the silages of other plants and in addition to this the concentrate feed requirement of ruminant livestock which are fed with corn silage decreases by 33-50% (Sade and Soylu 2008). Corn is the most important plant grown for silage making both in our country and in the worldwide (Turgut 2002).

Using a suitable corn cultivars in corn silage production is highly important for producing high quality feed (İptas and Acar 2006). The yield and the quality of corn silage is remarkably related with genotype as well as the factors such as climate and soil conditions, altitude, planting time, irrigation and harvesting time (Cusicanqui and Lauer 1999).

Research has proven the negative effects of chemical fertilizers on our health. Whereas, the organic fertilizers do not excessive change the nitrate content in the plants compared to the plants those treated with no chemical fertilizer (Anastasios et al. 2007, Nasım et al. 2012). Approximately 65% of agricultural soils of Turkey have low organic material content. In fact, the organic matter of the soil is one of the most important factors that limits agricultural production. For this reason, the treatments of organic materials such as farm manure, compost and green manure is highly required (Kacar 1994). There is not enough information on how much of the nitrogen requirement of plants can be supplied with poultry manure or organic fertilizers in nitrogenous fertilizing. As a matter of fact, it is incredibly difficult to give a certain amount that is applicable in everywhere. The nitrogen contents of poultry manure changes from farm to farm and the amounts of useful nitrogen by plants in poultry manure varies according to plant cultivars, amounts of manure, application procedure, soil characteristics and climatic conditions (Korkmaz et al. 2000). It is assumed that the treatment of poultry manure in a diluted form through drip irrigation system will provide an easy treatment and improve its efficiency.

No scientific research has been made before in our region about the corn silage. The determination of effects of organic and inorganic fertilizer treatments on plant and silage crude protein contents of hybrid corn cultivars (*Zea mays* L. *indentata* S.) was targeted in this research.

2. Materials and Methods

The research was conducted at the research fields of Eskipazar Vocational School in the years 2011 and 2012 under the ecological conditions of the district of Eskipazar in the province of Karabük, Turkey. Three different (PR 31Y43, OSSK-644, Lacasta) hybrid corn cultivars (*Zea mays* L. *indentata* S.) were used as materials in this research. Three different fertilizer treatments were applied (organic, inorganic, ½ organic + ½ inorganic) to these cultivars. The poultry manure named *Organica* of Keskinoglu company which was pelletized after fermentation was used as organic fertilizer in the treatments while composite fertilizer 13.24.12.10.1.1 (13% N, 24% P_2O_5, 12% K_2O, 10% SO_3, 1% Zn, 1% Fe) was applied as base fertilizer. Ammonium nitrate (33% N) was used as top-dressing fertilizer in inorganic fertilizer treatments. Drip irrigation method was used in irrigation that the system consist of hydro PCND driplines of the John Deere Company having 16 mm diameter emitter with a flow rate 2.35 lt h^{-1} which are at 50 cm emitter spacing.

The experimental design was a randomized complete block in a split-plot arrangement with three replications. The fertilizer treatments (organic, inorganic, ½ organic + ½ inorganic) were placed randomly on the main plots and the cultivars (PR 31Y43, OSSK-644, Lacasta) were placed randomly on the split plots. The split plots size was 2.8 by 5 m with four rows per plot. The plant density were arranged to be 70x12 cm (119040 plant ha^{-1}) in all plots.

The planting was made by hand on 25th of May in the first year of the research and on 10th of May in the second year of the research. After the plants are emerged and the rows became clear, the first hoeing was made when the plant was 4-5 leafed and driplines were placed to the plots. The driplines were placed 1.4 m apart and each dripline was centered between two corn rows spaced 70 cm.

The water used in the research was drinkable and was classified as low sodium and medium salty according to the examinations.

A transition climate between the Black Sea and continental climate is seen in Eskipazar district where the research was carried out. Some of the climate data recorded in Eskipazar district during the corn growing season of the years 2011-2012 when the research was carried out, and the long term means of these data (1985–2006) were given in Table 1. From the examination of Table 1, it can be seen that the total rain, temperature and relative humidity means in the research years of 2011 and 2012, have been close to the long term data.

Soil samples were taken before treatments from 0-30 cm depths and analysed in order to determine the physical and chemical properties of the research soils . The analysis results of the soil samples were given in Table 2. As seen from this table, the soils are clay-loam textured and the organic matter content is low (1.49%).

