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The effects of sodium selenate application on yield, feed quality and selenium content of silage maize

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Abstract

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This study conducted field experiments to investigate the effect of sodium selenate application on silage maize yield, selenium content of maize herbage and feed quality for animal nutritient. Eight selenium levels (0-5-10-15-25-50-75-100 g Se ha^{-1}) were used. Selenate was applied from foliar when plant height reached 50-70 cm. Applications did not affect the green herbage and dry matter yield, statistically. But applications had a significant effect on the selenium content of maize herbage, statistically. Total selenium values ranged between 31-333 μg Se kg^{-1} and the highest value was obtained from 100 g Se ha^{-1} application. Increasing of the selenium content of maize herbage with the application is the most important finding in terms of selenium nutrition of animals. Also applications have affected crude ash, crude protein, crude fat, crude cellulose, metebolic energy, neutral detergent fiber, acid detergent fiber and acid detergent lignin values, statistically.

The highest crude ash, crude fat and crude cellulose value was obtained with 10 g Se ha^{-1}application. It is understood that 45.27% neutral detergent fiber values obtained from 15 g Se ha^{-1} applications are within sufficient limits in terms of consumability in animal nutrition. Acid detergent fiber values of 19.61% and 16.35% obtained from 10 g Se ha^{-1} application were found to be within sufficient limits for digestibility in animal nutrition. It was observed that the acid detergent lignin values obtained from the study were slightly higher than the reported values, and that the acid detergent lignin values of the lignin contents which were not digested by animals were not within sufficient limits. As a result, it is clearly seen that selenium applications do not affect green herbage yield, applications are effective especially in terms of Se content and feed quality of maize herbage and sodium foliar applications are effective in this regard.

Keywords: maize; selenium; foliar application; yield; forage quality

Introductıon

Intensive farming has not spreading in Turkey, and animal husbandry developed as a livestock pasture (Acikgoz, 2001). Grazing is carried out with a large number of animals with low yield capacity without respecting the pasture management rules. This adversely affects the natural meadows and pastures and causes the insufficiency of the existing animals.In our country, requirement of high roughage is show up deu to overgrazing and early grazing, fall into ruin as a result of neglect or animals which are brought from abroad or obtained from breeding studies are suitable for intensive and semi–intensive farming. Since the animals are fed in shelters in the intensive animal husbandry system, the need of the enterprises for forage plants increases significantly.

Forage, especially quality roughage deficit is one of the problems that lead to inadequate animal production (Ayan et al., 2006). For this reason, on the one hand increasing the areas where forage crops are cultivated, on the other hand the studies that aremore efficieny and quality products from the unit areashouldbe done. In our current forage crops cultivation areas, most clover plants (36.6%) are grown, followed by vicia sativa (31.9%), maize (21.4%) and sainfoin (9.7%), respectively (Anonymous, 2006a). 68.9% of the amount of dry grass produced of maize, 19.32% of the alfalfa, 8.32% of the vicia sativa, 3.4% of the sainfoin, 0.07% of the clover, 0.06% of the bitter vetch is composed of dry grass.

Maize has a versatile use as human food and animal feed, and an inceasing potantial of production and consumption as grain product. It is one of the most used plants after wheat and paddy in human nutrition, it is the most popular plant especially used in silage production in addition to being used as grain in animal nutrition. 60% of maize production is used as animal feed, 20% is used as human food (direct consumption), 10% is processed food and 10% is used as seed with other consumption. Maize have become indispensable in animal nutrition and participate in feed rations by 15-65% because of high protein and Vit-A content (Deliboran et al., 2017; Deliboran et al., 2018a). Today, maize, which is the most popular plant used in silage production, has become one of the most important silage plants in the world due to various reasons such as being able to produce too much green parts from the unit area, suitability for silage making, and high nutritional value and flavor of silage (Acikgoz, 1991).

In recent years, the importance of quality food in the human and animal nutrution has been inceasing steadily. In this context, in the World, selenium (Se) is one of the most studied micronutrients which is important for human and animal health. Se has been known for many years as a highly toxic, even carcinogenic element. It was first shown in 1957 as auseful element for biological systems (Deliboran et al., 2018b). Se is essential material for both humans and animal, and must be taken with nutrients in sufficient amount (Cakmak et al., 2009; David et al., 1995; Surai, 2000; Deliboran, 2016).

