Turk J
Field Crops
2019, 24(2), 138-144
DOI: 10.17557/tjfc.540782

EVALUATION OF SOLID BIOGAS FERMENTATION RESIDUE AS A SOURCE OF ORGANIC FERTILIZER ON BERSEEM CLOVER (*Trifolium alexandrinum* L.)

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Received: 08.04.2019

ABSTRACT

The study was carried out in order to investigate the effects of 5 different solid biogas fermentation residue doses (0, 5, 10, 15, 20 t ha^{-1}) on the yield and quality of berseem clover (*Trifolium alexandrinum* L.) in Aydın province. In the study, no chemical fertilizers were applied and the harvest was carried out at 50-100% flowering time. In the study, hay yield (t ha^{-1}), leaf / stem ratio (%), Ca (%), Mg (%), crude ash content (%), acid detergen fiber (ADF, %), neutral detergent fiber (NDF, %), crude protein content (%) parameters are measured. Crude protein yield yield (t ha^{-1}) and relative feed value calculated after the measurements. According to the results, in 2016-2018 years average hay yield was obtained from 5.529 t ha^{-1} of 15 t ha^{-1} solid biogas residue application. In terms of crude protein content, the highest value in 2016-2018 years was found as 22,88% in 10 t ha^{-1} fertilizer application. As a result of the study, it was found that solid biogas waste had positive effects on feed efficiency and quality when all parameters were evaluated. Especially 10 t ha^{-1} and 15 t ha^{-1} solid biogas residue fertilizer doses were determined to come to the fore in the berseem clover.

Keywords: Berseem clover, biogas residue, fertilizer, forage quality

INTRODUCTION

Feeding programmes for ruminant livestock in Mediterranean basin can't rely on seasonally roughage and low quality forage resources. Some alternative forage crops should be grown as winter catch crops for complete quality fodder deficit (Caballero Garcia de Arevelo et al., 1994). One of these resorces. Berseem clover (*Trifolium alexandrinum* L.) is an annual forage legume species native to western Asia. It is extensively cultivated in Mediterranean basin in irrigated and rainfed farming conditions due to its excellent feeding value (Abogedallah and Quick, 2010; Zaghlamı Khelil et al., 2015; Yucel et al., 2018). However this is not widely grown in Turkey but, it has the potential to be considered as a winter catch crops in corn and cotton cultivation areas in order to reduce the lack of quality roughage.

The number of biogas and biomass power plants has reached 82 in Turkey (Atlas of Energy, 2019). Not all of these plants have the same characteristics, while some power plants evaluate animal wastes, while some power plants evaluate herbal and garbage waste. The biogas can be used for producing heat, electric power and vehicle fuel. Moreover, the digestate can be used as a fertilizer on arable land, enabling recirculation of plant nutrients and then reducing the need for fossil fuel-dependent mineral fertilizer. (Holm-Neilsen et. al., 2009; Moller et al., 2009; Abubaker et al., 2012; Wentzel and Joergensen, 2016a; Hupfauf et al., 2016; Risberg et al., 2017). Biogas production is increasingly popular in many countries due to climate change and environmental pollution (Islam et al., 2010; Insam et al., 2015; Rozylo et al., 2015; Risberg et al., 2017).

Biogas fermentation residue is a secondary prodcut that is also inexpensive and organic fertilizer. It is not only rich in macronutrients and micronutrients, but also rich in amino acids, vitamins, enzimes, materials or factors inhibited the pest and diseases (Wu-Di, 2002; Islam et al., 2010; Alburquerque et al., 2012). The use of these residues as fertilizers closes nutrient cycles in organic farming systems. It provides N, P, K and improves the structure of the soil (Stinner et al., 2008; Arthurson, 2009; Fouda et al., 2013; Nkoa, 2014; Wentzel and Joergensen, 2016b). Although it is considered that there is no need to fertilize the legumes due to nitrogen binding, they are more sensitive in terms of phosphorus than grasses Thus it is possible to use in legumes as it contains phosphorus.

