NARDI FUNDULEA, ROMANIA ROMANIAN AGRICULTURAL RESEARCH, NO. 31, 2014
www.incda-fundulea.ro Print ISSN 1222-4227; Online ISSN 2067-5720

EFFECTS OF DIFFERENT LIQUID-MANURE TREATMENTS ON YIELD AND QUALITY PARAMETERS OF SECOND-CROP SILAGE CORN UNDER REDUCED TILLAGE CONDITIONS

Akar Taner[1, 2*], Kaplan Mahmut[1], Sagir Nami[3] and Gelebur Ahmet[3]

[1]Department of Field Crops, Faculty of Agriculture, University of Erciyes, 38030 Talas- Kayseri, Turkey
[2]Deprtment of Agronomy, Faculty of Agriculture, Akdeniz University, 07059 Konyaalt /Antalya, Turkey
[3]ILCI Cicekdagi Agricultural Farm, 40700 Cicekdagi-Kirsehir, Turkey
[*]Correspondent author: Taner Akar; e-mail: yezakar66@yahoo.com

ABSTRACT

The objective of this study was to determine the effects of different liquid-manure doses and manure + chemical fertilizer combinations on yield and quality parameters of silage corn cultivated as second crop, under reduced tillage condition. The experiments were carried out in randomised block design with 4 replications during the years 2010 and 2011 in Turkey. A total of 12 treatments were tested in the experiments and some morphological and quality parameters were investigated. Average of two years indicated that green herbage yield varied between 3.02-4.37 t ha^{-1}, plant height between 186.70-220.83 cm, cob ratio between 31.80-36.38 %, leaf ratio between 15.45-20.77%, stem ratio between 43.78-48.54%, crude protein ratio between 4.17-7.94%, Neutral detergent fibre (NDF) between 66.41-69.72% and acid detergent fibre (ADF) between 34.36-37.79%. Comparisons between green herbage yields of single chemical nitrogen treatment (control) and liquid manure combinations revealed that 20 ton liquid manure + 20 kg ha^{-1} chemical nitrogen combination (L2N2) was not significantly different (4,37 t ha^{-1}) but better than control treatment (4,32 t ha^{-1}). However, crude protein ratio of control treatment (7.9%) was higher than L2N2 treatment (5.34%) and the difference between them with regard to crude protein ratio was found to be significant. The first experiment on sustainable second crop silage maize production under reduced tillage conditions in Central Anatolia demonstrated that chemical nitrogen use can significantly be reduced and replaced by using liquid manure as an alternative source, without any negative effects on soil characteristics.

Key words: Green herbage yield, liquid manure, quality parameters, reduced tillage, second crop silage corn.

INTRODUCTION

The need for quality forage is ever-increasing parallel to increase in livestock production. Manure applications and reduced tillage practices may provide significant contributions in reducing forage production costs, increasing yields and performing an ecological production. Corn is the most common silage crop worldwide (McDonald et al., 1991; Meeske et al., 1993) because of high unit area green herbage yield, easy harvest, availability for silage, high nutritive value, taste and consumption (Kaplan, 2005).

Environment-friendly manure storage, handling and application will both increase soil fertility and reduce chemical fertilizer costs. Cattle manure contains on average 1.67 % nitrogen, 1.07% phosphorus and 2.73% potassium (Mkhbela and Materechera, 2003) and may provide significant savings from commercial fertilizers (Chadwick and Laws, 2002). Combining chemical fertilizers with manure may reduce input costs, increase yields and provide environmental protection (Bukert et al., 2000). There are various ways to apply liquid manure (Chambers et al., 2001) and the amount to be applied can easily be adjusted at different plant growth stages. Abunyewa et al. (2007) investigated the effects of single manure treatments of 4 and 80 t/ha and combined treatments with 60, 17.5 and 33 kg ha^{-1} NPK on corn yield and observed a yield increase of 55.6% in the first year and 120% in the third year of experiments with manure treatments, and also observed higher efficiencies in combined treatments. Repeated manure treatments increased soil fertility indicators such as

Received 5 December 2013; accepted 13 February 2014. First online: 20 June 2014. DII 2067-5720 RAR 2014-458

organic matter, cation exchange capacity and pH. Korucu et al. (1998) compared conservation tillage, reduced tillage and traditional tillage systems with each other and indicated the lowest fuel consumption (24,12 l/ha, 49,08 l/ha and 73,6 l/ha), lowest labour need (1.2 h/ha, 2.2 h/ha and 3 h/ha) and the lowest erosion rates (2 t/ha/year, 11.75 t/ha/year and 22.5 t/ha/year) respectively for conservation, reduced and traditional tillage.

This is the first study conducted in a big private scale agricultural farm to cultivate sustainable silage corn as second crop under reduced tillage in Central Anatolia, escaping from early frost damage due to the fact that second crop silage corn is a routine practice in lowland conditions. Additionally, main aim of the research was to determine the potential use of liquid manure, either alone or in combination with chemical fertilizers, and the amounts to be used in second-crop silage corn cultivation under reduced tillage conditions without any loss in green herbage yield and quality, while not creating any negative side effect to the soil.

MATERIAL AND METHODS

Experiments were carried out over experimental fields of Kırsehir Cicekdağı private Agricultural Farm during the years 2010 and 2011.

In both years, 75% vetch and 25% barley combination was cultivated ahead of silage corn. Tarm Beyazı Hungarian vetch genotype and Aydanhanım barley genotype were used in vetch/barley mixture. Mix sowing was carried out in winter, row spacing was 36 cm and sowing depth was 5 cm. Vetch barley mixture was harvested in spring for forage at 25 % flowering stage. Reduced tillage was performed for soil preparation of second-crop silage corn. Following the harvest of vetch + barley, different doses of liquid manure were applied to experimental plots and then the first plough was performed at 15 cm depth with a chisel plough and corn sowing was performed just after ploughing. A total of 12 treatments, consisting of different doses of liquid manure alone and different combinations of liquid manure and chemical fertilizers were used in the present study.