Major purchases Se of animal is realization with feed, however, the selenium taken with the feed is thrown out by digestion and therefore, animal can not benefit from Se. But food-bound organic Se is stored in body proteins (Shamberger, 1984; Deliboran et al., 2017). When animal feed with this plant, animal can use Se. For these reasons, it is thought that binding of Se to the plant with fertilization applications is important for animal nutrition. Se shows a synergistic effect with vitamin E (vit-E) in animal, it undertakes a powerful antioxidan task. It is managed this by glutathione peroxidase enzyme (GSH-Px) (Lawrence et al., 2003). The harmful effects of free radicals cannot be prevented in Se and Vit-E deficiency with the deficiency of GSH-Px, cell integrity is impaired and metabolic functions are deficient (Surai, 2000; Kaneko, 1989).

Although it is not seen as an essential nutrient for most plant species, it is important for plants by incorporation of amino acids and proteins after absorption (Eriksson, 2001). Major source of Se in plant-based foods is soil (Mikkelsen et al., 1989; Marchner, 1995). Plants can absorb Se at very low rate from atmospheric ways. Se must be soluble chemically and at absorbable form to be received by plants from soil. Se plays an important role at environmental stresses such as drought, low temperature. Plants accumulates Se in their bodies functionally but rather accumulate mainly in their seeds (Steven, 1994). Se applications does not affect grain or silage yield and other plant characteristics in plants, such as wheat (Cakmak et al., 2009) and maize (Chilimbia et al., 2012), but it affects the Se concentration of the grain and increase the value. According to Deliboran et al. (2017), sodium selenite and sodium selenate applications did not statistically affect yield and oil content of grain. While selenite applications made from soil did not statistically affect the Se content of the grain, the selenate application from the foliar effected the Se content of the grain, and the Se content of the grain increased with the applications.Accoording to the researchers, 96 µg Se kg^{-1}accumulated in the grain with 15 g Se ha^{-1} application, 125 µg Se kg^{-1} with 25 g Se ha^{-1} application, 214 µg Se kg^{-1} with 50 g Se ha^{-1} application, 420 µg Se kg^{-1} with75 g Se ha^{-1} application and 523 µg Se kg^{-1} with 100 g Se ha^{-1} application, Se levels are suitable for both human and animal nutrition. Se levels were increased to the appropriate level for both human and animal nutrition.

This study conducted field experiments on the Harran Plateau to investigate the effect of sodium selenate (Na_2SeO_4) application (1) on maize herbage yield, dry matter yield, dry matter ratio, (2) on Se contentof maize herbage, (3) on amounts of crude ash, crude protein, crude fat and crude cellulose which are feed quality parameters in maize herbage, (4) on amount of ADF (Acid detergent fiber), NDF (neutral detergant fiber) and ADL (Acid detergent lignin) and metabolic energy (ME) values of maize herbage.

Materıal and Method

Experiment location

The research was carried out in 2013 and 2014 at GAP Agricultural Research Institute, located in Sanliurfa. Sanliurfa is located in the Southeastern Anatolia climatic region but it is under the influence of the Mediterranean climate. The climate is characterized by warm and dry summers and mild winters. The amount of precipitation increases from south to north and west to east. Monthly average temperatures are around 32°C in July and Agust. The highest daily tempera-

Table 1. Some of the physical and chemical properties of pre-test soil that belongs to the research area

Soil property	Year		Soil property	Year	
	2013	2014		2013	2014
Texture	clay	clay	Total N (mg kg^{-1})	600	700
Sand, %	28.5	27.5	Available P (mg kg^{-1})	30.4	16.8
Silt, %	19.6	19.3	Available K (mg kg^{-1})	552	604
Clay, %	51.9	53.2	Available S (mg kg^{-1})	18.5	16.6
EC ds m^{-1}	0.98	1.06	Available B (mg kg^{-1})	0.32	1.27
pH	7.9	7.5	Available Mg (mg kg^{-1})	1678	840
Lime, %	31.2	29.2	Available Mo (mg kg^{-1})	34.10	37.84
Organic material, %	1.57	1.92	Available Se (µg kg^{-1})	3.90	3.50

tures are observed in the same months, and the highest daily temperature recorded to date was 48°C in July. The avarage of daily sunbathing time is over 12 hours in summer. Sanliurfa is on the lowest relative humidity line in Turkey and the relative humidity in summer is around 35%. The soil in the experiment fields is clay loam. The main characteristics of the soil in each year of experiment are shown in Table 1.

