Turkish Journal of Field Crops, 2011, 16(2): 197-202

THE EFFECTS OF SOME ORGANIC AND CHEMICAL FERTILIZER APPLICATIONS ON YIELD, MORPHOLOGY, QUALITY AND MINERAL CONTENT OF COMMON VETCH (*Vicia sativa L.*)

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Received: 22.06.2011

ABSTRACT

A field experiment was conducted to evaluate the effects of some organic and chemical fertilizers on morphological, yield and quality properties and mineral contents of common vetch (*Vicia sativa* L.) between 2007 and 2008 in Gümüşhane, Turkey. Treatments were control (no fertilizer), liquid manure (LM = 51-52 L ha^{-1} N), chemical fertilizer (CF = 30 kg N ha^{-1} + 80-100 kg P_2O_5 ha^{-1}), three leonardite doses (L_1= 2.8; L_2= 5.6 and L_3= 8.4 kg N ha^{-1}), three zeolite doses (Z_1= 0.4; Z_2= 0.8 and Z_3= 1.2 N kg ha^{-1}) and three solid cattle manure doses (SM_1= 34-35 kg N ha^{-1}, SM_2= 68-70 kg N ha^{-1}, SM_3= 102-105 kg N ha^{-1}). Dry hay yield (DHY), leaf weight, stem weight, plant height, leaf number, crude protein content (CP), crude protein yield (CPY), acid detergent fiber (ADF), neutral detergent fiber (NDF), Ca, Fe, K, Mg, B, Cu, Mn, Na, Ni, P, Pb, S and Zn contents were determined. Organic and chemical fertilizer applications had significant effect (P<0.01) on DHY, leaf weight, stem weight, CP, CPY and mineral contents except leaf number, ADF and NDF in the both years. The plant height were significantly (P<0.05) affected by the treatments in the first year. The SM_2 application in the first year and control and LM applications in the second year resulted to obtain improved yield components and crude protein yield. Z_2 and Z_3 applications also loomed large in terms of mineral contents.

Keywords: Chemical fertilizer, liquid manure, solid manure, zeolite, leonardite, common vetch

INTRODUCTION

The organic livestock production has expanded rapidly in many of the countries worldwide in the past ten years. The most important requirement of organic livestock production is to integrate the organic forage crops production. The cultivation of organic forage crops has some differences when compared to conventional production (Yolcu and Tan, 2008), particularly in fertilization (Yolcu 2010a). The rotation, intercropping mixture, green manure, solid and liquid farmyard manures, poultry manure, compost, leonardite, zeolite and biological fertilizers were actively used in organic agriculture as compared to the conventional agriculture in which chemical fertilizers are heavily used (Yolcu 2010b).

Manure improves the chemical, physical and biological characteristics of soils (Yolcu et al., 2010) and increases the yield and quality of crops. The producers have recently started using zeolite and leonardite on a limited scale. Leonardite, as an organic material, is soft coal-like deposits that occur at shallow depths and the leonardite is a concentrated form of humic and fulvic acids used in agricultural production (Ece et al., 2007). Zeolites are naturally occurring groups of minerals containing a cage-like structure which may promote plant growth by enhancing nutrient availability, soil conditioning, and improving soil moisture holding capacity (Wiedenfeld 2003) and it provides higher yields and better quality (Gevrek et al., 2009).

The effects of chemical fertilizers in plant production have been extensively examined in many studies made by Çelen and Akdemir (1998), Bilgili and Acikgoz (2007), Yolcu and Turan (2008), Yolcu and Serin (2009), Turk et al. (2009) and Albayrak and Yuksel (2010) in Turkey. Though there are not many concurrent studies conducted to evaluate the effects of organic and chemical fertilizers in crop production. Thus, this study was designed to evaluate the effects of organic and chemical fertilizers on yield, morphologic, quality properties and mineral contents of common vetch (*Vicia sativa* L.) under field conditions.