Experiments were carried out in randomised block design with 4 replications. Treatments were arranged as follows: 1) Control (not fertilized); 2) 10 t ha^{-1} Liquid Cattle Manure (L1); 3) 10 t ha^{-1} Liquid Cattle Manure + 40 kg ha^{-1} N (L1N4); 15 t ha^{-1} Liquid Cattle Manure (L1.5); 5) 15 t ha^{-1} Liquid Cattle Manure + 30 kg ha^{-1} N(L1.5 N3); 6) 20 t ha^{-1} Liquid Cattle Manure (L2); 7) 20 t ha^{-1} Liquid Cattle Manure + 20 kg ha^{-1} N(L2N2); 8) 2.5 t ha^{-1} Liquid Cattle Manure (L2.5); 9) 2.5 t ha^{-1} Liquid Cattle Manure + 10 kg ha^{-1} N (L2.5 N1); 10) 3 t ha^{-1} Liquid Cattle Manure (L3); 11) 3 t ha^{-1} Liquid Cattle Manure + 5 kg ha^{-1} N (L3 N0.5) and 12) 120 kg ha^{-1} P205 and N (L12). Macro and micro nutrient contents of liquid manure are provided in Table 1.

Table 1. Macro and micro nutrient content of liquid manure samples

Years	N (%)	P (%)	K (%)	Fe (%)	Zn (%)	Mg (%)	Ca (%)
2010	2.7	0.2	0.8	0.14	0.02	0.5	2.2
2011	2.4	0.4	0.9	0.13	0.04	0.3	2.5

Medium-early corn genotype OSSK 644 was used as the plant material of this study. Liquid manure was applied over the 8.4 x 30 m plots just before sowing and 2.8 m strips were left between the plots to prevent interferences. Chemical fertilizer combinations were applied all in one as top dressing practice. Row spacing was 70 cm, on-row seed spacing was 15 cm and sowing depth was 6 cm.

In chemical fertilizer treatment 12 (N12), all of the 120 kg ha^{-1} phosphorus and half of nitrogen were applied at sowing and remaining half of nitrogen was applied before the second hoeing. Weed control was performed twice with mechanical hoeing.

Irrigations were performed after the first hoeing and then in every 15 days; a total of 600 mm irrigation water was applied. Soil samples were taken to determine the soil characteristics (texture, pH, organic matter, salinity, N-P-K contents, and lime content) before liquid manure applications. Soil texture was sandy-loam with slight alkalinity, low organic matter, phosphorus, nitrogen and medium lime (Table 2).

Table 2. Pre-sowing soil characteristics

Treatment	Texture	pH	Organic matter (%)	Salt (%)	K (kg ha^{-1})	P (kg ha^{-1})	N (%)	$CaCO_3$ (%)
The first year								
Control	Sandy-Loam	8.16	1.13	0.011	1533.7	29.8	0.06	11.69
L1	Sandy-Loam	8.11	0.86	0.014	1179.7	37.5	0.04	12.45
L1N4	Sandy-Loam	8.17	0.92	0.014	1415.7	28.1	0.05	15.84
L1.5	Sandy-Loam	8.19	0.83	0.015	1179.7	38.3	0.04	12.45
L1.5N3	Sandy-Loam	8.10	0.80	0.014	1651.7	24.7	0.04	12.45
L2	Sandy-Loam	8.18	0.79	0.013	1415.7	29.8	0.04	12.07
L2N2	Sandy-Loam	8.20	0.84	0.014	1179.7	20.4	0.04	13.77
L2.5	Sandy-Loam	8.10	0.88	0.015	1533.7	23.0	0.04	12.07
L2.5N1	Sandy-Loam	8.08	0.67	0.014	1415.7	30.7	0.03	10.56
L3	Sandy-Loam	8.19	1.04	0.014	1651.7	30.7	0.05	9.81
L3N0.5	Sandy-Loam	8.16	0.95	0.011	1415.7	26.4	0.05	12.82
N12	Sandy-Loam	8.00	0.78	0.015	1179.7	38.3	0.04	10.56
The second year								
Control	Sandy-Loam	8.19	1.21	0.012	1769.6	40.2	0.06	17.44
L1	Sandy-Loam	8.19	1.12	0.008	1415.7	29.5	0.06	16.83
L1N4	Sandy-Loam	8.14	1.20	0.014	1533.6	34.4	0.06	14.78
L1.5	Sandy-Loam	8.16	1.05	0.013	1769.6	40.2	0.05	15.92
L1.5N3	Sandy-Loam	8.15	0.91	0.015	1769.6	41.0	0.05	15.54
L2	Sandy-Loam	8.19	1.18	0.013	1887.6	41.8	0.06	16.30
L2N2	Sandy-Loam	8.19	0.96	0.015	1533.6	32.8	0.05	15.54
L2.5	Sandy-Loam	8.15	1.05	0.013	1651.6	49.2	0.05	16.68
L2.5N1	Sandy-Loam	8.18	1.25	0.014	2005.5	39.4	0.06	15.85
L3	Sandy-Loam	8.16	1.16	0.014	1769.6	32.8	0.06	18.20
L3N0.5	Sandy-Loam	8.17	1.01	0.007	2595.4	45.9	0.05	16.68
N12	Sandy-Loam	8.17	1.10	0.010	2005.5	54.9	0.06	13.12

Temperatures of the first year were higher than both the temperatures of the second year and long-term averages. Temperatures of the second year were close to long-term averages. Distribution of precipitations varied with months and total precipitations during experimental years were higher than long-term averages (Table 3). Effects of treatments on silage corn green herbage yield and quality were investigated over plant samples harvested from a 3 x 1.4 m^2 area from each plot. Beside green herbage yield, plant height, shoot diameter, cob weight as morphological characteristics were also determined (Soylu and Sade, 1995).