This expriment was conduced to examine the possibility of using the solid biogas fermentation residue as an organic fertilizer for production of berseem clover (*T. alexandrinum* L.).

MATERIALS AND METHODS

The research was conducted during the 2016-2018 growing seasons in Aydın Province (37°45’ 44’’ N, 27°45’31’’ E; elevation 30 m), located in Aegean region of Turkey. According to soil analysis report of Soil Science Department of Faculty of Agriculture, the soil characteristics in 0-30 cm depth of the experimental area was loamy and alkaline with low organic matter. Lime content of soil is 3.82%, total saline content of 0.02%, phosphorus (P) content of 35 ppm and available potassium of 320 ppm (Table 1). Climate data of experimental area shown in Figure 1. Total precipitation of 2016, 2017 and long years are 303.8 mm, 407.2 mm, 669 mm, respectively. Aveage teperature of 2016, 2017 and long years are 16.86, 17.85, 17.35, respectively. As it can be seen from the climate data, the years in which the experiment is made are dry and the amount of rainfall in the first year is less than half of the average for long years rainfall.

Table 1. Soil analysis report of experimental area

	Sand (%)	Silt (%)	Clay (%)	Texture	Total Salt (%)	pH	Lime (%)	Org. Matter (%)
	47,19	34,56	18,25	Tınlı	0,0189	8,10	3,82	1,10
					Saltless	Alkali	Limy	Low
P (ppm)	**K (ppm)**	**Ca (ppm)**	**Mg (ppm)**	**Na (ppm)**	**Fe (ppm)**	**Zn (ppm)**	**Mn (ppm)**	**Cu (ppm)**
35	320	3218	413	240	10,62	3,71	5,24	21,80
High	High	High	Very High	High	High	Enough	Enough	Enough

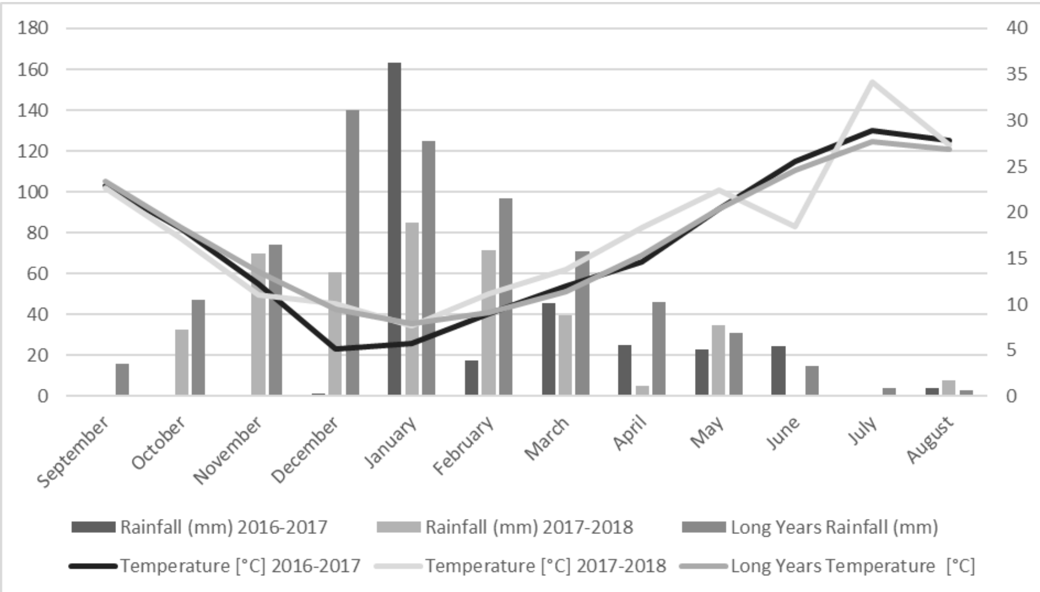

Figure 1. The average of monthly climate values for the years of 2016-18 (obtained from the Meteorology Station of the Faculty of Agriculture of Aydın Adnan Menderes University) and for long years in the Cakmar Quarter of the Kocarlı District of Aydın province (Anonymous, 2018).