MATERIALS AND METHODS

This study was carried out in the research station of Kelkit Aydın Dogan Vocational College in Gumushane University located in the North East Turkey (40° 08' N, 39º 25' E) in 2007 and 2008 years. The research was designed in a randomized complete block design with three replicates. The study composed of control (no fertilizer), liquid manure (LM = 51-52 L ha^{-1} N), chemical fertilizer (CF = 30 kg N ha^{-1} + 80-100 kg P_2O_5 ha^{-1}), three leonardite doses (L_1= 2.8, L_2= 5.6 and L_3= 8.4 kg N ha^{-1}), three zeolite doses (Z_1= 0.4, Z_2= 0.8 and Z_3= 1.2 N kg ha^{-1}) and three solid cattle manure doses (SM_1= 34-35 kg N ha^{-1}, SM_2= 68-70 kg N ha^{-1}, SM_3=

102-105 kg N ha^{-1}) and three replications consisted of 36 parcels (Table 1).

Table 1. Treatments of some organic and chemical fertilizer used in the study.

Treatments	
Control	No manure, chemical, leonardite, zeolite
LM	51-52 L ha^{-1} N (10000 L ha^{-1} liquid cattle manure)
CF	30 kg N ha^{-1} + 80-100 kg P_2O_5 ha^{-1} chemical fertilizer
L_1	2.8 kg N ha^{-1} (250 kg ha^{-1} leonardite application)
L_2	5.6 kg N ha^{-1} (500 kg ha^{-1} leonardite application)
L_3	8.4 kg N ha^{-1} (750 kg ha^{-1} leonardite application)
Z_1	0.4 kg N ha^{-1} (250 kg ha^{-1} zeolite application)
Z_2	0.8 kg N ha^{-1} (500 kg ha^{-1} zeolite application)
Z_3	1.2 kg N ha^{-1} (750 kg ha^{-1} zeolite application)
SM_1	34-35 kg N ha^{-1} (10 ton ha^{-1} solid cattle manure)
SM_2	68-70 kg N ha^{-1} (20 ton ha^{-1} solid cattle manure)
SM_3	102-105 kg N ha^{-1} (30 ton ha^{-1} solid cattle manure)

Common vetch was sown in April of 2007 and 2008 and in the dose of 120 kg ha^{-1} with 24 cm row spacing (Serin et al., 1995 and Serin et al., 1996). The sizes of plot were 3.0 m length by 1.68 m width and were 5.04 m^2. The characteristics of experimental soil were shown in Table 2. Climatic data of study area in 2007 and 2008 and long-term averages were presented in Table 3. There were seven spring frost days in April of 2007. Some properties of solid, liquid cattle manures, leonardite and zeolite used were recorded in Table 4 and 5. Chemical fertilizers, leonardite, zeolite and cattle manure were applied before seeding; and liquid cattle manure was applied after seeding. The research area was irrigated twice with 15 days intervals (Serin and Tan, 2001), and common vetch were harvested at the embodiment period of bottom fruits (Acikgoz 2001).

Table 2. Some characteristics of the research location soils at Kelkit. Turkey.

	Soils	**pH**	**$CaCO_3$**	**OM**	**P**	**N**	**Cu**	**Mn**	**Fe**	**Zn**	**Ca**	**K**	**Mg**	**Na**	**CCC**
	cm		**%**				**ppm**					**me/100 gr**			
First year	0-30	7.57	9.94	2.28	12.56	16.74	1.00	1.19	3.14	2.64	14.35	5.28	3.27	1.34	26.91
First year	30-60	7.62	6.50	3.23	17.79	23.72	1.42	1.69	4.45	3.74	9.39	3.45	2.59	1.30	18.57
Second year	0-30	7.65	19.37	2.07	11.40	15.20	0.91	1.08	1.60	2.62	17.08	5.74	3.56	1.19	20.95
Second year	30-60	7.65	15.47	3.00	16.52	22.03	1.32	1.57	2.31	3.80	16.46	5.53	3.43	1.18	20.22

