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Effects of Organic and Chemical Fertilizers on Forage Yield and Quality of Globe Artichoke (*Cynara scolymus* L.)*

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Abstract: To study the effect of organic and chemical fertilizers on forage yield and quality in globe artichoke (*Cynara scolymus* L.) an experiment was conducted using a randomized completed block design (RCBD) with four replications at the Research Farm of College of Agriculture, University of Tehran, Karaj, Iran in 2006. The treatments included five levels of chemical fertilizers, four levels of manure, five levels of mixture of different ratios of chemical fertilizers and manure (integrated system) and a control treatment without any fertilizers. Fertilization treatments significantly affected forage quantity and quality of artichoke. For chemical fertilizers, total DM yield was increased to 4.13 and 3.7 t ha^{-1} by the treatments (kg ha^{-1}) $N_{200}/P_{200}/K_{240}$ and $N_{160}/P_{160}/K_{192}$, respectively. For organic systems, the highest yields of 2.86 and 2.77 t ha^{-1} were obtained by treatments of 30 and 40 tones of cattle manure/ha, respectively. In the integrated system, the highest DM values of 4.86 and 4.06 t ha^{-1} were obtained in treatments $N_{80}/P_{80}/K_{96}$/manure$_{20,000}$ and $N_{120}/P_{120}K_{144}$/manure$_{10,000}$, respectively. The effects of three soil fertilization systems on forage quality traits were inconsistent. Chemical and integrated systems increased crude protein (CP), K and P contents in globe artichoke. For dry matter digestibility (DMD) there were no significant differences among fertilizing systems, although all of them produced higher DMD compared to control. For water-soluble carbohydrates (WSC), the positive effect of organic fertilization was higher than in the other two systems. It was concluded that artichoke, as a new forage crop, has a good yield and quality potential for livestock feeding in terms of soil fertilization systems But further studies would be needed for considering of Artichoke as a new source of forage crops.

Key words: Artichoke (*Cynara scolymus* L.), forage yield, qnality traits, soil fertilizing systems

INTRODUCTION

The globe artichoke (*Cynara scolymus* L.) is a perennial rosette plant grown throughout the world for its large, fleshy heads. Most of its cultivation area is in the Mediterranean countries. Other possible uses of *Cynara* spp. are the production of lignocellulosic biomass for energy or paper-pulp and grains for oil and protein production (Jones and Earle, 1966; Foti *et al*., 2000). Fresh globe artichoke is used as good quality forage for livestock (Coon and Ernst, 2003) and its leaves are used as medication against various diseases (Gebhardt, 2001).

Elia and Santamaria (1994) determined the optimum levels of N, P and K fertilizers for globe artichoke. They declared that nutrient solution should contain at least 130 mg N L^{-1} and respective