Maize variety and selenium sources

In this study, C-955 F_1 were used as agrain maize variety, Na_2SeO_4 were used as Se source. Solid Na_2SeO_4 is a water-soluble compound (85 g/100 g water at 20°C) and its molecular weight is 188.94 g. The Se in Na_2SeO_4 is at the high oxidation level (+6) and it is stable under alkaline and other oxidizing conditions. Sodium selenate is the most common form of Se in alkaline water (Sangbom et al., 2005).

Experimental design

The experiment was designedas a randomized completed blockin three replicates. Eight Se levels (0-5-10-15-25-50-75-100 g Se ha^{-1}) were used. Na_2SeO_4 was applied from the foliar when plant height reached 50-70 cm. Sowing operation was done with pneumatic seeder as 70 cm between rows and 16 cm above the rows in each two years of the research (June 24 2013/June 17 2014). The amount of fertilizer was determined after the analysis of soil samples taken before the experiment in the field in each two years of the research (Table 1). Amount of fertilizer given to maize plants during the vegetation period was completed with pure 25 kg da^{-1}nitrojen (N) and 10 kg da^{-1} phosphorous (P). Potassium (K) was not applied since the amount of soil available K was sufficient. All of the P and some of the N were given to soil as a base fertilizer before the final tillage application. The remainder of the nitrogenous fertilizer was supplied as a top fertilizer with maize plants reached 30-40 cm in length. Water was given immediately after sowing. Other irrigation was given equal water to the parcels by flood irrigation procedure. It was set between parcels to prevent surface flow. Anchor and once throat filling were done at appropriate times. Weed medicine were used against weeds after seed emergence, also drug fighting was done aganist harmful stalk and steed. The water sample was taken from the water source in the area where the pre-test experiment was analyzed (Table 2).

Vegetal measurements

Green herbage yield (kg ha^{-1}) was determined by weighing plants harvested from the middle two rows. Plants with ½-1/3 milk line (60-65% water) were harvested. The shape is made from a height of 5-6 cm above the soil level. The data obtained were converted to unit area yield (kg ha^{-1}). For dry matter yield (kg ha^{-1}), one plant sample were taken randomly from each parsels plants after harvesting and shredded (1-2

Table 2. Results of irrigation water analysis

Property		Year		Property		Year	
		2013	2014			2013	2014
Cations (me L^{-1})	EC (µSm^{-1})	354	356	Anions (me L^{-1})	CO_3	-	-
	Na	0.08	0.08		HCO_3	1.9	2.8
	K	0.02	0.02		Cl	1.1	1.2
	Ca+Mg	3.2	3.3		SO_4	0.3	0.4
	Soil cation	3.3	3.4		Soil annion	3.3	3.3
pH		7.45	7.49		B	-	-
SAR		0.06	0.06		Class	T_2A_1	T_2A_1

cm) and dried at 105^0C in a drying cabinet for 48 hours. Then the sample was stored in a desiccator for 24 hours and weighed to determine the dry matter content. The obtained dry matter value was multiplied by green grass yield and the unit area was converted to dry matter yield. Dry matter (DM,%) was determined by proportionality between wet and dry grass values.

Chemical Analysis

The amount of crude ash (CA,%) was calculated on the remaining weight after 1 g of material was left in ceramic crucibles at 550°C until grayish white color was formed. Crude protein (CP,%), was calculated with Kjeldahl method (Bremmer, 1965) after the total nitrogen analysis by multiplying the value found by factor 6.25. The crude fat (CF,%) was extracted with hexane solution using the fully automatic soxhelet instrument. Crude cellulose (CC,%) was obtained by subtracting acid detergent fiber values from neutral detergent fiber values (Crampton &Maynard, 1938). Neutral detergent fiber (NDF), which is the nitrogen soluble part of cellulose (%) and an indicator of the consumability of feed is one of the feed cell wall components. Acid detergent fiber (ADF) and acid detergent lignin (ADL) are the parameters used to estimate digestibility (Goering & Van Soest, 1970). Metebolic energy (ME, kcal kg^{-1}DM), CP, CF, CC and CA values were calculated using the following formula:

$$ME\ (kcal\ kg^{-1}\ DM) = 3019 - 10.66\ \%CP + 37.33\ \%CF - 26.90\ \%CA - 23.29\ \%CC$$