Table 3. Climatic data of study area in 2007. 2008 and long-term average (1975-2006) at Kelkit, Turkey.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total/Mean
Years	Total Precipitation (mm) (Montly) *												
2007*	53.0	25.3	52.0	35.1	40.7	32.2	1.1	31.4	1.2	54.3	98.6	69.0	493.9
2008*	40.8	23.3	38.4	51.4	28.4	35.8	2.6	20.0	30.3	35.2	21.1	34.4	361.7
1986-2006*	33.1	35.5	38.3	57.7	68.3	45.1	14.8	13.8	26.3	50.6	45.1	37.6	466.2
	Mean air temperature (°C) (Monthly)												
2007	-1.9	-0.2	3.6	5.4	17.3	18.2	21.6	21.6	18.6	12.9	3.7	-0.8	10.0
2008	-6.1	-4.4	8.1	11.6	11.7	16.6	20.1	21.5	17.1	11.9	6.6	-0.7	
1986-2006	-1.8	-1.0	3.1	9.4	13.3	16.8	20.2	20.1	16.3	11.3	4.4	0.5	9.4
	Mean relative humidity (%) (Monthly)* Period of mean bringing light (hours)**												
2007*	69.5	66.1	69.6	68.2	59.0	65.8	57.6	64.6	60.1	69.2	74.3	77.4	66.8
2008*	70.7	71.4	63.0	65.0	68.3	69.6	68.5	69.4	68.3	73.0	72.9	73.2	69.4
1975-2006**	1.3	3.7	5.1	6.2	7.4	9.3	10.1	10.0	8.1	5.6	2.1	0.8	5.8

Table 4. Some properties of solid and liquid cattle manures used in research (2007-2008)

	Manure	pH	Moisture	Dry matter	Organic Matter	N	P	K	Ca	Mg	Na	Fe	Zn
			%						Ppm				
First year	Solid	7.42	83.4	16.6	27.20	3400	2000	600	3500	995	625	425	584
First year	Liquid	6.86	-	-	-	5200	1000	4200	100	89	58	40	45
Second year	Solid	7.65	78.8	21.2	28.00	3500	2300	1200	3100	972	650	438	580
Second year	liquid	6.86	-	-	-	5100	1200	4800	100	88	72	38	36

Table 5. Some properties of leonardite and zeolite used in research (2007-2008)

Fertilizer	pH	OM	Humic acid + Fulvic acid	N	P	S	K
	(1/5 v/v)			%			
Zeolite	4.24	14.24	40	0.16	0.04	1.20	0.32
Leonardite	6.70	50.60	41	1.12	0.09	0.11	0.51
	Ca	Mg	Fe	Mn	Zn	Cu	Na
			mg kg^{-1}				
Zeolite	6500	1800	192	65	224	45	1420
Leonardite	14000	2400	6800	255	685	120	960

Leaf numbers and height of common vetch were determined as the average of 10 plants. In determining dry leaf and stem weight, dry leaf and stem weight of 10 plants were taken into consideration. The hay samples were oven-dried at 68 ºC for 48 h, ground to pass through a 1 mm sieve, and analyzed for N, Ca, Fe, K, Mg, B, Cu, Mn, Na, Ni, P, Pb, S and Zn contents. The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany) were used to determine total N (Bremner 1996) in common vetch. Macro and micro-elements of crop material were determined after wet digestion sub-samples using a HNO_3-H_2O_2 acid mixture (2:3 v/v) with three steps (first step: 145ºC, 75%RF, 5 min; second step: 180ºC, 90%RF, 10 min and third step: 100ºC, 40%RF, 10 min) in microwave (Bergof Speedwave Microwave Digestion Equipment MWS-2) (Mertens 2005a). The Ca, Fe, K, Mg, B, Cu, Mn, Na, Ni, P, Pb, S and Zn contents of hay samples were determined with Inductively Couple Plasma Spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA) (Mertens 2005b). Crude protein content of common vetch was calculated multiplying the N contents by a coefficient of 6.25 (Frank, 1975). ADF and NDF contents were determined according to Van Soest (1963).