Solid biogas fermentation residues used in the experiment were obtained from Efeler Biogas Plant in Aydın. When the chemical content of biogas residue fertilizer was evaluated, it was found that the content of nitrogen was 1.42%, P_2O_5 content was 2.33%, K_2O was 0.60% and organic matter was 91.18%. Also CaO content of applied material was 2.94% and MgO content was 0.90%.

The experiment was designed in randomized complete block design with 3 replications. Every plot consisted of 6 (5m x 1.2m) m^2 area and sowing was carried out using 20 cm row spacing. Following the application of 5 different doses of solid biogas residue fertilzer (0, 5, 10, 15, 20 t/ha^{-1}) to the floor, it was carried out with sowing seed drill in November of 2016 and 2017. No fertilization has been performed except for the biogas waste fertilization. Berseem clover cv. Derya was evaluated as material and 0,02 t ha $^{-1}$ seed was used (Acıkgoz, 2001). The mowing process was carried out from a height of 5 cm with the mower (Bcs 615 L Max Honda Gx200) when the plants reached 50-100% flowering time according to Yucel et al. (2018). Ten different plants were taken from the parcels for the measure of plant height (cm), stem diameter (mm) and leaf/stem ratio (%). One edge row from each side of plot were cut out and then rest of the plot was harvested and weighed to determine fresh forage yield. Hay yield (t ha^{-1}) was measured by fan drying oven (Mikrotest, MST) at 70°C until the weight was fixed (Cook and Stubbendieck, 1986). The dried samples were ground in a mill passed through a 2 mm screen. Crude ash was determined at 550 ºC (Bulgurlu and Ergul, 1978). The crude protein ratio (%) of the samples taken from the experiment were measured according to the method of AOAC (2003); NDF and ADF contents (%) were measured according to Van Soest et al. (1991). The crude protein yield (t ha^{-1}) and relative feed value were calculated by the obtained data with following procedures of Horrocks and Vallentine (1999). NIRS-FT (Brüker-MPA) method was preferred to measure Ca and Mg contents.

In order to compare the results obtained from the study, variance analysis was applied with randomized blocks trial design with the help of SAS statistical package program (SAS, 1998). Duncan multiple comparison test was used in comparison of the averages. Boxplots were made in SPSS statistical package program (SPSS, 1995)

RESULTS AND DISCUSSION

All the data obtained from the experiment was a result of first mowing. Although sprinkler irrigation was performed after mowing, no roughage of economic importance was obtained for the 2nd mowing. When the hay yield is examined, the second year average in terms of year averages is higher than the first year average with 5.76 t ha^{-1}. When the application averages were taken into consideration, the highest value was obtained at 15 t ha^{-1} as 5.52 t ha^{-1}. When the interaction of the applications according to years was examined, it is observed that the yield increases due to the increase in the fertilizer dose. (Table 2. and Figure 2.) In addition, considering the difference in yield between the two production years, it is thought that the situation in the climate is different. The irregularities in rainfall and low amount of precipitation in 2016-17 had a negative effect on yield. Sullivan et al. (2006) says in their study; the application of organic fertilizer may significantly chnage the soil microbial communities, resulting in improvements of the soil quality. This results increase yield and quality.

Table 2. Hay yield (t ha $^{-1}$) averages of soild biogas fermentation residue doses.