Plant samples were dried to a constant weight at 40ºC in an air circulating dryer cabinet for Se analysis. The dried and ground grain samples were prepared for Se determination by wet digestion in microwave oven with 5 ml concentrared HNO_3 and 2 ml 30% hydrogen peroxide (H_2O_2) by using a digesting program, which have been developed for the grain samples. All Se measurements in plantmeterials were checked against certificated Se values in different reference plant material (1547 Peach Leaves, NIST) obtained from the National Institute of Standarts and Technology (Gaithersburg USA). After digestion, the total volume was completed up to 20 ml, and Seconcentration of the samples were measured by Atomic Absorption Spectroscopy (AAS) equipped with VGA 77 (vapor generation accessories) and ETC-60 (electrothermal temperature controller). First, Se (+VI) in the samples was reduced to Se (+IV) form by treatment with hydrochloric acid. After, Se was reacted with sodium tetraborate ($NaBH_4$) reductive in acidic medium and reduced to form volatile hydrogen selenide (SeH_2) in the hydride forming unit which VGA-77 mounted in front of the sample entry system of the AAS device, and measured by atomizing SeH_2 at high temperature (850-950ºC) with ETC-60 instrument. The accuracy and reproducibility of the analysis values were controlled using standard reference materials in every 10 samples in the analyzes (Cakmak et al., 2009).

In soil samples, texture was determined by hydrometer method (Bouyoucos, 1951); pH in 1:2,5 soil: water mixture, electrical conductivity (EC) with electirical conductivity instrument in the saturated soil paste, lime ($CaCO_3$) with Scheiblercalcimetry (Tuzuner, 1990); organic matter by modified Walkley-Black method (Black, 1965); total N by modified Kjeldahl method; changeable K, calcium (Ca), magnesium (Mg) and sodium (Na) by 1 N ammonium acetate (pH=7) extraction (Kacar, 1995); available P by $NaHCO_3$ extraction (Olsen & Sommers, 1982); available iron (Fe), zinc (Zn), manganase (Mn) and copper (Cu) by di ethylene tri amine penta acetic acid-tri ethanol amine(DTPA-TEA) excraction (Lindsay &Norvell, 1978); available boron (B) was determinated by exacting B from the soil with hot water based on the color intensity of azomethine-H complex (Kacar, 1995), available Se was determined by KH_2PO_4 extraction method by reading the ASS connected to ETC-60 and VGA-77 apparatus ontained (Cakmak et al., 2009).

Statistical analyses

All data were anlysed using MSTAT-C software package. The data obtained from the experiments were evaluated with variance analysis every year, homogeneity tests were made and the differences between experiment subjects were cheched with LSD tests. The levels of significant were 0.05.

Results and Dıscusıon

Green herbage yield, dry matter yield, dry matter content and Se content of maize herbage

Se applications did not affect the maize herbage yield, dry matter yield, and dry matter ratio values, statistically. The values ranged between 64.53-72.52 t ha^{-1}, 22.01-24.88 t ha^{-1} and 32-36%, respectively. The highest maize herbage yielde and dry matter yield were obtained from 0 g Se ha^{-1} and 100 g Se ha^{-1} application. Se applications had a statistically significant effect on the Se content of maize herbage, total Se values ranged between 31-333 µg Se kg^{-1} (0.031-0.333 mg Se kg^{-1}) and the highest value was obtained from 100 g Se ha^{-1} application (Table 3).

In the study, Se applications did not affect the yield, but it affect the Se content of maize plant. This results supports with many research results. In many studies,it have been suggested that Se applications increase the Se content of grain or plant (Cakmak et al., 2009; Duscay et al., 2007; Deliboran et al.,

Table 3. The effect of sodium selenate application to maize herbage yield, dry matter yield and dry matter ratio

Application	Green herbage yield, t ha^{-1}			Dry matter yield, t ha^{-1}			Dry matter ratio, %			Se ontent of maize herbage, µg kg^{-1}		
	2013	2014	ORT	2013	2014	ORT	2013	2014	ORT	2013	2014	ORT
0 g ha^{-1}	67.78	77.25	72.52	23.74	24.88	24.31	36	32	34	39	24	31e
5 g ha^{-1}	62.49	75.90	69.20	23.41	24.75	24.08	37	33	35	40	25	32e
10 g ha^{-1}	67.38	73.14	70.26	23.77	22.10	22.94	36	30	33	57	31	44de
15 g ha^{-1}	64.12	74.09	69.11	23.17	22.01	22.59	35	29	32	92	32	62de
25 g ha^{-1}	64.80	72.81	68.81	22.56	23.99	23.28	35	33	34	135	46	90cd
50 g ha^{-1}	60.77	68.28	64.53	24.40	22.29	23.35	38	33	36	139	60	100c
75 g ha^{-1}	65.61	68.67	67.14	25.43	23.38	24.41	38	34	36	297	120	209b
100 g ha^{-1}	59.85	73.52	66.69	23.57	24.53	24.05	39	33	36	502	163	333a