Soil samples in the study area (0-60 cm) were collected prior to the experiment in 2007 and 2008. Soil samples were air-dried, crushed, and passed through a 2-mm sieve prior to analysis. The soil samples were analyzed for cation exchange capacity (CEC) (Sumner and Miller, 1996), Kjeldahl-N (Bremner 1996), Olsen-P (Olsen et al., 1954), pH (1:2,5 H_2O w/v, McLean 1982), organic matter (OM) (Nelson and Sommers, 1982), exchangeable Ca, Mg, K, and Na (Rhoades 1982) and extractable Fe, Mn, Zn, and Cu contents (Lindsay and Norvel, 1978). Analysis of variance (ANOVA) was computed by SAS GLM (SAS Institute 2002) with a mean separation according to the LSD test.

RESULTS AND DISCUSSION

The results were presented by year, since the effects of years were important for dry hay yield, leaf weight, stem weight, plant height, leaf number, CP, CPY, Ca, Fe, K, Mg, B, Cu, Mn, Na, P, Pb, S and Zn contents.

Various fertilizer sources had significant ($P<0.01$) effect on dry matter yields in the first and the second year (Table 6). Lanyasunya et al. (2007), Efthimiadou et al. (2009), Gul et al. (2009), Naveen et al. (2009), Fateh et al. (2009) and Urkurkar et al. (2010) also reported significant differences in yield with the application of different fertilizer sources. The highest hay yield was determined with SM_2 (1603.0 kg ha^{-1}) application in 2007 (Table 6). Elamin and Elagib (2001) also reported that chicken manure had greater effect on yield as compared to the green manure and chemical fertilizer. SM_3 application yielded 1445.3 kg ha^{-1} hay and CF (1246.2 kg ha^{-1}) and SM_1 (1244.3 kg ha^{-1}) applications yielded lower hay yield respectively (Table 6). Middle level of solid cattle manure had higher effect compared to the other applications. Higher levels of manure might have negative effects on plant-Rhizobium ssp relation (Tan and Serin, 1995; Acikgoz 2001). The lowest hay yield was obtained in control (735.4 kg ha^{-1}) in 2007, however the highest dry matter (2378.6 kg ha^{-1}) was obtained in control at the second year of the experiment. The highest leaf weightes in 2007 were measured in SM_2 (7.77 g) and LM (7.61 g) applications, respectively (Table 6). These applications were followed by SM_3 (7.28 g), SM_1 (6.78 g) and control (6.78 g) applications. L_1, control and LM applications yielded 4.88, 4.79 and 4.69 g leaf weightes in the second year, respectively. These applications had higher leaf weights as compared to the other applications. The highest stem weights were measured with SM_2 (6.57 g) and LM (5.99 g) applications in the first year, respectively (Table 6). The order of stem weights for the applications were LM (5.74 g), SM_3 (5.62 g), SM_2 (5.23 g) and L_3 (5.10 g) in the second year, respectively. The highest plant heights were obtained in LM (41.20 cm), SM_2 (38.90 cm), L_1 (38.70 cm) and SM_3 (38.60 cm) applications in the first year, respectively. Similar plant height differences were reported between control, organic, inorganic and inorganic + organic fertilizer by Ayoola and Makinde (2007) and between manure, mulch and chemical fertilizer by Efthimiadou et al. (2009). Different fertilizer sources had no effect on common vetch leaf numbers in the second year. Fertilizer sources were ($P<0.01$) affected in crude protein contents at the first and second year of the experiment (Table 6). The differences in crude protein were also reported between swine lagoon effluent and commercial fertilizer by Adeli et al. (2005), between chemical, organic and integrated fertilizer application by Fateh et al. (2009) and between zeolite, leonardite and manure applications by Yolcu et al. (2011). The fertilizers used increased crude protein content when compared with control. The highest crude protein contents were determined in SM_3 (17.77 %), L_2 (17.58 %) and SM_2 (17.33 %) applications. These applications were followed by L_3 (16.79 %), LM (16.79 %) and L_1 (16.69 %) applications in the first year. The highest crude protein contents were found in L_2 (17.88 %), SM_3 (17.77%), LM (17.65 %) and L_3 (17.6 %) application in the second year. Different fertilizer sources had significant ($P<0.01$) effect in crude protein yield in the both years (Table 6). Similar differences in crude protein yield were stated with manure and fertilizer applications by Lanyasunya et al. (2007) and with manure, zeolite and leonardite applications by Yolcu et al. (2011). All applications increased crude protein yield of