TDR (time domain reflectometry) device was used for measurement of the soil moisture for determining the irrigation program during the research. The irrigation was started when the consumption of 30% readily available soil moisture and the water was given from the system by calculating the water amount in a manner to bring 25 cm soil profile to the field capacity in the first periods and 50 cm soil profile to the field capacity after the stem elongation period.

When the plants grow to a height about 40 cm, secondary hoeing were made. Three different fertilization treatments (organic, inorganic, ½ organic + ½ inorganic) were applied to all cultivars. The total N dose of the fertilizer treatments were determined as 3 g $plant^{-1}$. A part of the nitrogen, the whole of the phosphorus and the potassium (0.75 g $plant^{-1}$ N, 1.4 g $plant^{-1}$ P_2O_5, 0.7 g $plant^{-1}$ K_2O) were given as the base fertilizer on the plots where inorganic fertilizing treatment was made. The rest of the nitrogen (2.25 g $plant^{-1}$) were given with each irrigation in the form of ammonium nitrate (33% N). In organic fertilizer treatments, 5 units of water were added to the 1 unit of pelleted poultry manure and waited for 2 days then filtered through 200 mesh filter and then the poultry manure was applied in each irrigation through drip irrigation system (Table 3).

Table 1. *Climatic data of the research location in the years 2011 and 2012 with the long term means (1985-2006) at Eskipazar, Turkey*

Months	Precipitation (mm)			Temperature (°C)			Relative Humidity (%)		
	2011	2012	Long term	2011	2012	Long term	2011	2012	Long term
May	68.4	68.2	57.1	13.4	15.4	14.3	73.9	66.7	60.2
June	54.8	21.8	54.8	16.9	20.2	17.9	72.3	58.7	60.8
July	8.2	51.4	24.8	21.6	22.6	20.9	63.1	57.7	55.4
August	17.0	48.0	22.9	19.9	19.9	21.1	62.0	59.9	53.9
September	4.4	6.0	21.6	17.1	18.7	16.3	57.4	54.7	57.5
Total/Mean	152.8	195.4	181.2	17.8	19.4	18.1	65.7	59.5	57.6

Table 2. *Physical and chemical soil properties of the research location at Eskipazar, Turkey*

Properties		**Properties**	
Sand (%)	38.0	pH	7.60
Silt (%)	20.0	Salt (%)	0.04
Clay (%)	42.0	Lime (%)	37.59
Texture Class	Clay-Loam	Field Capacity (%), ($v\ v^{-1}$)	26.32
Total N (kg ha^{-1})	0.34	Wilting Point (%), ($v\ v^{-1}$)	16.25
P_2O_5 (kg ha^{-1})	23.60	Bulk Density (g cm^{3-1})	1.23
K2O (kg ha^{-1})	170.10	Organic Matter (%)	1.49

Table 3. *Some properties of pelleted and diluted poultry manure used in research (2011-2012)*

Pelleted poultry manure		**Diluted poultry manure (1/5)**	
Total N (%)	2.30	Total N (%)	0.42
P_2O_5 (%)	5.86	P (ppm)	343.50
K_2O (%)	3.31	K (ppm)	350.82
Organic Matter (%)	61.40	Organic Matter (%)	2.07

In organic fertilizer treatments 54 kg of diluted poultry manure solutions were applied in each irrigation and 3 g $plant^{-1}$ N, 0.24 g $plant^{-1}$ P_2O_5, 0.25 g $plant^{-1}$ K_2O were given in total. In ½ organic + ½ inorganic fertilizer treatments half of the N dose (1.5 g $plant^{-1}$) were provided from the poultry manure and the other half (1.5 g $plant^{-1}$) were provided from inorganic fertilizers. In this treatment 3 g $plant^{-1}$ N, 0.82 g $plant^{-1}$ P_2O_5, 0.47 g $plant^{-1}$ K_2O was given in total.

After removing border effects, two center rows of each split plot were harvested. The harvesting was made at milk-line was between 50 and 75%. The plant based measurements were made on five plants randomly selected from two center rows of each split plot. Then the plants were made silage with machines and packaged. As for the package material, 57x75 sized, 80 micron thick white sacs used that produced from 20% virgin and 80% recycling low density polyethylene. The silage based analyses were made after a fermentation period of 75 days. The dry leaf-stem ratio (%), plant crude protein (%), plant crude protein yield (t ha^{-1}) and silage crude protein (%) were examined in these analyses (RTMFAL 2010).