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rates of 100 and 250 mg L^{-1} of P and K for optimum plant growth. These rates increased plant height, leaf area and number, shoot fresh and dry weight as well as root dry weight along with the improvement of the root: shoot ratio. In an another study, Elia *et al*. (1996) investigated 4 different ratios 100:0, 70:30, 30:70 and 0:100 of ammonium:nitrate (NH_4:NO_3) for artichoke growth. Their results showed that NO_3 was the preferred N form, with 70-100% NO_3 resulting in the best vegetative growth, largest leaf area and root volume and greatest dry weight. Increasing NO_3-N to 100% increased water use efficiency by 2.5-fold compared with 100% NH_4. Gerakis and Houma (1969) reported that the fresh plant weight of globe artichoke which grows in an organic soil in Michigan (USA) was markedly influenced by N fertilizer up to 200 kg N ha^{-1}, while P and K levels had no significant effect. El-Abagy (1993) investigated three levels of low (71 kg N, 57 kg P_2O_5 and 119 kg K_2O ha^{-1}), medium (142 kg N, 114 kg P_2O_5 and 238 kg K_2O ha^{-1}) and high levels (213 kg N, 171 kg P_2O_5 and 357 kg K_2O ha^{-1}) of NPK on globe artichoke production in a clay soil in Egypt. They recommended that the medium level of fertilizers led to increased plant height, leaf number and leaf fresh and dry weight. Pedreno *et al*. (1996) reported that the reduction of nitrogen application from 500 to 300 kg N ha^{-1} resulted in reduction of total biomass of artichoke. Salamah (1997) investigated the response of artichoke (cv. Herious) to N-fertilization levels ranging from 95 to 380 kg ha^{-1} in Egypt. Their results indicated that all the plant growth characteristics such as leaf number and leaf fresh and dry weight were markedly increased by using 95 to 285 kg N ha^{-1}. Slightly differences were observed in eco-physiological responses of artichoke to different levels of nitrogen fertilizer. Foti *et al*. (2000) noticed that the response of leaf transpiration and stomatal conductance to nitrogen rates was not linear. The physiological traits were higher by using 200 kg N ha^{-1} compared to control. However, there was no significant difference between 200 and 400 kg N ha^{-1}. Elia *et al*. (1991) evaluated artichoke productivity with N application rates of 150 and 300 kg N ha^{-1} compared to the control. They noticed that the application of 150 kg N ha^{-1} was sufficient to increase the yield by 3 t ha^{-1} through both a higher number and weight of buds per plant without further increase occurring above 300 kg N ha^{-1}. Medium NPK fertilizer levels (142 kg N, 114 kg P_2O_5 and 238 kg K_2O ha^{-1}) ranked the first among the three investigated combinations of NPK levels concerning production of both early and total yield (El-Abagy, 1993). Moreover, medium level of NPK proved to be sufficient under clay soil conditions in Egypt for increasing of weight of bud and its edible part. Pedreno *et al*. (1996) announced that bud yield was not affected by increasing N application in calcareous soil from 300 to 500 kg N ha^{-1}. Salamah (1997) reported that application of 285 kg N ha^{-1} promoted earliness and significantly increased the early yield. However, increasing N fertilization to 380 kg N ha^{-1} significantly delayed bud appearance and decreased the early yield. Bud traits such as length and weight as well as receptacle diameter were improved by using N fertilization rate higher than 95 kg N ha^{-1}. Increasing N levels had no effect on the bud diameter and thickness of receptacle.

Foti *et al*. (2000) demonstrated that 200 kg N ha^{-1} as NH_4NO_3 is sufficient for economic yield of artichoke in southern Italy. The yield response to nitrogen rates was not linear. Bud yield with 0 kg N ha^{-1} was the lowest and followed an increasing trend in treatments fertilized with either 200 or 400 kg N ha^{-1}. At the same type, a wide range of soil types can be use for any commercial artichoke production. However, optimum productivity level was taken on deep, fertile, well-drained soils of sandy loam to clay loam textures.

The goal of the study was to evaluate the effects of different soil fertilizing systems on potential forage yield and quality of globe Artichoke (*Cynara scolymus* L.) for livestock feeding .

MATERIALS AND METHODS

Field experiment was conducted at the Research Farm of College of Agriculture, University of Tehran, Karaj, Iran (35°26′ N, 71°28′ E, 1321 m above sea level) during growing seasons of 2005-

Table 1: Used dosages of the soil fertilization treatments and fertilizer types

Fertilization	Treatment No.	Fertilizer: Chemical ($kg\ ha^{-1}$) K_2O	P_2O_5	N	Manure ($t\ ha^{-1}$)
Control	1	-	-	-	-
Chemical	2	48	40	40	-
	3	96	80	80	-
	4	144	120	120	-
	5	192	160	160	-
	6	240	200	200	-
Integrated (Chemical + Organic)	7	48	40	40	25
	8	96	80	80	20
	9	144	120	120	15
	10	192	160	160	10
	11	240	200	200	5
Organic	12	-	-	-	10
	13	-	-	-	20
	14	-	-	-	30
	15	-	-	-	40

2006. The location characterized by semi-arid conditions of cold winter and dry hot summer. The long term average annual participation was 250-400 mm for period 1997-2007. The experiment site has a clay loam, soil with having pH (7.4), organic matter (6.1 $g\ kg^{-1}$), total nitrogen (0.08%), P_2O_5 (22.8 $mg\ kg^{-1}$) and K_2O (140 $mg\ kg^{-1}$). Globe Artichoke (*Cynara scolymus* L.) seeds sample of the local ecotypes were provided from Pakan Bazr Inc, Isfahan, Iran.