Table 3. Climate date for experimental years (2010-2011) and long-term averages (1975-2011)

Months	Temperature (^oC)			Precipitation (mm)		
	2010	2011	Long-Term	2010	2011	Long-Term
May	16.6	13.9	15.2	24.3	30.6	42.1
June	20.9	18.6	19.6	82.5	84.6	34.4
July	25.6	24.3	23.2	12.9	5.9	7.4
August	26.7	22.6	22.9	0	1.0	5.6
September	21.4	18.8	18.4	0.4	4.0	12.1

Measurements

Green herbage samples were taken from each plot and dried at 70°C for 48 hours. Dried samples were ground in a grinder with 1 mm sieve and analyses were performed over these samples. Kjeldahl method was used to determine nitrogen (N) content. Crude protein was calculated with N x 6.25 formula (AOAC, 1990). Neutral detergent fibre (NDF) (Van Soest and Wine, 1967) and acid detergent fibre (ADF) (Van Soest, 1963) were determined by using ANKOM 200 Fiber Analyzer (ANKOM Technology Corp. Fairport, NY, USA).

Statistical analysis

Experimental results were subjected to variance analysis by using SAS (SAS Inst., 1999) software. Significance of differences between treatments means was tested by Duncan's multiple range test.

RESULTS

Liquid manure treatments had significant effects on green herbage yields, agro-morphological characteristics and chemical compositions of both years (Table 4).

Table 4. Effects of single and combined liquid manure treatments on green herbage yield, plant height and plant diameter

Treatments	Green herbage yield (kg ha^{-1})			Plant height (cm)			Plant diameter (mm)		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Control	**25457 f**	**35040 f**	**30248 e**	**181 f**	**192 e**	**187 e**	**12.8 d**	11.3 d	**12.1 c**
L1	30690 e	43240 d	36965 d	206 bc	226 c	216 ab	**14.1 a**	**11.3 d**	12.7 c
L1N4	37353 b	48690 b	43022 a	193 de	237 ab	215 ab	13.9 ab	15.3 abc	14.6 ab
L1.5	34000 c	45067 c	39533 b	191 e	**243 a**	217 ab	13.5 abc	17. 1 a	**15.3 a**
L1.5N3	37407 b	49113 ab	43260 a	190 e	242 a	216 ab	13.1 cd	15.6 abc	14.4 ab
L2	32597 d	45427 c	39012 bc	185 ef	243 a	214 b	13.1 cd	**17.3 a**	15.2 a
L2N2	37273 b	**50263 a**	**43768 a**	205 bc	206 d	206 c	13.4 bcd	16.9 a	15.2 a
L2.5	32563 d	40763 e	36663 d	189 ef	207 d	198 d	13.3 bcd	13.7 bcd	13.5 bc
L2.5N1	33847 c	42787 d	38317 c	199 cd	229 c	214 b	13.5 abc	16.3 ab	14. 9ab
L3	34613 c	39787 e	37200 d	**223 a**	213 d	218 ab	13.8 ab	15.0 abc	14.4 ab
L3N0.5	37053 b	39497 e	38275 c	203 bc	195 e	199 d	13.7 ab	13.0 dc	13.4 bc
N12	**41310 a**	45167 c	43238 a	211 b	231 bc	**221 a**	13.9 ab	15.7 abc	14.8 ab
Mean	34514^b	43737^a		198^b	222^a		13.5^b	14.9^a	
Year			**			**			**
Treatments	**	**	**	**	**	**	**	**	**
Year x treatments	**	**	**	**	**	**	**	**	**

* values in the same column followed by the same letter are not significantly different at P≤0.05;
** values in the same column followed by the same letter are not significantly different at P≤0.01; **NS:** non-significant.

Relatively high temperatures above the long-term average in the first year resulted in significant decreases in green herbage yield, agro-morphological characteristics and protein ratios, while such high temperatures did not cause any negative effects on ADF and NDF ratios.

Effects of liquid manure treatments on green herbage yield, plant height and plant diameter of second crop silage corn in both years were statistically significant ($P<0.01$). Treatments, years and year x treatment interaction were found to be significant with regard to average yields of the years 2010 and 2011 ($P<0.01$).

Green herbage yields, plant heights and diameters are provided in Table 4. Green herbage yields varied between 25457 and 41310 kg ha^{-1} in the year 2010 and between 35040 and 50263 kg ha^{-1} in the year 2011. The highest yield was obtained from N12 treatment in the first year and from L2N2 and L1.5N3 treatments in the second year. As the average of years, the highest values were observed in L1N4 (43022 kg ha^{-1}), L1.5N3 (43260 kg ha^{-1}), L2N2 (43768 kg ha^{-1}) and N12 (43238 kg ha^{-1}) treatments and the lowest value in control treatments with 30248 kg ha^{-1}. Plant heights varied between 181 and 222 cm in 2010 and between 192 and 243 cm in 2011 and years-average was between 187 and 221 cm. The highest plant heights were observed in L3 treatment of the first year and L1N4, L1.5, L1.5N3 and L2 treatments of the second year. With regard to average of years, the highest values were obtained from L1, L1N4, L1.5, L1.5N3, L3 and N12 treatments.