All data were analyzed using analysis of variance according to experimental design of randomized complete block in a split plot. The LSD procedure was used to separate mean values when the F test was significant (Mstat-C 1980).

3. Results and Discussion

In the first research year, the dry leaf-stem ratio values between the cultivars were statistically significant ($P<0.05$). The highest dry leaf-stem ratio values (53.9 and 52.1) were obtained from PR 31Y43 and Lacasta hybrid corn cultivars (Table 4).

The plant crude protein values among the fertilizer treatments were found statistically significant ($P<0.01$) in both research years. In the first year, the highest plant crude protein values (10.5) were obtained from inorganic fertilizer treatments and in the second year the highest plant crude protein values were obtained from inorganic and ½ organic + ½ inorganic (7.0 and 6.7) fertilizer treatments (Table 4).

Table 4. Effects of fertilization and hybrid corn cultivars on dry leaf-stem ratio (%), plant and silage crude protein (%) and plant crude protein yields (t ha^{-1})

Fertilization (F)	Cultivars (C)	Dry Leaf-Stem Ratio (%)		Plant Crude Protein (%)		Plant Crude Protein Yields (t ha^{-1})		Silage Crude Protein (%)	
		2011	2012	2011	2012	2011	2012	2011	2012
Organic	PR-31Y43	51.9	58.4	7.4 b	6.9	0.88	1.26	7.1 d	6.6
	OSSK-644	42.4	46.0	7.6 b	6.0	1.08	0.95	6.7 d	5.8
	Lacasta	51.9	48.2	7.2 b	5.1	0.94	0.82	6.8 d	5.0
Inorganic	PR-31Y43	52.6	61.2	10.2 a	7.5	1.70	1.74	8.7 b	6.5
	OSSK-644	36.6	55.7	10.6 a	6.6	2.27	1.59	8.6 b	6.1
	Lacasta	50.1	58.9	10.7 a	7.0	1.91	1.59	9.2 a	6.9
O+I	PR-31Y43	57.3	54.6	8.1 b	7.3	1.39	1.66	7.8 c	6.1
	OSSK-644	47.8	47.0	8.3 b	6.6	1.35	1.60	8.0 c	6.1
	Lacasta	54.3	57.1	11.0 a	6.3	1.84	1.29	9.4 a	6.0
F Average	Organic	48.7	50.9	7.4 c	6.0 b	0.97 c	1.01 b	6.9 b	5.8
	Inorganic	46.4	58.6	10.5 a	7.0 a	1.96 a	1.64 a	8.8 a	6.5
	O+I	53.1	52.9	9.1 b	6.7 a	1.53 b	1.52 a	8.4 a	6.1
LSD		ns	ns	0.83**	0.60**	0.33**	0.30**	0.63**	ns
C Average	PR-31Y43	53.9 a	58.1	8.6 b	7.2 a	1.32	1.55 a	7.9 b	6.4
	OSSK-644	42.3 b	49.6	8.8 ab	6.4 b	1.57	1.38 ab	7.8 b	6.0
	Lacasta	52.1 a	54.7	9.6 a	6.1 b	1.56	1.23 b	8.5 a	6.0
LSD		7.76*	ns	0.83**	0.60**	ns	0.21*	0.45*	ns
FXC int.	LSD	ns	ns	1.44**	ns	ns	ns	0.45*	ns

*, **significant at 0.05 and 0.01 probability level; ns – not significant

The plant crude protein values obtained from the cultivars were statistically significant (P<0.01) in first and second study years. The highest plant crude protein (9.6) was obtained from Lacasta cultivar and the highest plant crude protein (7.2) was obtained from PR 31Y43 cultivar in first and second study years respectively (Table 4).

The plant crude protein values obtained from the fertilizer treatments x cultivars interactions were statistically significant (P<0.01) in first study year. The highest plant crude protein values (11.0, 10.7, 10.6 and 10.2 respectively) were obtained from ½ organic + ½ inorganic x Lacasta interaction and inorganic x Lacasta, inorganic x OSSK-644 and inorganic x PR 31Y43 interactions (Table 4).