The treatments were arranged as five levels of chemical fertilizer including N, P and K (Chemical fertilizing system), four levels of animal manure (Organic fertilizing system) and five levels of combined use of manure and chemical fertilizers (Integrated fertilizing system) (Table 1). The first half of the nitrogen fertilizer and total phosphorus and potassium fertilizers were applied before sowing (30 April, 2006) and the rest at 9-10 leaf stage on 16 July, 2006. The sources of N, P, K and animal manure were urea, superphosphate, potassium sulfate and dairy cow manure, respectively. A randomized complete block design was used with four replications in this study. Plot size was adjusted as to be 9×3.75 m. Spaced plants were established in 5 rows in 75 cm apart with 65 cm spacing within rows in 6 May 2006.

Three or four seeds were sown per hill and thinning was done as to be one plant per hill after full establishment. Each plot consisted of 60 plants in rate of 3 $kg\ ha^{-1}$. Planting date and sowing depth (4 cm) were as recommended by agricultural specialist for similar farming conditions. Normal cultural practices were applied uniformly on all units during the study. The plots were hand-weeded at early vegetative stage of artichoke. Irrigation was applied regular. Pests were not observed; therefore, pesticide were not applied. Plants were hand-harvested in areas of 5 m^2 from each plot. Data were recorded at 14-15 leaf, vegetative rosette stage for aboveground biomass ($kg\ ha^{-1}$) and forage quality in 8 October, 2006. To determined dry matter yield a samples for each plots was weighed, dried at 70°C for 24 h and reweighed. This sample subsequently were ground with a Retsch Impeller-type mill (1 mm screen) for measurements of quality traits.

Quality traits including crude protein (CP %), acid detergent fiber (ADF), water-soluble carbohydrate (WSC), total ash and dry matter digestibility (DMD) were estimate by near infrared spectroscopy (NIR). Details of the methodology and calibrations of NIR are given by Jafari *et al.* (2003). In the same procedure, DMD were estimate similar to that described by De Boever *et al.* (1994). WSC was determined using a modification of the method described by Fales et al (1982). Crude protein % was calculated as Nitrogen %×6.25. Nitrogen was estimated using a LECO 228 (LECO Corporation St. Joseph. MI, USA) nitrogen determinator. Total ash were estimated by Ignite a 5 g of sample at 550°C, for at least 2 h and allowed to cool in desiccator and weighted. ADF were determined by Fibertec (Van Soest, 1994). NIR scanning and spectra analyses were performed using a Inframatic 8620. The calibration equation were developed using Multiple linear regression (MLR) with the lowest standard error of prediction (SEP), high R^2 (coefficient of determination (Jafari *et al*., 2003). This was the calibration used for all subsequent analyses.

The collected data were analyzed using analysis of variance (ANOVA) SAS-9 software (SAS, 1989) and mean values were grouped by Duncan ($p \leq 0.05$).

RESULTS AND DISCUSSION

Forage Dry Matter

Forage dry matter production is one of the most important quantitative parameters in a forage crop. Soil fertilizing systems had a significant ($p<0.01$) effect on artichoke dry matter production (Table 2). The results of mean comparisons (Table 3) showed that the highest DM yield was obtained by application of integrated treatment 8 (N = 80, P = 80, K = 96 kg ha^{-1} + OM = 20 t ha^{-1}) by 4860 kg dry matter production per ha. Treatment 6 (N = 200, P = 200, K = 240 kg ha^{-1}) had the highest productivity of 4130 kg ha^{-1} among chemical treatments. For organic fertilization system, treatments 14 (OM = 30 t ha^{-1}) and 15 (OM = 40 t ha^{-1}) had the highest values. Application of any fertilizer significantly increased biomass of artichoke compared to control. The rates of increasing are 56, 61 and 6% for chemical fertilizer, integrated system and organic systems, respectively. Eghbal *et al*. (2001) and Adediran *et al*. (2004) support these results. It seems that organic fertilizing systems had less effect on biomass compared to the other fertilizing treatments. This is probably due to the slower nutrient releasing from manures in the first year of application (transient period). In some of the integrated fertilizing systems that received higher amounts of manures than others did, the same results can be expect. However, in some of the integrated fertilizing systems, biomass increases only because they had no transient period (Acharya *et al*., 1998). It seems that manure or other organic fertilizing will show an increasing effect on DM yield in the second or third year of application. Similarly, Gerakis and Honma (1969) reported that application of a mixture of chemical and manure fertilizers had a significant effect on DM yield. In a similar experiment Ghosh *et al*. (2004) obtained the highest values of DM yield in the integrated fertilizing system compared to organic and chemical fertilizers in soybean (*Glycine max*) and sorghum (*Sorghum bicolor*). Pomares *et al*. (1993) studied the effect of three rates of NPK fertilizer on artichoke (cv. Blanca de Espana) productivity in Valencia, Spain. There was no significant response on the yield with N rates higher than 200 kg ha^{-1}, whereas ouly slight differences were obtained with 400 or 600 kg N ha^{-1}. Moreover, P and K fertilizers did not increase bud yield. Their results showed that the available levels of P from 27-33 mg kg^{-1} and K from 250-282 mg kg^{-1} in the soil were adequate for the optimal growth of artichoke. Eghbal and Power (1999) and Adeddiran *et al*. (2004) reported that application of manure fertilizer based on percent of absorbable nitrogen, could produce the same yield as chemical systems. In contrast, Loecke *et al*. (2004) showed that only well-decayed manure could produce the same yield as the chemical fertilizers. Van Lauw *et al*. (2001) showed that application of organic fertilizers alone could not fulfill the nitrogen requirements of plants. Kramer *et al*. (2002) reported that although total nitrogen absorption by plants in the organic system is lower than in the chemical system, the continuous release of nitrogen from organic matter lead to a continuous and sustainable nitrogen absorption that results in a better synchronization between absorption rate and availability of nitrogen leading to a higher yield. Reviews of previous studies on the nutritive value of leaves and bracts of artichoke (*Cynara scolymus*) suggested that despite relatively low amino acids contents, artichoke bracts might be use as a constituent of diets for dairy and beef cattle. Its potassinm, iron, manganese and copper are relatively high and its energy value estimated at 0.76 feed unit kg^{-1} DM. It was concluded that in cattle diets,