Table 6. Effects of some organic and chemical fertilizer applications on dry hay yield. morphologic and quality parameters of common vetch

	DHY (kg/ha)	Leaf Weight	Stem Weight	Plant Height	Leaf Number	CP (%)	CPY (kg/ha)	ADF (%)	NDF (%)
					2007				
Control	735.4F	6.78ABC	4.37EFG	30.50d	15.33	12.98G	95.51H	30.78	38.69
LM	1141.5D	7.61A	5.99AB	41.20a	18.37	16.79C	191.72DE	29.14	36.65
CF	1246.2C	6.16BCD	4.83CDEF	35.90abcd	16.37	16.21DE	202.07CD	28.49	37.17
L_1	1148.7D	6.57ABCD	5.17BCDE	38.70ab	18.70	16.69C	191.70DE	28.74	35.64
L_2	1209.3CD	5.43DE	4.62DEF	33.73bcd	16.67	17.58AB	212.60C	28.62	37.53
L_3	817.7EF	5.51CDE	4.28FG	30.90d	16.50	16.79C	137.28FG	30.08	36.82
Z_1	1172.7CD	6.18BCD	4.17FG	32.67bcd	16.93	15.23F	178.58E	30.57	37.13
Z_2	766.7F	4.80E	3.53G	29.33d	15.67	16.27D	124.84G	28.29	38.92
Z_3	886.1E	5.84CDE	4.42EF	31.53cd	16.97	15.92E	141.00F	28.32	41.24
SM_1	1244.3C	6.78ABC	5.45BCD	37.57abc	17.47	16.21DE	201.61CD	27.25	36.01
SM_2	1603.0A	7.77A	6.57A	38.90ab	17.60	17.33B	277.87A	30.02	36.96
SM_3	1445.3B	7.28AB	5.57BC	38.60ab	18.17	17.77A	256.85B	27.97	36.71
Mean	1118.0B	6.39A	4.91a	34.96B	17.06A	16.31 B	184.3 B	29.02	37.46
Lsd	87	1.3	0.9	6.6	n.s.	3.5	15.3	n.s.	n.s.
					2008				
Control	2378.6A	4.79A	4.54BCD	44.50	11.70	13.96H	332.05A	29.44	39.48
LM	1829.4B	4.69A	5.74A	40.57	11.80	17.65ABC	322.76A	31.50	39.98
CF	952.3EF	2.92CD	3.60EF	49.66	11.80	17.25DE	164.26D	28.29	37.16
L_1	1821.7B	4.88A	5.07ABC	42.07	10.80	16.85FG	307.04A	29.18	38.43
L_2	1527.5C	3.12BCD	4.25CDEF	41.70	12.50	17.88A	273.17B	26.20	36.37
L_3	1203.4D	4.05AB	5.10AB	35.17	11.67	17.60ABC	212.61C	27.94	38.29
Z_1	1451.9C	4.07AB	4.43BCDE	42.23	11.03	17.39CD	252.56B	28.69	33.88
Z_2	1855.9B	3.10BCD	3.80DEF	37.20	10.30	17.54BC	325.42A	31.13	37.36
Z_3	1164.3D	2.66D	3.47F	39.13	10.10	17.10EF	199.16C	32.04	36.13
SM_1	942.3F	3.36BCD	4.63BCD	32.83	13.30	16.81G	158.47D	29.01	36.75
SM_2	1238.0D	4.08AB	5.23AB	47.70	12.17	17.48CD	216.44C	26.04	38.80
SM_3	1094.0DE	3.79ABC	5.62A	39.60	11.20	17.77AB	194.31C	30.67	37.14
Mean	1455.0 A	3.79B	4.62b	41.03A	11.53B	17.11A	246.5 A	29.18	37.48
Lsd (Treat.)	147	1.1	0.8	n.s.	n.s.	0.3	25.7	n.s.	n.s.
Lsd (Year)	34	0.3	0.2	2.6	0.6	0.1	5.9	n.s.	n.s.
Lsd (Treat. x Year)	118**	n.s.	0.8**	n.s.	n.s.	0.3**	20.6**	n.s.	n.s.