Plant diameters were between 12.8 and 14.1 mm in the first year, between 11.3 and 17.3 mm in the second year and between 12.08-15.27 mm as the average of years. The highest diameter was observed in L1 treatment of the first year and N12, L1N4, L3, L3N0.5, L2.5N1 and L1.5 treatments were placed into the same statistical group. The lowest plant diameters of the first year were seen in control treatment. In the year 2011, the highest value was obtained from L2 treatment but the treatments L1.5, L2N2, L2.5N1, N12, L1.5N3, L1N4 and L3 were placed into the same group. While the lowest value of the year 2011 was observed in L1 treatment, the treatment L3N0.5 and control treatment were placed in the lowest group. With regard to average values of the years 2010 and 2011, the highest value was obtained from L1.5 treatment and the treatments L2, L2N2, L2.5N1, N12, L1N4, L3 and L1.5N3 were placed into the same statistical group. The lowest average was obtained from the control treatment, and the treatments L1, L3N05 and L2.5 were placed into the same group.

Cob, leaf and stem ratios of second-crop silage corn are provided in Table 5. Single and combined liquid manure treatments had significant effects on cob and leaf ratios of both years and average of years at $P<0.01$ level. Year and year x treatment interaction were also found to be significant with regard to cob and leaf ratio ($P<0.01$). Effects of years and treatments on stem ratio were not found to be significant. Cob ratios varied between 29.37 and 33.87% in the first year, between 34.22 and 40.24 % in the second year and average of years was between 31.80 and 36.38%. The highest cob ration of the first year was observed in L3 treatment and the treatments L1, L1N4, L1.5, L2N2 and N12 were placed into the same group. The lowest ratio was seen in control treatment and the treatments L2.5N1, L3N0.5, L2.5, L2 and L1.5N3 were observed into the same group. During the second year, the highest cob ratio was obtained from L1N4 treatment and the treatments L1.5, L1.5N3, L2, L2N2, L3 and N12 were placed into the highest group. The lowest ratio was observed in again control treatment and L1, L2.5, L2.5N1 and L3N05 were also placed into the lowest group. With regard to average of years, the highest value was observed in L3 treatment and the treatments L1N4, L1.5, L1.5N3 L2, L2N2 and N12 were placed into the highest group. The lowest ratio was seen in control treatment and the treatments L2.5, L2.5N1 and L3N0.5 were included into the lowest group.

Leaf ratios varied between 19.28 and 22.69% in 2010, between 11.61 and 18.83% in 2011 and between 15.45 and 20.77 as the average of years.

Table 5. Effects of single and combined liquid manure treatments on cob, leaf and stem ratios

Treatments	Cob ratio (%)			Leaf ratio (%)			Stem ratio (%)		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Control	**29.37 d**	**34.22 e**	**31.80 e**	22.28 ab	17.03 ab	19.65 bc	48.34 a	**48.73 a**	**48.54 a**
L1	32.08 abc	36.36 bcde	34.22 bcd	19.97 ef	15.83 bcd	17.90 ef	47.95 ab	47.81 a	47.88 ab
L1N4	32.45 abc	**40.24 a**	36.35 a	**19.28 f**	**11.61 f**	**15.45 h**	48.27 a	48.15 a	48.21 ab
L1.5	33.54 ab	38.94 ab	36.24 ab	19.32 f	14.52 cde	16.92 fg	47.14 abc	46.54 a	46.84 abc
L1.5N3	31.46 bcd	38.92 ab	35.19 abc	19.87 ef	13.26 ef	16.57 g	**48.67 a**	47.82 a	48.24 ab
L2	31.41 bcd	39.21 ab	35.31 abc	20.84 cde	13.42 ef	17.13 fg	47.75 ab	47.37 a	47.56 abc
L2N2	33.17 ab	37.99 abcd	35.58 ab	21.39 a-d	15.63 bcd	18.51 de	45.43 cd	**46.38 a**	45.91 c
L2.5	30.88 cd	35.28 cde	33.08 de	21.76 abc	16.34 bc	19.05 cd	47.36 abc	**48.38 a**	47.87 ab
L2.5N1	30.55 cd	36.43 bcde	33.49 cde	21.10 b-e	16.26 bc	18.68 cde	48.35 a	47.31 a	47.83 ab
L3	**33.87 a**	38.90 ab	**36.38 a**	20.11 def	13.96 de	17.04 fg	46.02 bcd	47.14 a	46.58 bc
L3N0.5	30.78 cd	35.01 de	32.90 de	21.81 abc	18.54 a	20.17 ab	47.41 abc	47.45 a	46.93 abc
N12	32.24 abc	38.69 a	35.47 abc	**22.69 a**	**18.83 a**	**20.77 a**	**45.07 d**	**42.48 b**	**43.78 d**
Mean	31.82^{b}	37.51^{a}		20.87^{a}	15.44^{b}				
Year			**			**			*NS*
Treatments	**	**	**	**	**	**	**	*	**
Year x treatment			*NS*			**			*NS*

* values in the same column followed by the same letter are not significantly different at P≤0.05;
** values in the same column followed by the same letter are not significantly different at P≤0.01; **NS:** non-significant

The highest value of the first year was observed in N12 and the lowest in L1N4. The highest value of the second year was obtained from N12 treatment and treatments L3N0.5 and control was included into the same group. The lowest ratio was observed in L1N4 treatment and the treatments L1.5N3 and L2 were placed into the same group. With regard to average of years, the highest value was observed in N12 and the treatment L3N0.5 was also included into the highest group. The lowest average was seen in L1N4 treatment. The highest stem ratio of the year 2010 was obtained from L1.5N3 (48.67%) and the lowest in N12 (45.07%) treatment. In the second year, the highest value was observed in control treatment (48.73%) and the entire treatments except for N12 (42.48 %) were included into the highest group. Average of years varied between 43.78 and 48.54 %, the highest value was observed in control treatment and the treatments L1, L1N4, L1.5, L1.5N3, L2, L2.5, L2.5N1 and L3N0.5 were placed into the same group. The lowest value was observed in N12 treatment.