Hay Yield (t ha^{-1})			
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**
Control (0)	1.71±1.05	4.65±1.10	3.18 ^{D}
5	2.68±0.89	5.56±0.28	4.12 ^{BC}
10	2.92±0.27	6.18±0.63	4.55 ^{B}
15	3.02±0.81	8.03±0.83	5.52 ^{A}
20	2.83±0.32	4.39±0.95	3.61 ^{CD}
Average	2.63 ^{B}	5.76 ^{A}	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

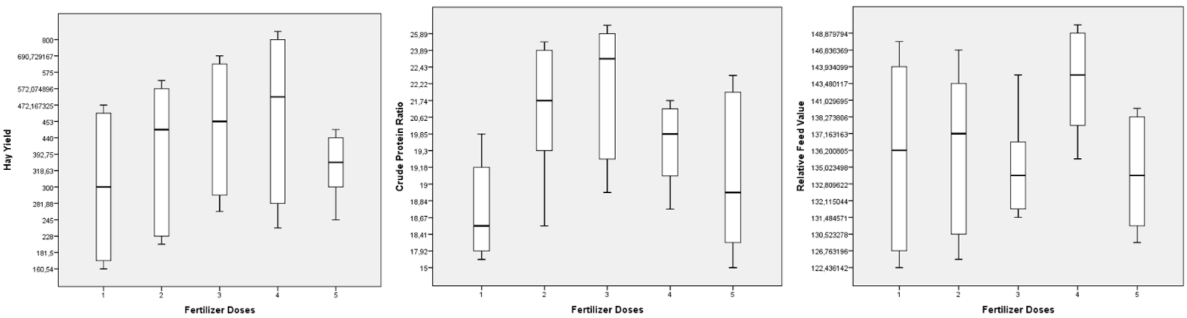

Figure 2. Boxplot graphics of Hay yield (t ha $^{-1}$), Crude protein ratio (%), Relative feed value

Among the nutrients, deficiency of P in soil has an adverse impact on legume production as it is required for energy transformation in nodules and enhanced N-fixation. The limited availability of P in soil leads to poor plant growth and development of legume crops. P deficiency has some negative effects on nodule formation, and photosynthetic ability in leaf and hence reduces photosynthesis (Mitran et al., 2018). Islam et al. (2010) reported from their study; the biogas residue fertilizer increase fodder maize yield. But excessive doses of fertilizer decrease forage yield and quality. Results of Koc (2013) shown the similar about this stiuation. He found in his study; excessive amount of phosphorus fertilization reduced yields in legumes. Surmen et al. (2011) reported that P fertilization have positive effect on forage yield of legumes. In studies related to berseem clover, results of Hakyemez and Sancak (2005) shown similar in terms of forage yield and quality. But results of Yucel et al. (2018) shown some differences.

When the mean of plant height averages analyzed, the average of the 2nd year was determined as 93.08 cm. According to the application averages, the highest value of 5 t ha^{-1} is 83.40 cm. When the stem diameter averages were evaluated, the highest stem diameter was obtained with 90.40 cm in the first year. As per the application averages, the highest value was determined with 85.56 mm in 5 t ha^{-1} application (Table 3.). It is thought that changes in plant height and stem diameter are caused by different climates, especially between two years. Therefore, the occurrence of the rainfall seen in the first year may have affected the body diameter instead of the plant height.

Table 3. Plant height (cm) and stem diameter (mm) averages of soild biogas fermentation residue doses

	Plant Height (cm)			Stem Diameter (mm)		
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**	**2016-2017**	**2017-2018**	**Average**
Control (0)	64.50±1.21	88.53±2.13	**76.51 ^{B}**	92.66±1.15	70.46±6.17	**81.56 ^{A}**
5	67.13±2.51	99.66±3.05	**83.40 ^{A}**	101.33±5.77	69.80±7.20	**85.56 ^{A}**
10	56.93±0.41	84.26±2.02	**70.60 ^{C}**	70.66±5.03	59.60±13.51	**65.13 ^{B}**
15	58.60±1.31	98.60±3.83	**78.60 ^{B}**	87.33±2.30	65.20±11.80	**76.26 ^{A}**
20	60.33±1.60	94.33±4.04	**77.33 ^{B}**	100.00±0.00	73.73±9.60	**86.86 ^{A}**
Average	**61.50 ^{B}**	**93.08 ^{A}**		**90.40 ^{A}**	**67.76 ^{B}**	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