*Significant at %5 level. **significant at %1 level; Values followed by small and capital in a column shows significantly differences at p< 0.05 and p< 0.01 levels. Respectively

common vetch when compared with control in the first year. SM_2 (277.87 kg ha^{-1}) and SM_3 (256.85 kg ha^{-1}) resulted to obtain the highest crude protein yield in the first year. High crude protein yields were found in control (332.05 kg ha^{-1}), Z_2 (325.42 kg ha^{-1}), LM (322.76 kg ha^{-1}) and L_1 (307.04 kg ha^{-1}) applications in the second year. Organic and chemical fertilizer application had no significant effects on ADF and NDF in both years of the experiment (Table 6). Yolcu et al. (2011) also reported that no differences in ADF and NDF when applied different fertilizer sources.

All applications had significant (P<0.01) effect on mineral contents of common vetch (Figures 1 and 2). The highest Ca (23284.00 mg kg^{-1}), Mg (4472.67 mg kg^{-1}), B (68.79 mg kg^{-1}), Cu (12.02 mg kg^{-1}), Mn (68.63 mg kg^{-1}), Na (5886.33 mg kg^{-1}), P (4215.67 mg kg^{-1}), Pb (3.44 mg kg^{-1}), S (4861.33 mg kg^{-1}) and Zn (133.34 mg kg^{-1}) contents were obtained with L_3 application in the first year. The highest Fe (1188.67 mg kg^{-1}), Ca (22554.00 mg kg^{-1}), K (19422.67 mg kg^{-1}), Mn (68.22 mg kg^{-1}) and Ni (7.09 mg kg^{-1}) in L_2 application and Pb (3.24 mg kg^{-1}) in SM_3 application were found in the first year. The highest content of Ca (25797.00 mg kg^{-1}), Fe (1565. 33 mg kg^{-1}), Mg (4135.67 mg kg^{-1}) and Ni (7.78 mg kg^{-1}) in Z_1 application; Mn (98.89 mg kg^{-1}), P (5102.67 mg kg^{-1}) and Zn (120.30 mg kg^{-1}) in Z_3 application; Na (2779.00 mg kg^{-1}) and Pb (4.12 mg kg^{-1}) in Z_2 application; K (21737.33 mg kg^{-1}) and Na (2694.00 mg kg^{-1}) in SM_1 application; S (6494.00 mg kg^{-1}) in CF application, B (50.15 mg kg^{-1}) in L_1 application; K (20909.67 mg kg^{-1}) in L_3 application and Cu (8.01 mg kg^{-1}) in SM_3 application were achieved in the second year. Similar differences in P, K, Ca and Mg contents were reported among control, green manure, chicken manure, urea, superphosphate, potassium sulphate and NPK composite fertilizers by Elamin and Elagib (2001). Yolcu et al. (2011) also stated significant differences in K, Ca, S, Fe, Mn, Zn, P, Mg, Cu, B, and Na contents among manure, zeolite and leonardite applications.