Chemical composition parameters (crude protein, ADF, NDF) are provided in Table 6. Treatment had significant effects on crude protein, ADF and NDF ratios of both years (P<0.01). Effects of years and year x treatment interaction were also found the significant at P<0.01 level.

Crude protein ratios varied between 4.11 and 8.27% in the first year, between 4.17 and 7.60% in the second year and between 4.17 and 7.94% as the average of years. The highest value of the first year was observed in N12 treatment and the lowest in control treatment. In the second year, the highest ratio was observed in N12 treatment; the lowest in L1 treatment and the control, L2 and L2N2 treatment were included into the same group. With regard to average of years, the highest value was obtained from N12 and the lowest from control treatment.

NDF ratios varied between 63.91 and 71.32% in the first year, between 67.83 and 70.40% in the second year and between 66.41 and 69.72% as the average of years.

Table 6. Effects of single and combined liquid manure treatments on chemical composition of silage corn

Treatments	Crude protein (%)			NDF (%)			ADF (%)		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Control	**4.11 j**	4.23 gh	**4.17 h**	68.11 e	69.14 d	68.63 f	35.69 f	36.50 d	36.10 d
L1	5.81 c	**4.17 h**	4.99 dc	68.48 d	69.41 c	68.95 d	35.86 e	35.41 fe	35.64 fe
L1N4	5.58 e	4.52 e	5.05 c	68.17 e	70.33 b	69.25 c	35.59 g	34.31 g	34.95 g
L1.5	5.25 f	4.34 fg	4.80 e	69.83 b	**67.83 j**	68.83 e	37.31 c	35.04 f	36.18 d
L1.5N3	5.71 d	4.41 ef	5.06 c	67.48 f	68.04 ı	67.76 g	35.11 h	**33.61 h**	**34.36 h**
L2	4.26 ı	4.28 fgh	4. 27 g	68.74 c	68.52 f	68.63 f	37.74 b	37.83 b	**37.79 a**
L2N2	6.49 b	4.20 h	5.34 b	66.19 h	68.50 f	67.35 ı	33.66 j	37.15 c	35.40 f
L2.5	4.82 h	4.80 c	4.95 d	**71.32 a**	68.12 h	**69.72 a**	**38.90 a**	35.90 e	37.40 b
L2.5N1	5.10 g	4.50 e	4.66 f	67.07 g	68.20 g	67.63 h	36.31 d	35.42 fe	35.86 e
L3	4.90 h	4.67 d	4.78 e	67.07 g	68.12 h	67.59 h	34.10 ı	37.11 c	35.61 f
L3N0.5	5.20 f	5.42 b	5.31 b	68.82 c	**70.40 a**	69.61 b	36.32 d	37.02 c	36.67 c
N12	**8.27 a**	**7.60 a**	**7.94 a**	**63.91 ı**	68.92 e	**66.41 j**	**32.34 k**	**38.47 a**	35.41 f
Mean	5.46[a]	4.76[b]		67.94[b]	68.79[a]		35.75[b]	36.15[a]	
Year			**			**			**
Treatments	**	**	**	**	**	**	**	**	**
Year x treatment	**	**	**	**	**	**	**	**	**

** values in the same column followed by the same letter are not significantly different at P≤0.01.

The highest NDF ratio of the first year was observed in L2.5 and the lowest in N12 treatment. In the second year, the highest and the lowest values were respectively observed in L3N0.5 and L1.5 treatments. As the average of years, the highest value was observed in L2.5 and the lowest in N12 treatment.

While highest ADF ratio of the first year was observed in L2.5 treatment with 38.90%, the lowest value was seen in N12 treatment with 32.34%.

The highest value of the second year was obtained from N12 treatment with 38.47% and the lowest from L1.5N3 treatment with 33.61%. Average of the years 2010-2011 revealed the highest value for L2 treatment with 37.79% and the lowest value for L1.5N3 treatment with 34.36%.

Soil samples taken at sowing of both years were analysed with regard to pH, organic matter and salinity. Results indicated that liquid manure treatments did not have any negative impacts on soil characteristics.

DISCUSSION

Forage quality of silage corn sown after Hungarian vetch + barley combination is way higher than the quality of silage corn sown after wheat (Duman, 2007). This is a natural consequence of Hungarian vetch and higher green herbage yield of control plot of the second year without any fertilization application basically resulted from soil residual nitrogen due to fixated nitrogen of preceding Hungarian vetch cultivation. Such findings point out the significance of legumes to be used as preceding cropping in silage corn culture. Corn genotypes have different responses against nitrogen (Wiesler et al., 2001). However, in this experiment the differences between green herbage yields, agro-morphological characteristics and protein ratios of the experimental years were mainly due to higher temperatures of the second experimental year above long term-averages (Table 3). Response to liquid manure was always positive both in 2010 and 2011 years for green herbage yield till 15 tons ha^{-1} level compared to control plot. After this point there was no any positive reaction to increased liquid manure applications. This clearly shows effects of liquid manure application on green herbage yield of maize. Combination of the liquid manure with chemical fertilizer compared to its full liquid manure dose always increased green herbage yield of corn, too. This obviously demonstrates that higher green herbage yield can be obtained either combination of liquid manure and chemical fertilizer as top dressing or twice liquid manure application before and after planting. Compared to conventional soil tillage methods, Yalçın et al. (2003) did not observed significant differences in reduced tillage with regard to green herbage yields but reported 1-3 days savings in soil preparation and 20% saving in fuel consumption. Reduced tillage in this study resulted in similar green herbage yield like in the traditional tillage but contributed reasonable saving of fuel, soil preparation time and labour, too.