Table 2: Mean squares of soil fertilizing system effects on forage yield and quality traits of globe artichoke (*Cynara scolymus*)

		Mean squares					
SOV	df	DM (t ha^{-1})	CP (%)	Ash (%)	ADF (%)	DMD (%)	WSC (%)
Replication	3	1.7ns	3.55*	2.56**	18.13**	29.19**	3.85*
Soil fertilizing systems	14	3.3**	2.86*	0.56ns	12.32**	17.42**	1.98*
Error	42	0.73	1.14	0.37	3.87	5.88	1.06
CV	-	29.20	8.12	6.75	8.49	3.50	8.55

Ns: Means no significant at level ($p \leq 0.05$), *Means significant at level ($p \leq 0.05$) and **Means significant at level ($p \leq 0.01$)

Table 3: Mean comparison of forage traits as affected by soil fertilization

Fertilization treatments	Treat. No.	DMY (t ha^{-1})	Crude protein (%)	Water-soluble carbohydrates (%)	Dry matter digestibility (%)	Acid detergent fiber (%)	Ash (%)
Control	1	2.0de	11.5cd	11.69abc	65.37d	23.92bcd	9.06abc
Chemical	2	2.4cd	12.94bcd	12.28abcd	69.21abc	23.27bcd	8.92abc
	3	3.1bc	13.5abc	12.84a	67.52bcd	23.21bcd	8.34c
	4	2.7bcd	14.08abc	10.62c	69.95abc	22.86bcd	9.34abc
	5	3.7ab	14.26ab	12.65ab	73.16a	20.92cd	8.85abc
	6	4.1a	13.27abc	13.07a	71.36ab	20.73cd	9.43ab
Integrated	7	2.8bc	12.84bcd	12.06abc	70.83ab	21.31bcd	9.18abc
(Chemical + Organic)	8	4.8a	12.67bcd	12.60ab	70.42ab	22.82bcd	8.92abc
	9	4.0ab	13.35bcd	12.32abc	68.16bcd	24.60b	9.34abc
	10	2.5cd	13.03bcd	12.62ab	68.06bcd	22.99bcd	8.87abc
	11	2.3cd	14.98a	11.79abc	66.17cd	23.94bcd	9.62a
Organic	12	2.21d	13.13bcd	10.93bc	70.97ab	23.21bcd	9.68a
	13	1.41e	11.93d	11.51abc	70.37ab	22.20bcd	9.31abc
	14	2.46cd	11.67d	11.50abc	68.02bcd	27.88a	8.54bc
	15	2.77bcd	13.29bcd	12.32abc	68.21bcd	24.09bc	9.25abc

*Means in the same column followed by different letter(s) are significantly different using Duncan test ($p \leq 0.05$)

artichoke bracts have a nutritive value similar to that of maize silage (Galvano and Scerra, 1983). On the other hand, leaves, stems and industry residues can be used for cattle feeding (Pecaut, 1993).