The first year rate of leaf / stem ratio averages is higher with 1.008 than the second year. The highest value of the application average was determined as 0.927. Although the stem diameter of the first year is high, the plant height is shorter, increasing the leaf rate. However, as a result of this situation, hay yield was lower in the first year. When the crude ash content is examined, it is the highest with 20.57% in the first year according to the year averages. When the application averages was analyzed, the highest value was determined with 19.96% in 15 t ha^{-1} application. It is seen that the fertilizer application increases the amount of crude ash ratio due to the organic matter it has in fertilizer. However, the effect of large amounts of fertilizer on crude ash ratio is also negative (Table 4.).

Table 4. Leaf/Stem ratio (%) and crude ash content (%) averages of soild fermentation residue doses

	Leaf/Stem Ratio			Crude Ash Content (%)		
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**	**2016-2017**	**2017-2018**	**Average**
Control (0)	0.960±0.21	0.624±0.05	**0.792 ^{AB}**	22.34±2.39	12.71±2.32	**17.52 ^{BC}**
5	0.820±0.07	0.478±0.03	**0.649 ^{BC}**	19.27±0.54	13.27±1.80	**16.27 ^{C}**
10	1.180±0.13	0.675±0.09	**0.927 ^{A}**	17.11±1.23	17.17±0.20	**17.14 ^{BC}**
15	1.246±0.13	0.328±0.04	**0.787 ^{AB}**	21.78±0.39	18.14±2.20	**19.96 ^{A}**
20	0.833±0.11	0.415±0.06	**0.624 ^{C}**	22.38±1.84	15.66±0.45	**19.02 ^{AB}**
Average	**1.008 ^{A}**	**0.504 ^{B}**		**20.57 ^{A}**	**15.39 ^{B}**	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

Low Ca and Mg levels of forages have been implicated in several animal diseases of economic importance (Gross and Jung, 1981). Solid biogas applications made in terms of Ca and Mg content did not make a statistical difference, but only differences were observed between years. It is thought that these contents are not affected due to the fact that these elements in the fertilizer are not present in very high amounts and due to the study on the same variety. The highest value in terms of Ca content was determined as 1.82% in the first year, while the highest value in Mg content was found as 0.71% in the first year (Table 5.). Yavuz et al. (2012) reported that Ca contents of their experiment for Gelemen clover was changed between 1.39-1.61%. Mg contents was found between 0.33-0.39%. Our findings were higher than these values. Different species and environmental factors are thought to affect this situation.

Table 5. Ca (%) and Mg (%) contents averages of soild fermentation residue doses in 2016-2018

	Ca (%)			Mg (%)		
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**	**2016-2017**	**2017-2018**	**Average**
Control (0)	1.81±0.09	1.20±0.14	**1.50**	0.76±0.01	0.50±0.11	**0.63**
5	1.82±0.05	1.20±0.09	**1.51**	0.75±0.05	0.53±0.04	**0.64**
10	1.70±0.17	1.31±0.12	**1.51**	0.60±0.05	0.55±0.08	**0.57**
15	1.98±0.08	1.07±0.13	**1.52**	0.74±0.12	0.46±0.11	**0.60**
20	1.79±0.25	1.36±0.17	**1.58**	0.70±0.09	0.62±0.02	**0.66**
Average	**1.82 ^{A}**	**1.23 ^{B}**		**0.71 ^{A}**	**0.53 ^{B}**	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