2017; 2018; Longchamp et al., 2013; Chilimbia et al., 2012; Chilimba et al., 2012a). Chilimbia et al. (2012) were reported that silage maize yield ranged between 4758-15792 kg ha^{-1} on the basis of varieties, and the Se content of grain has been increased with Se application. According to Deliboran et al. (2018b) soil application of sodium selenite and foliar applications of sodium selenate do not affect grain yield and biomass properties of maize. Yield and biomass values ranged between 9.10-9.52 t ha^{-1} and 7.87-8.34 t ha^{-1} on selenite applications; between 8.28-8.99 t ha^{-1} and 8.01-8.50 t ha^{-1}on selenate applications, respectively. Also Se content of the grain increasedwith Se applications.Wank et al. (2013) were reported that soil and foliar Se applications in the form of Na_2SeO_3 did not affect maize grain and silage yield, yield on soil application ranged between 5.41-9.13 t ha^{-1} in 2009, 7.93-12.25 t ha^{-1} in 2010, respectively. Yield on foliar application ranged between 6.15-9.91 t ha^{-1} in 2009 and 9.58-17.05 t ha^{-1} in 2010.

According to the researchs, green herbage and dry matter yield, and dry matter ratio ranged between 56.29-72.44 t ha^{-1}, 17.76-21.79 t ha^{-1} and 27.68-30.18% in different frequency sowing applications and 22.59-77.44 t ha^{-1}, 3.42-32.54 t ha^{-1} and 14.25-45.51% in different harvest time in the GAP Region (Tas, 2010), respectively. Fiems et al. (1984) reported that dry matter content was positively correlated with starch value, and each 1 g increase of the silage dry matter ratio between 23-36% is increase the daily live weight of the animals by 9 g, the most appropriate dry matter ratio of maize silage should be 25%. Considering that milk formation of silage maize starts at 20% dry matter and pulp formation ends at 35-37% dry matter (DLG, 1987;1997), it is observed that harvesting is done at the appropriate time from the dry matter ratios obtained from our study (31-37%) and the results of study is plug literature. The most important finding our study was the increase of Se content of maize herbage with the application foliar sodium selenate in terms of Se nutrition of animals (332.50 µg Se kg^{-1} with 100 g Se ha^{-1} application).

As a result of research, 99.88 µg Se kg^{-1} (0.1 mg Se kg^{-1}) level was obtained from 50 g Se ha^{-1} application; 208.51 µg Se kg^{-1} (0.209 mg kg^{-1}) level from 75 g Se ha^{-1} application and 332.5 µg Se kg^{-1} (0.333 mg kg^{-1}) level from 100 g Se ha^{-1} application were appropriate for animal Se nutrient as Miller et al. (1991). It is thought that Na_2SeO_4 applications from the foliar are effective on the accumulation of Se in maize herbage in terms of animal nutrition. Thus, in the case of Se feeding of maize herbage, the levels of 50 g Se ha^{-1}, 75 g Se ha^{-1} and 100 g Se ha^{-1} may be recommended from Na_2SeO_4 applications. As a result of this study carried out in order to determine the effect of foliar Na_2SeO_4 applications on the Se content of maize herbage; Na_2SeO_4 applications from foliar are clearly seen to be effective (Figure 1).

CA, CP, CF and CC content of maize herbage

Selenate applications affected CA and CP values, statistically. CA values ranged between 3.26-5.05% in 2013 and 3.08-4.07% in 2014, and the highest CA rate was obtained from 10 g Se ha^{-1} application in both years. CP values ranged between 6.60-8.42%, and the highest value was ob-

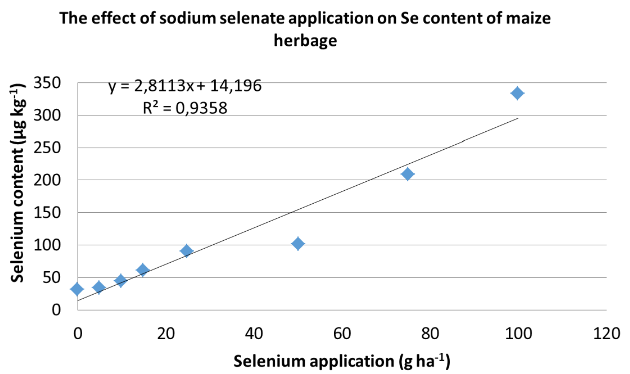

Fig. 1. Se content of maize herbage and values of regression analysis at Se application