Previous researches reported increased growth and development but decreased nitrogen-use efficiency and consequent green herbage yield decreases in corn with increasing nitrogen doses (Saglamtimur et al., 1987; Cullu et al., 1999). Nitrogen has a vital role in protein and enzyme synthesis in plants and enzymes control the entire metabolic processes of plants. Nitrogen is also included in synthesis of chlorophyll, the basic molecule absorbing the energy required for photosynthesis (Islam et al., 2010). Results of present study reflected the impacts of nitrogen from liquid manure on silage yield. Similar findings were also reported by Islam et al. (2010), Khan et al. (1996), Shahjalal et al. (1996). Nitrogenous fertilizer treatments generally increase the plant heights of corn but such an increase is not continuous (Sezer and Yanbeyi, 1997). Ping et al. (1993) reported nitrogen as the most significant nutrient effecting plant height of corn. Similarly, Yılmaz (2005) reported decreasing leaf ratios with increasing nitrogen doses, but Saruhan (2002) indicated insignificant effects of different nitrogen doses on leaf ratios. Some others also reported increased leaf area index values and consequent leaf ratios with increasing nitrogen doses (El-Hattab et al., 1980; Kang et al., 1986). In the present study, significant relationships were observed between liquid manure doses and leaf ratios, but increase in leaf ratios was not parallel to increase in liquid manure doses.

Nitrogen deficiency negatively affects the vegetative development of corn. When the plant is not able to get sufficient nitrogen, it is forced to blossom earlier and growth period is shortened. In this case, upper tassel and cob tassel development are slowed down and consequently very few kernels are formed over the tip of cob (Kırtok, 1998). Normal growth, cob and kernel development are only possible with sufficient nitrogen. Increased cob ratios normally indicate relatively decreased leaf and stem ratios. However, Islam et al. (2010) reported increased plant heights with nitrogen treatments. Plant height is mostly affected by plant genetic characteristics, soil nutrients, climate conditions, light intensity and quality and growth seasons. Saruhan (2002) and Tansı et al. (1996) reported insignificant effects of increased nitrogen doses on stem ratios of corn. Reiad et al. (1997) indicated that plant height may significantly be affected by environmental conditions.

Nitrogenous fertilizers generally increase cob ratios but such an increase is again not continuous. Leaf and stem ratios decreases, cob ratio and kernel formation increases with nitrogenous fertilizers. Current findings comply with the results of previous studies (Saglamtimur et al., 1987; Akçin et al., 1992; Kaplan and Aktas, 1993; Yılmaz, 2005). However, Saruhan (2002) indicated insignificant effects of increasing nitrogen doses on cob ratios.

Cox et al. (1993) reported increasing crude protein ratios with nitrogenous fertilizer treatments. Akçin et al. (1992) and Sarker (2000) also indicated positive impacts of increasing nitrogen doses on crude protein ratios. Increased crude protein ratios were also reported with liquid manure treatments in barley + vetch combination (Yolcu et al., 2010), oat (Zhang et al., 2006), corn (Lithourgidis et al., 2007) and grass (Blonski et al., 2004). Results of present study comply with the findings of Islam et al. (2012) with regard to crude protein ratios.

Nitrogenous fertilization decreases ADF and NDF ratios of plants. Min et al. (2002) reported significant effects of liquid manure treatments on ADF and NDF ratios. Yolcu et al. (2010) carried out a two-year study to investigate the effects of liquid manure treatments and reported insignificant effects on ADF and NDF ratios in the first year but significant effects in the second year of experiments. Adeli et al. (2005) observed increasing ADF and decreasing NDF ratios in bermuda grass with liquid lagoon effluent treatments. Current findings were higher than the results observed by Stekar et al. (1991) and Islam et al. (2012).

In this first study of second crop silage corn production under reduced tillage system in Central Anatolian highlands, liquid manure treatments had generally positive effects primarily on the green herbage yield, plant height, cob ratio like morphological characteristics and crude protein, ADF and NDF like quality parameters. Although 20-25 t ha^{-1} single liquid manure treatment was able to meet all of the phosphorus need and large portion of nitrogen need of corn without any adverse impacts, additional chemical nitrogen fertilization as top dressing resulted in significant increases in green herbage yield and quality parameters of silage corn. This situation may be due to application of liquid manure just once before the sowing and consequent nitrogen deficiency or nitrogen leaching through irrigations. In case of ecological and economical sustainable second-crop silage corn cultivation with single liquid manure application, liquid manure should be applied twice, one just before the sowing and another one just before upper tassel formation period with the highest nitrogen demand under reduced tillage conditions. Second application may significantly improve protein quality and this can contribute to sustainable second crop silage maize production under reduced tillage conditions among especially resource poor farmers in Central Anatolian highlands.

CONCLUSIONS

Two year experiments on the second crop silage maize in non tropical conditions demonstrated that chemical nitrogen use can be significantly reduced and partially replaced by using liquid manure, without any yield loss even under reduced tillage conditions. Adoption of reduced tillage system and liquid manure application will result in cost effective silage maize production, especially for resource poor farmers under highland conditions.

Acknowledgement

We kindly acknowledge the partial financial contribution of TAGEM (General Directorate of Agricultural Research and Policy) for the project.