Quality Traits

Forage quality was shown close linkage with fiber content, which is needed in coarse form to maximize rumen function. The lignified part of fiber is indigestible, yet it is required because unlignified material will not elicit adequate rumination activities (Van Soest, 1994).

Crude Protein (CP)

There is little published research about forage quality of artichoke. Soil fertilization treatments significantly ($p \leq 0.05$) affected CP% (Table 2). CP varied from 11.5% in treatment 1 (control) to 15.0% in treatment 11 (N = 200, P = 200, K = 240 kg ha^{-1} + OM = 5 t ha^{-1}). In chemical treatments, the Treatment numbers 6, 3, 4 and 5 were at the same statistical groups by 13.27, 13.5, 14.08 and 14.26 CP%, respectively. For the integrated system, the highest CP% values were obtained at treatment 9 (14.98%) and 11 (13.95%). For organic system, treatments 9 and 11 with 13.29 and 13.13% had the highest CP%, respectively (Table 3). Significant differences were obtained for three fertilizing systems (chemical, integrated and manure systems) compared to control with the mean values of 18, 16 and 9%, respectively. The lower CP% for organic treatments were probably due to the slow release of nitrogen in these fertilizers. These results are strongly supported by other research. Eghbal *et al*. (2001) stated that only about 20 and 35% of nitrogen in manures becomes available to plants in years 1 and 2, respectively.

Dry Matter Digestibility (DMD)

Soil fertilization systems significantly affected DMD ($p<0.01$) (Table 2). DMD values varied from 65.3% in control to 73.2% in treatment 5 (Table 3). Chemical and integrated fertilization treatments were grouped in the same statistical category. For integrated fertilization system, the highest DMD was obtained in treatments 7 (70.83%) and 8 (70.42%). Treatments 12 and 13 had the highest values at organic system with 70.97% and 70.37% respectively. Three soil fertilizing systems were increased the DMD% compared to control treatment. The mean values were 7.5, 6.3 and 5%, respectively. It is likely that the increasing DMD values in chemical compared to other systems were due to the rapid release of nitrogen from inorganic fertilizers.

Water-Soluble Carbohydrates (WSC)

The water-soluble carbohydrates in forage represent the rapidly digestible portion of the non-structural or stored carbohydrate in the plant. They are important for microbial activities in rumen. If the WSC are increased before ensiling, the silage pH will increase and silage quality will decrease (Van Soest, 1994). Soil fertilization significantly affected the WSC% ($p = 0.05$). The WSC values varied from 10.6% in treatment 4 to 13.1% in treatment 6. In the chemical system, except for treatment 4, there was no significant difference among them. Additionally, no significant difference was observed among five levels of integrated fertilization. The wsc in organic systems decreased by 1% compared to control.

Acid Detergent Fiber (ADF)

ADF was significantly affected by soil fertilization ($p<0.01$). The highest and lowest ADF values were obtained in treatments 14 (OM = 30 t ha^{-1}) and 6 (N = 200, P = 200, K = 240 kg ha^{-1}) with 73 and 20%, respectively. Compared to control treatment there was an increasing trend in ADF values from chemical (-7%) to integrated (-3%) and organic system (+2%). The lower ADF values in chemical and integrated systems could be explained by rapid release of N and its consumption by plants (Eghbal *et al*., 2001). As mentioned before, only a small portion of N (30%) was likely to have been released from organic fertilizers in the first year, while almost all the N in chemical fertilizer was readily available in the same period. This explanation is supported by the corresponding trend in crude protein content, whereby higher CP was observed in chemical treatments compared to integrated and organic fertilization systems (Buxton *et al*., 1999).

Ash

Soil fertilization systems had no significant effect on ash percentage in plants. Ash varied from 8.3% (treatment 3) to 9.6% (treatment 11). For this trait, organic and integrated fertilization resulted in higher values than chemical fertilization. The ash content in plants in organic and integrated systems was higher than in the chemical one. These results verified by studies that stated soil fertilization with manures led to increased availability of micronutrients (Rashid and Ryan, 2004; Elia *et al*., 1996). Ash percentage had a positive and significant relation with crude protein content. These results are agreed with Buxton *et al.* (1999).