Table 4. The effect of selenium application to crude ash, crude protein, crude fat and crude cellulose of maize herbage

Application	Crude ash,%			Crude protein, %			Crude fat, %			Crude cellulose, %		
	2013	2014	AVR	2013	2014	AVR	2013	2014	AVR	2013	2014	AVR
0 g ha^{-1}	3.42 c	3.08 c	3.25	8.39	8.45	8.42 a	1.33 cd	1.60	1.47	6.9 f	13.11	10.01
5 g ha^{-1}	4.09 bc	3.13 c	3.61	7.70	8.21	7.96 ab	1.62 cd	1.69	1.66	11.2 cd	13.59	12.40
10 g ha^{-1}	5.05 a	4.07 a	4.56	6.42	7.47	6.95 bc	2.52 a	1.94	2.23	15.8 a	13.47	14.64
15 g ha^{-1}	4.60 ab	3.62 b	4.11	5.99	7.35	6.67 c	2.10 b	1.81	1.96	14.0 ab	14.44	14.20
25 g ha^{-1}	3.69 bc	3.21 bc	3.45	5.12	8.08	6.60 c	1.66 c	1.84	1.75	12.4 bc	15.08	13.74
50 g ha^{-1}	3.74 bc	3.18 c	3.46	5.79	7.97	6.88 c	1.42 cd	1.78	1.60	9.7 de	11.09	10.40
75 g ha^{-1}	3.34 c	3.33 bc	3.34	5.83	7.71	6.77 c	1.25cd	1.60	1.43	9.2 de	12.19	10.70
100 g ha^{-1}	3.26 c	3.27 bc	3.27	5.65	8.03	6.84 c	1.23d	1.48	1.36	8.3 ef	11.94	10.12

tained from 0 g Se ha^{-1} application. When analyzed CF and CC values, and evaluated the years collectively, there was a statistical difference between the subjects. However, since the year x subject interaction was also significant, the years were evaluated separately. They have changed between 1.23-2.52% and 6.90-15.80% in 2013 and between 1.48-1.94% and 11.09-15.08% in 2014, respectively. The highest values were obtained from 10 g Se ha^{-1}application (Table 4).

According to Gungor et al. (2008), CA, CP, CF and CC values of dry maize herbage were ranged from 7.67 to 8.22%; from 5.08 to 6.33%; from 1:02 to 2:05 and from 1 to 5%; according to Alicicek et al. (1999) from 4.56 to 13.46%; from 4:09 to 9:03%; from 1.76 to 3.74%; from 30.87 to 31.72%, respectively. According to Akinfemi et al. (2012), CA, CP and CC values were 7.53%; 2.54% and 17.94%. In the internationally accepted tables, mean CC and CA value-sare 32.3% and 3.2% (Perry et al., 2004). According to NRC (1989) and DLG (1997), the average CA value of maize silage is about 2.2%. The crude ash values obtained from our study were higher than NRC (1989) and DLG (1997), lower than Gungor et al. (2008) and Akinfemi et al. (2012), and in accordance with the Alcicek et al. (2012); the crude protein values were higher than Akinfemi et al. (2012); Gungor et al. (2008); Perry et al. (2004) and lower than Alcicek et al. (1999). Crude fat and crude cellulose values were found to be compatible with the researchers.

ME, NDF, ADF and ADL content of maize herbage

When the effects of Se applications on ME, NDF and ADF contents were examined, it was observed that the variance was homogeneous in the homogeneity test and combined variance analysis was applied. There was a statistical difference between the subjects, when analyzed ME values and evaluated the years collectively. However, since the interaction of the year-theme was also important, the years were evaluated separately. ME values varied between 2541-2726 kcal kg^{-1} DM in 2013 and 2564-2657 kcal kg^{-1} DM in 2014. The highest values were obtained from the application of 0 g Se ha^{-1} and 100 g Se ha^{-1} with 2726 and 2724 kcal kg^{-1} DM in 2013 and 50 g Se ha^{-1} with 2657 kcal kg^{-1} DM in 2014 (Table 5).