REFERENCES

Abunyewa, A.A., Osei, C., Asiedu, E.K. and Safo, E.Y., 2007. *Integrated manure and fertilizer use, Maize production and sustainable soil fertility in subhumid zones of west Africa*. Journal of Agronomy, 6 (2): 302-309. DOI: 10.3923/ja.2007.302.309

Adeli, A., Varco, J.J., Sistani, K.R., Rowe, D.E., 2005. *Effects of swine lagoon effluent relative to commercial fertilizer applications on warm-season forage nutritive value*. Agronomy Journal, 97: 408-417. DOI:10.2134/agronj2005.0408

Akçin, A., Sade, B., Tamkoç, A., Topal, A., 1992. *Konya ekolojik şartlarında farklı bitki sıklıgı ve azotlu gübre uygulamalarının TTM-813 melez mısır çeşidinde (Zea mays L. indendata sturt) dane verimi, verim unsurları ve bazı morfolojik özelliklere etkisi*. Doga-Tr. J. of Agricultural and Forestry, 17: 281-294.

AOAC (1990) Official Methods of Analysis. 15^{th} ed. Association of Official Analytical Chemists, Washington, DC.US. ISBN: 9780935584240

Blonski, L.J., Bork, E.W., Blenis, P.V., 2004. *Herbage yield and crude protein concentration of rangeland and pasture following hog manure application in southeastern Alberta*. Canadian Journal of Plant Science, 84: 773-783. DOI: 10.4141/P03-103

Bukert, A., Bationa, A. and Possa, K., 2000. *Mechanism of residue Mulch- induced cereal growth increase in West Africa*. Soil. SCiSoc. Am. J., 64: 346-358. DOI:10.2136/sssaj2000.641346x

Chadwick, D. and Laws, J., 2002. *The impact of novel slurry application techniques on ammonia emission, silage quality and sward acceptance by grazing cattle*. IGER innivations, UK.

Chambers, B., Nicholson, N., Smith, K., Pain, B., Cumby, T., Sotford, I., 2001. *Managing livestock manures booklet 3. spreading systems for slurries and solid manures*. Ministry of Agriculture, Fisheries and Food, London.

Cox, W.J., Kalonge, S., Cherney, D.JR., Reid, W.S., 1993. *Growth, yield and quality of forage maize under different nitrogen management practices.* Agron. J., 85: 843-347. DOI:10.2134/agronj1993. 00021962008500020033x

Cullu, M.A., Ulger, A.C., Guzel, N., Ortas, I., 1999. *Bazı melez mısır çesitlerinin artan azot dozlarına tepkilerine saptanması.* Tr. J. of Agricultural and Forestry, 23 (1): 115-124.

Duman, I., 2007. *Determination of some quality properties and yield of silage maize on application of varied nitrogen fertilization after different pre-plants management*. Gaziosmanpasa University Graduate School of Natural and Applied Science Department of Field Crop Science, Master's Thesis.

El-Hattab, H.S., Husseın, M.A., El-Hatfab, A.H., Abdel Raouf, M.S., Elnomany, A.A., 1980. *Growth analysis of maize plant in relation to grain yield as affected by nitrogen levels*. Z. Acker-Und Pflanzenbau (J. Agron. and Crop Sci.), 149: 46-57.

Islam, M.R., Rahman, S.M.E., Md. Rahman, M., Oh. D.H., Ra, C.S., 2010. *The effects of biogas slurry on the production and quality of maize fodder.* Turk J. Agric. For., 34: 91-99. DOI:10.3906/tar-0902-44

Islam, M.R., Garcia, S.C., Horadagoda, A., 2012. *Effects of irrigation and rates and timing of nitrogen fertilizer on dry matter yield, proportions of plant fractions of maize and nutritive value and in vitro gas production characteristics of whole crop maize silage.* Animal Feed Science and Technology, 172: 125-135. DOI:10.1016/j.anifeedsci.2011.11.013

Kang, J.H., Lee, H.J., Park, B.H., 1986. *Effect of nitrogen level and plant population on agronomic characteristics and yield of silage maize.* Soil and fertilizers, 52 (1): 95.

Kaplan, M., 2005. *Effects of different intra and inter row spacing on yield and yield components of second crop silage maize (Zea mays L.) under Kahramanmaras conditions*. Univercity of Kahramanmaras Sutcu Imam Enstitute of Natural and Applied Science Department of Field Crops. MSc Thesis.

Kaplan, M., Aktas, M., 1993. *Amonyum nitrat ve üre gübrelerinin hibrit mısırda etkinliklerinin karsılastırılması ve bu bitkinin azotlu gübre isteginin belirlenmesi*. Doga-Tr. J.of Agricultural and Forestry, 17: 649-657.

Khan, M.J., Shahjalal, M., Sarkar, A.R., 1996. *Yield, chemical compositionand nutritive value of oat (Avena sativa) fodder at different levels of nitrogen fertilizer*. Bang J. Anim. Sci., 25: 109-115.

Kırtok, Y., 1998. *Mısır üretimi ve kullanımı*. Kocaoluk Yayınevi, Istanbul.

Korucu, T., Kirişçi, V., Görücü, S., 1998. *Korumalı toprak işleme ve Türkiye'deki uygulamaları*. Tarımsal mekanizasyon 18. Ulusal kongresi,Tekirdağ.

Lithourgidis, A.S., Matsi, T., Barbayiannis, N., Dordas, C.A., 2007. *Effect of liquid cattle manure on corn yield, composition, and soil properties.* Agronomy Journal, 99: 1041-1047. DOI:10.2134/agronj2006.0332

McDonald, P., Henderson, A.R., Heron, S.J.E., 1991. *The Biochemistry of Silage*. Second Edition. 340 p. Chalcombe Publication.