The plant crude protein yield values between the fertilizer treatments were statistically significant (P<0.01) in both study years. The highest plant crude protein yield (1.96) was obtained from inorganic fertilizer treatments and the highest plant crude protein yield (1.64 and 1.52) were obtained from inorganic and ½ organic + ½ inorganic fertilizer treatments in first and second study years respectively (Table 4).

The plant crude protein yield values obtained from the cultivars were statistically significant (P<0.05) in the second study year. The highest plant crude protein yield (1.55) was obtained from PR 31Y43 cultivar (Table 4).

The silage crude protein values between the fertilizer treatments were statistically significant (P<0.01) in the first research year and the highest silage crude protein values (8.8 and 8.4) were obtained from inorganic and ½ organic + ½ inorganic fertilizer treatments (Table 4).

The silage crude protein values obtained from the cultivars were statistically significant (P<0.05) in the first research year and the highest silage crude protein (8.5) was obtained from Lacasta cultivar (Table 4).

The silage crude protein values obtained from the fertilizer treatments x cultivars interactions were statistically significant ($P<0.05$) in the first research year and the highest silage crude protein values (9.4 and 9.2 respectively) were obtained from ½ organic + ½ inorganic x Lacasta interaction and inorganic x Lacasta interaction (Table 4).

The fertilizer treatments were statistically significant on the plant crude protein and yield in both research years. The highest values were obtained from inorganic and ½ organic + ½ inorganic fertilizer treatments (Table 4). Those results correspond with the lower effectiveness of nitrogen from organic fertilizer on the plant crude protein rate and yields compared with the nitrogen from inorganic fertilizer. The sole use of organic manures cannot compensate the produce obtained by inorganic applications (Ahmad et al. 2012). Integrated use of chemical fertilizers and organic material may be a good approach for sustainable production of crops (Bekeko 2013).

The results obtained from many researches, which are made on the effects of organic, inorganic and ½ organic + ½ inorganic fertilizer treatments on the plant and silage crude protein contents are supporting our findings (Ibeawuchi et al. 2007, Lanyasunya et al. 2007, Fateh et al. 2009, Nazlı 2011, Yolcu 2011, Nasım et al. 2012) while some researches provide different results (Sleugh et al. 2006, Tavassoli et al. 2010, Ahmad et al. 2011). The similarities and differences in the research results regarding the fertilizer treatments may be due to the ecological conditions and the differences and similarities of the genetics of the cultivars used in these researches.

The corn cultivars were statistically significant on the plant crude protein in both research years. The cultivars were statistically significant on dry leaf-stem ratio and silage crude protein in the first research year while they were significant on the plant crude protein yield in the second research year. The highest plant crude protein were obtained from Lacasta and OSSK-644 cultivars in the first year and from PR 31Y43 cultivar in the second year. In the first research year, the highest dry leaf-stem ratio and silage crude protein were obtained from Lacasta and PR 31Y43 cultivars. In the second research year the highest plant crude protein yield was obtained from PR 31Y43 cultivar (Table 4).

Fertilizer treatments x cultivars interactions were statistically significant on the plant and silage crude protein. In the first research year the highest plant crude protein values were obtained from ½ organic + ½ inorganic x Lacasta interactions and Lacasta, OSSK-644 and PR 31Y43 interactions of the inorganic fertilizer treatments. The highest silage crude protein was obtained from ½ organic + ½ inorganic x Lacasta and inorganic x Lacasta interactions (Table 4).

The findings obtained in our research provided similar results with most of the previous researches made for determination of the plant and silage crude protein contents of the corn cultivars (Geren 2001, Darby and Lauer 2002, Erdem 2011, Azizi and Hajibabaei 2012, Oz et al. 2012, Ozata et al. 2012) but also provided different results with other researches (Akdeniz et al. 2004, Gencturk 2007, Erdal et al. 2009). The differences and similarities between the results of these researches regarding the cultivars may be due to the differences and similarities of the ecological conditions of the places where the researches were carried out as well as due to the cultural conditions such as planting densities, irrigation and fertilizer treatments.

4. Conclusion

As a result of the research, high protein yields obtained from PR 31Y43 corn cultivar and inorganic, ½ organic + ½ inorganic fertilizer treatments. When we consider the sums paid for the export of inorganic fertilizers and the negative effects of these inorganic fertilizers on human and environmental health, we may see that ½ organic + ½ inorganic fertilizer treatments would be preferable in the silage corn growing.

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