NDF is the nitrogen soluble part of cellulose and an indicator of the consumability of feed is one of the feed cell wall components, significant difference was found between the subjects statistically. NDF values ranged between 30.72-40.21%, the highest value was obtained from the application of 10 g Se ha^{-1} and 15 g Se ha^{-1}. There was a statistically significant difference between the ADF valuewith a significance level of 0.05. ADF values ranged between 10.44-16.35%. According to the combined variance analysis, the application of 10 g Se ha^{-1} in group 1, 15 g Se ha^{-1}, 25 g Se ha^{-1} and 50 g Se ha^{-1} in group 2, 5 g Se ha^{-1} application 3. group. When analyzed the ADL values, it was found that the vari-

Table 5. The effect of selenium application to ME, NDF, ADF ve ADL content of maize herbage

Application	ME, kcal kg^{-1}			NDF, %			ADF, %			ADL, %		
	2013	2014	AVR	2013	2014	AVR	2013	2014	AVR	2013	2014	AVR
0 g ha^{-1}	2726 a	2600	2663	33.97 bc	28.43	31.20 BC	12.59 bcd	12.94	12.77 BCD	10.52 cd	12.78c	10.01
5 g ha^{-1}	2627 cd	2594	2611	35.99 abc	35.74	35.87 ABC	14.67 abc	12.93	13.80 ABC	12.33bc	15.93bc	12.40
10 g ha^{-1}	2541e	2589	2565	43.14 ab	34.37	38.76 A	19.61 a	13.09	16.35 A	17.31a	15.82 bc	14.64
15 g ha^{-1}	2584de	2575	2580	45.27 a	35.14	40.21 A	17.60 ab	14.06	15.84 AB	14.90 ab	22.64a	14.20
25 g ha^{-1}	2639 bcd	2564	2602	43.20 ab	33.01	38.11 AB	15.82 abc	14.81	15.32 AB	14.26 b	18.05ab	13.74
50 g ha^{-1}	2683abc	2657	2670	39.29 abc	27.70	33.50 ABC	14.75 abc	14.43	14.59 AB	11.09 cd	16.02bc	10.40
75 g ha^{-1}	2699ab	2623	2661	31.43 c	31.84	31.64 BC	10.77 cd	11.06	10.92 CD	9.08 d	17.68b	10.70
100 g ha^{-1}	2724a	2622	2673	31.22 c	30.21	30.72 C	8.91 d	11.96	10.44 D	8.41d	15.72b	10.12

ances were homogeneous and combined variance analysis was applied. There was a statistical difference between the subjects, when the years were evaluated collectively. However, since the interaction of the year theme was also important, the years were evaluated separately. In 2013, ADL values ranged between 8.41-17.31% and in 2014, between 12.78-22.64%. The highest value was obtained from 10 g Se ha^{-1} with 17.31% in 2013 and 15 g Se ha^{-1} with 22.64% in 2014 (Table 5). NDF and ADF value were ranged between 47.5-58.9% and 24.1-40.9% according to Ozata et al. (2012); between 49-60% and 31-41% according to Oner et al. (2011) and between 41.2-70.9% and 21.7-40.7% according to Hutjens (1998). Canpolat (2012) was determined that NDF, ADF and ADL value of maize herbage were 53.2%, 30.1% and 6.3%, respectively. Gungor et al. (2008) were explained that ADF and ADL value of maize silage were ranged between 31.64-35.10% and 5.93-6.85%, respectively. According to Alcicek et al. (1997), ADL value of maize herbage was ranged between 3.88-5.10% (Figure 2).

In our study, Se applications statistically affected ME, NDF, ADF and ADL values. Hayirli (2000) emphasizes that ME values of feeds such as maize herbage and grain should be between 1900-2400 kcal kg^{-1}DM in terms of good animal nutrition. The ME values obtained from our study were within the appropriate limits for animal nutrition. According to Canpolat (2012), high NDF values of feeds cause the animal to feel satiety as it slows down digestion and reduces the amount of feed taken by the animal. According to the researcher, the NDF value of the maize yield was 53.2%, the ADF value was 30.1% and the ADL value was around 6.3%. The low digestibility of ADL and ADF leads to low levels of both in diets.

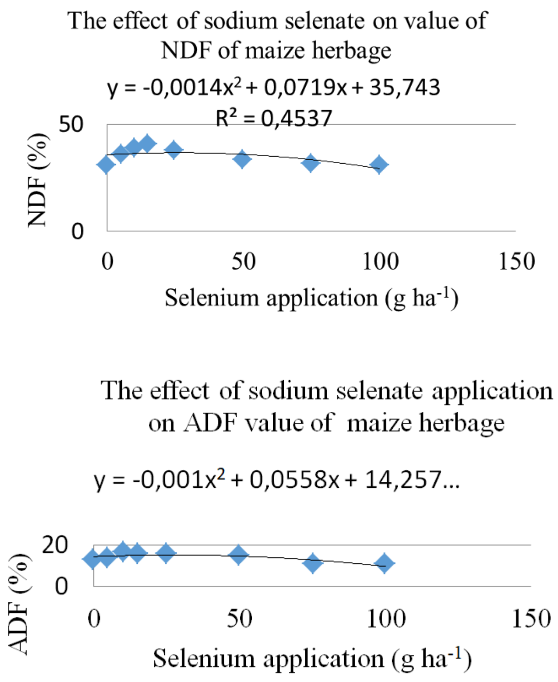

Fig. 2. Value of NDF-ADF and regression analysis of maize herbage at Se application