Statistical Correlation Among Traits

Correlation between DM and fresh weight yield was found strongly positive (0.80**). The correlation between DM and fresh weight yield vs. quality traits were inconsistent, suggesting that quality traits are largely independent of DM yield; hence, it should be possible to improve both yield and forage quality. DMD had positive correlation with CP and strongly negative one with ADF (Table 4). Because ADF is completely indigestible fiber, a negative correlation between these two parameters is expected and is in agreement with other work (Abdalla *et al*., 2007; Van Soset, 1994;

Table 4: Correlation coefficients between forage yield, quality traits of globe artichoke (*Cynara scolymus*) as affected by soil fertilization

Traits	Ash (%)	CP (%)	ADF (%)	DMD (%)	WSC (%)	FW (t ha^{-1})	DM yield (t ha^{-1})
Ash (%)							
CP (%)	0.36**						
ADF (%)	0.13	-0.28*					
DMD (%)	0.007	0.40**	-0.77**				
WSC (%)	-0.40**	-0.12	-0.24	-0.13			
FW (t ha^{-1})	0.14	0.16	0.05	0.20	-0.07		
DM yield (t ha^{-1})	0.13	-0.01	-0.02	0.15	0.17	0.80**	

Ns: Means no significant (p<0.01), *Means significant at level (p<0.05) and **Means significant at level (p<0.01)

Jafari and Naseri, 2007). Total ash content was found positive but statistically significant with CP. This result is expected since total ash is produced from minerals. In contrast, WSC was negatively correlated with both total ash content. For WSC vs. CP, correlations were negative and non-significant. In agreement, Humphreys (1989) suggested that in perennial ryegrass, as growth increases with rapid uptake of nitrogen fertilizer, an increase in CP and a decrease in WSC content are enviroumentally induced effects. There was no significant correlation between forage yield and quality traits, but there was positive correlation between fresh weight and dry weight (r = 0.8**) (Table 4).

CONCLUSIONS

This research has shown that this crop has a high potential and produce quality forage for the livestock. It is of special interest that this potential has been achieved (except in the first year) in a low input management system. It was possible to obtain around 5 t ha^{-1} dry biomass and up to 30 t ha^{-1} fresh weight per year. Soil fertilization had a significant effect on forage yield and quality of artichoke. Crude protein percent increased in chemical, integrated and organic systems by 18, 16 and 9% compared to control treatment but nitrogen had played the most important role on it. This assumption that high solubility and availability of the nitrogen mineral in chemical and integrated systems caused a significant increase in it. The effects of soil fertilization treatments on dry matter digestibility was similar for all treatments (except Treatment 5). All the fertilization treatments significantly increased forage quality parameters compared to control.

All obtained findings indicate that the soil on the experimental site was poor and increasing soil nutrients can enhance the forage quality. During the study, statistically insignificant responses were obtained for effects of soil fertilization on fiber (ADF) values, suggesting no effects on lignifications of the artichoke. Regarding water soluble carbohydrates, there was no significant differences between chemical and integrated systems compared to control; however, these treatments had more WSC than organic system. The correlation between soil mineral nutrients (including nitrogen) and water-soluble carbohydrates was strongly affected by enviroumental factors. The losing rate of the nitrogen was higher for the organic systems compared to other treatments. The treatments 11 (N = 200, P = 200, K = 240 kg ha^{-1} + OM = 5 t ha^{-1}) and 9 (N = 120, P = 120, K = 144 kg ha^{-1} + OM = 10 t ha^{-1}) had the highest nitrogen loss rate among the integrated treatments. For chemical fertilization, treatments 5 (N = 160, P = 160, K = 196 kg ha^{-1}) and 6 (N = 200, P = 200, K = 240 kg ha^{-1}) had higher nitrogen loss rate than others.

A lack of quality forage and limited arable lands allocated to forage crops production in Iran call for a higher attention to be paid to work on high quality forage crops with high potential for biomass production. In respect to potential ability of artichoke to produce, 40 and 5 tons of fresh and dry yield, respectively, per hectare at 20,500 plants/ha density, it seems to be a good forage crop. But it is suggested that further complementary studies need to be conducted on this new forage crop in Iran and further studies on silage properties and quality of artichoke, the effect of micronutrients on yield and quality of artichoke should be done. In addition, it is necessary to be done more experiment like this more than one year to evaluate the effects of fertilizations properly.

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