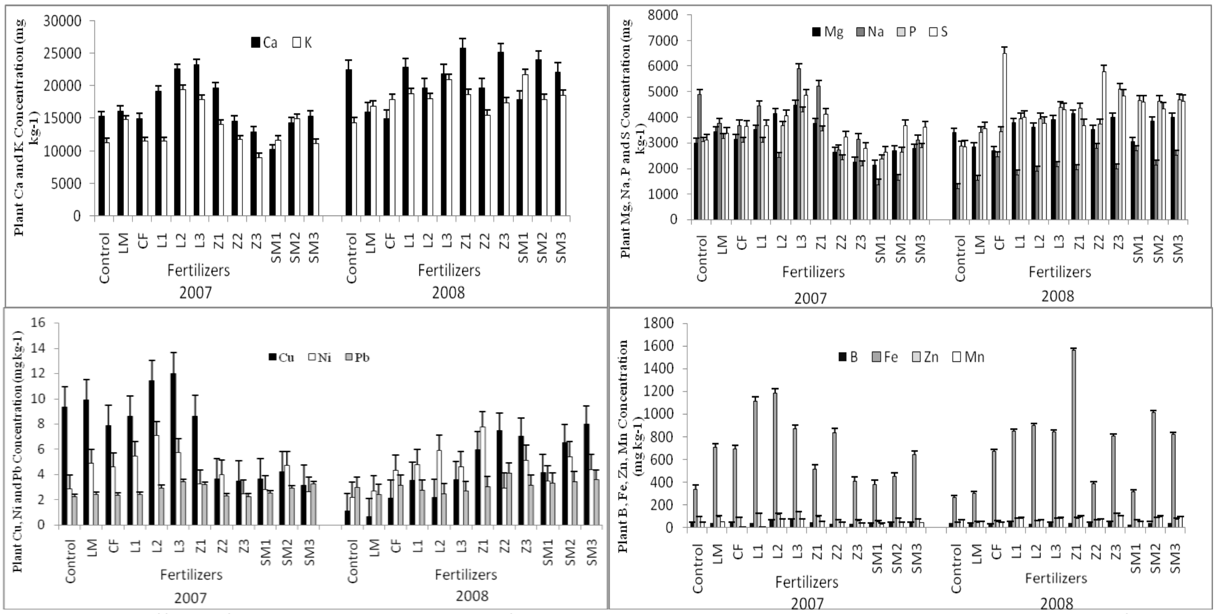

Figure 1. The effects of some organic and chemical fertilizer applications on the macro and micro element content of Common vetch hay (with lsd bar).

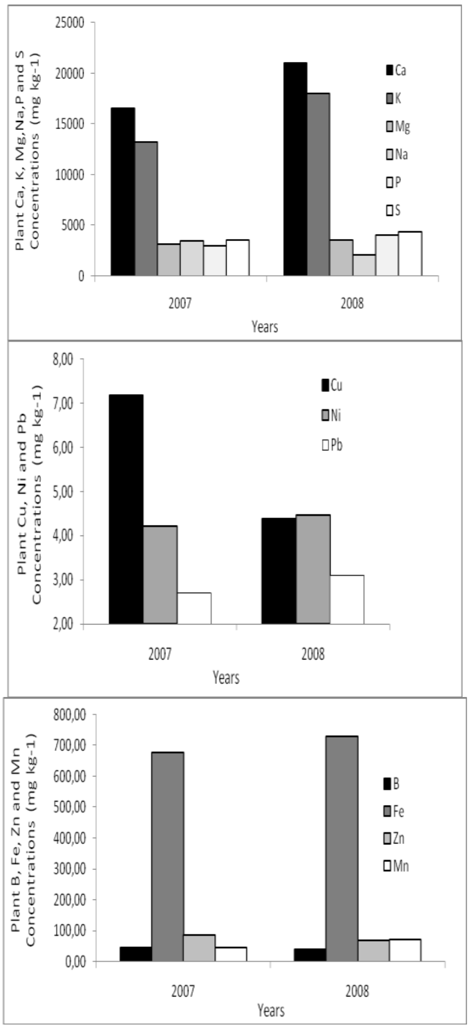

Figure 2. Changing of macro and micro element content of Common vetch hay in study years.

CONCLUSION

The SM_2 application in the first year and control and LM applications in the second year resulted to obtain improved yield components and crude protein yield. SM_2 (68-70 kg N ha^{-1}, 20 ton ha^{-1} solid cattle manure) and LM (51-52 L ha^{-1} N, 10000L/ha liquid cattle manure) may be applied to the fields to obtain high quality forages. Meanwhile, these applications improved the chemical, physical and biological properties of experimental soil. Z_2 and Z_3 applications also loomed large in terms of mineral contents. Thus, Z_2 (0.8 kg N ha^{-1}, 500 kg ha^{-1} zeolite) and Z_3 (1.2 kg N ha^{-1}, 750 kg ha^{-1}zeolite) doses may be applied to obtain higher mineral contents. Soil and water pollution will be decreased using organic materials in agriculture that will result to obtain healthy plant and animal production.

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