According to Hutjens (1998) NDF value varies between 41.2-70.9% and ADF value varies between 24.1-40.9%. In our study, 41.07% and 45.27% NDF values obtained from 15 g Se ha^{-1} applications were within sufficient limits in terms of consumability in animal nutrition. ADF values of 19.61% and 16.35% obtained from 10 g Se ha^{-1} application are within sufficient limits for digestibility. The ADL values obtained in the study were slightly higher than the reported values, and the ADL values of the lignin contents which were not digested by animals were not within sufficient limits. According to Hutjens (1998) NDF value varies between 41.2-70.9% and ADF value varies between 24.1-40.9%. In our study, 41.07% and 45.27% NDF values obtained from 15 g Se ha^{-1} applications were within sufficient limits in terms of consumability in animal nutrition. ADF values of 19.61% and 16.35% obtained from 10 g Se ha^{-1} application are within sufficient limits for digestibility in animal nutrition. The ADL values obtained in the study were slightly higher than the reported values, and the ADL values of the lignin contents which were not digested by animals were not within sufficient limits. Yaylak et al. (2003) were reported that when considered balancing feeder cattle rations, maize silage quality factors as energy, cellulose and starch content can be counted as the degree of digestion, provide of energy and protein are form part of beef cattle ration cost.

According to the researcher, therefore, maize silage/herbage is the most sensible alternative feed raw material suitable for the purpose of providing sufficient energy in feeder cattle feeding programs, rations containing maize silage should be formulated with sufficient energy to provide daily live weight gain of 1000-1200 g, thus typical feeder cattle ration should be added 70-75% maize silage/herbage, 15-20% fodder and 5-10% protein or energy source additive.

Conclusion

Se applications did not affect the green herbage yield, dry matter yield and dry matter ratio values, statistically. Se applications have affected CA, CP, CF, CC, ME, NDF, ADF and ADL values, statistically. The highest CA, CF and CC value was obtained with 10 g Se ha^{-1}application.It is understood that 45.27% NDF values obtained from 15 g Se ha^{-1}selenate applications are within sufficient limits in terms of consumability in animal nutrition. ADF values of 19.61% and 16.35% obtained from 10 g Se ha^{-1}selenate application were found to be within sufficient limits for digestibility in animal nutrition. It was observed that the ADL values obtained from the study were slightly higher than the reported values, and that the ADL values of the lignin contents which were not digested by animals were not within sufficient limits.Increasing of the Se content of maize herbage with the application of foliar sodium selenate is the most important finding in terms of Se nutrition of animals (332.50 µg Se kg^{-1} with 100 g Se ha^{-1} application). At the end of the study, it is understood that 99.88 µg Se kg^{-1} (0.1 mg Se kg^{-1}) was obtained from 50 g Se ha^{-1} application, 208.51 µg Se kg^{-1} (0.209 mg Se kg^{-1}) from 75 g Se ha^{-1} application and 332.5 µg Se kg^{-1} (0.333 mg Se kg^{-1}) from 100 g Se ha^{-1} levels are within sufficient limits in term of animal Se feeding according to Miller et al. (1991). It is thought that foliar sodium selenate applications are effective on the accumulation of Se in maize herbage in terms of animal nutrition. Thus, in the case of Se feeding of silage/herbage maize, the levels of 50 g Se ha^{-1}, 75 g Se ha^{-1} and 100 g Se ha^{-1} may be recommended from sodium selenate applications. As a result of this study carried out in order to determine the effect of foliar sodium selenate applications on the Se content of silage maize; foliar sodium selenate applications were found to be effective.

As a result of this study, the effects of foliar sodium selenate applications on some plant characteristics of silage maize and Se, protein, and fat content of maize yield were determined. It is clearly seen that Se applications do not affect green herbage yield, applications are effective especially in terms of Se content and feed quality of maize herbage and sodium foliar applications are effective in this regard.

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