Meeske, R., Ashbell, G., Weinberg, Z.G. and Kipnis. T., 1993. *Ensiling forage sorghum at two stages of maturity with the addition of lactic acid bacterial inoculants*. Anim. Feed Sci. Technol. 43: 165-175. DOI: 10.1016/0377-8401(93)90076-V

Min, D.H., Vough, L.R., Reeves, J.B., 2002. *Dairy slurry effects on forage quality of orchardgrass and reed canarygrass and alfalfa-grass mixtures.* Animal Feed Science and Technology, 95: 143-157. DOI: 10.1016/S0377-8401(01)00318-2

Mkhabela, T.S. and Materechera, S.A., 2003. *Factors influencing the utilization of cattle and chicken manure for soil fertility management by emergent farmers in moist Midlands of Kwazulu-natal province, South Africa*. Nutrient cycling in Agrosystem, 65: 151:162. DOI: 10.1023/A:1022156210667

Ping, W.U., Dai, Q., Tao, Q., 1993. *Effect of fertilizer rates on the growth, yield and kernel composition of sweet corn.* Commun. Soil Sci. Plant Anal., 24 (3, 4): 237-253. DOI:10.1080/00103629309368795

Reiad, M.S., Al-Abdulsalam, M.A., El-Naim, A.A., 1997. *Effect of nitrogen fertilizer rates and clipping stage on growth and yield of maize grain, sorghum and popcorn*. J. Agric. Sci., 5: 243-252.

Saglamtimur, T., Guzel, N., Tansı, V., 1987. *Çukurova koşullarında ikinci ürün mısırda en uygun azot, fosfor ve potasyum dozlarının saptanması üzerinde bir araştırma*. Türkiye Tahıl Sempozyumu, 6-9 Ekim 1987, Bursa: 615-624.

Sarker, V., 2000. *Effect of different doses of nitrogen fertilizer on growth, yield, chemical composition and degradability of Zamboo grass (Hybrid jowar).* MS Thesis, Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Saruhan, V., 2002. *Diyarbakır kosullarında farklı azot dozları ve bitki sıklığının mısırın(Zea mays L.) hasıl verimi ve bazı tarımsal karakterlerine etkisi*. Ç.Ü. Fen Bilimleri Enstitüsü. Yüksek Lisans Tezi, Adana.

SAS 1999. SAS User’s Guide: Statistic. Statistical Analysis Systems Institute Inc., Cary, NC.

Sezer, I., Yanbeyi, S., 1997. *Çarşamba Ovasında yetiştirilen cin mısırında bitki sıklığı ve azotlu gübrenin tane verimi, verim komponentleri ve bazı bitkisel karakterler üzerine etkileri.* Türkiye II Tarla Bitkileri Kongresi, 22-25 Eylül 1997: 128-133, Samsun.

Shahjalal, M., Selim, S.M., Rahman, A., 1996. *Effect of nitrogen fertilization on yield, chemical composition and in vitro digestibility of maize (Zea mays) and oat (Avena sayiva) fodder*. Bang. J. Anim. Sci., 25: 65-72.

Soylu, S., Sade, B., 1995. *Melez at dişi mısırda farklı ekim zamanları ve azot dozlarının verim, verim unsurları ve kalite üzerine etkileri.* SÜ. Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Konya.

Stekar, J.M.A., Stibilj, V., Golob, A., Kodra, M., 1991. *Quality and nutritive value of maize prepared from different hybrids*. CIHEAM - Options Mediterraneennes, 16: 137-139.

Tansı, V., Ülger, A.C., Saglamtimur, T., Kızılsimsek, M., Çakır, B., Yücel, C., Baytekin, H., Öktem, A., 1996. *Güneydoğu Anadolu Bölgesinde ikinci ürün mısırda bitki sıklığı ve azot gübrelemesinin tane ve hasıl verimi ve bazı tarımsal karakterlerine etkisi üzerinde araştırmalar*. Ç.Ü. Ziraat Fakültesi Genel Yayın no: 158. GAP Yayınları no: 99.Adana.

Van Soest, P.J., 1963. *The use of detergents in the analysis of fibre feeds. II. A rapid method for the determination of fibre and lignin*. Journal of the Association of Official Analytical Chemists, 46: 829-835.

Van Soest, P.J. and Wine, R.H., 1967. *The use of detergents in the analysis of fibrous feeds*. IV. Determination of plant cell wall constituents. Journal of the Association of Official Analytical Chemists, 50: 50-55.

Wiesler, F., Behrens, T. and Horst, W.J., 2001. *The Role of Nitrogen-Efficient Cultivars in Sustainable Agriculture.* Research Article Optimizing Nitrogen Management in Food and Energy Production and Environmental Protection: Proceedings of the 2nd International Nitrogen Conference on Science and Policy The ScientificWorld, 1(S2), 61-69. DOI 10.1100/tsw.2001.264

Yalçın, H., Çakır, E., Akdemir, H., Öcel, T., Soya, H., 2003. *Dogrudan Ekim Ve Dipkazan Uygulamalarının ikinci Ürün Mısırda Verime Etkileri*. Tarımsal Mekanizasyon 21. Ulusal Kongresi. 3-5 Eylül 2003, KONYA, Bildiriler Kitabı, S: 167-171.

Yılmaz, M., 2005. *Silajlık Olarak Yetistirilen Bazı Mısır (Zea mays L.) Çesitlerinde Azotlu Gübrelemenin Verim ve Bazı Agronomik Özelliklere Etkisi*. GOP. Üniv. Fen Bilimleri Ens. Yüksek Lisans Tezi, Tokat.

Yolcu, H., Gunes, A., Dasci, M., Turan, M., Serın, Y., 2010. *The effects of solid, liquid and combined cattle manure applications on the yield, quality and mineral contents of common vetch and barley intercropping mixture*. Ekoloji, 19, 75: 71-81. DOI: 10.5053/ekoloji.2010.7510

Zhang, M., Gavlak, R., Mitchell, A., Sparrow, S., 2006. *Solid and liquid cattle manure application in a subarctic soil: Bromegrass and oat production and soil properties.* Agronomy Journal, 98: 1551-1558. DOI:10.2134/agronj2006.0045