As the ADF increases, the digestibility of the forage usually decreases. The NDF value refers to the total cell wall and is composed of the ADF fraction plus hemicelluloses. As NDF percentages increase, the dry matter intake will generally decrease (Joachim and Jung, 1997). With regards to the ADF averages, the lowest value was the first year, while the value was 32.11%. The effect of fertilizer applications on ADF ratio was not found to be significant. According to NDF averages, the lowest year average was found as 41.91% in the first year and the lowest average was obtained with 41.06% in 15 t ha $^{-1}$ fertilizer application. (Table 5). The lower values of ADF and NDF in the first year showed itself in the relative feed value. Plant height is higher than the first year of the second year to increase the amount of lignin in order to keep the plant upright, this situation has led to an increase in ADF and NDF rates. Results of Koc (2013), when the dose of phosphorus fertilizer increased, the rate of ADF and NDF increased. Results of Yucel et al. (2018) shown higher ADF and NDF ratio than our results. They found already higher hay yield and these results related between ADF and NDF results.

ADF and NDF contents were white clover (36.9-55.4%) and red clover (41.9-58.5%) (Stewart et al., 2008); berseem clover (22.0-32.0%) (Karslı et al., 1999); crimson clover (25.8-43.7%) (Ladyman et al., 2003). ADF and NDF contents of berseem clover were similar to other clovers.

Table 6. ADF (%) and NDF (%) averages of soild fermentation residue doses

	Acid Detergent Fiber (%)			Neutral Detergent Fiber (%)		
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**	**2016-2017**	**2017-2018**	**Average**
Control (0)	32.22±0.71	34.68±0.87	**33.45**	41.58±1.17	45.25±2.21	**43.41 ^{A}**
5	32.01±0.35	34.72±1.58	**33.36**	41.24±0.49	44.35±0.35	**42.80 ^{A}**
10	31.94±0.30	34.36±0.96	**33.15**	43.39±1.71	43.33±0.65	**43.36 ^{A}**
15	31.66±0.22	34.61±1.25	**33.13**	40.42±0.72	41.70±0.25	**41.06 ^{B}**
20	32.73±0.75	34.38±0.75	**33.55**	42.94±0.82	44.38±0.45	**43.66 ^{A}**
Average	**32.11 ^{B}**	**34.55 ^{A}**		**41.91 ^{B}**	**43.80 ^{A}**	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

When the average of the crude protein ratio was examined, the highest year average was determined as 21.26% in the 2nd year average. According to the application averages, the fertilizer amount has a positive effect and the highest value is obtained as 22.88% in 10 t ha^{-1}. Graves et al. (1987) reported that berseem clover has 21% average crude protein ratios. Our results seen similar with this research. When the crude protein yield data were examined, the highest value in terms of year averages was 1.24 t ha^{-1} in 2nd year average. The highest application average was found in 15 t ha^{-1} fertilizer dose with 1.12 t ha^{-1}. It is observed that the second year average of crude protein yield is significantly higher than the first year average. The reason for this is that the second year average of hay yield is higher than the average of the first year. On the other hand, in terms of the relative feedvalue averages, there has been a statistical difference just between the years. The highest value was obtained with 141.89 in the first year. It is thought that this situation is due to the low amount of fiber due to the low yield in the first year (Table 7. and Figure 2.). Yavuz et al. (2012) stated that forages with an RFV value over 151, 150-125, 124-103, 102-87, 86-75, and less than 75 are categorized as prime, premium, good, fair, poor and rejected, respectively. Based on the average of the 2 years berseem clover relative feed values ranging between 133.74-142.97. Therefore, our results could be categorized as premium values.

Table 7. Crude protein ratio (%), crude protein yield (t ha^{-1}) and relative feed value averages of soild fermentation residue doses

	Crude Protein Ratio (%)			Crude Protein Yield (t ha^{-1})		
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**	**2016-2017**	**2017-2018**	**Average**
Control (0)	19.23±0.59	17.79±0.68	18.51 ^{C}	0.32±0.10	0.82±0.21	**0.57 ^{B}**
5	19.52±0.99	23.83±1.58	21.67 ^{AB}	0.51±1.42	1.32±1.09	**0.92 ^{A}**
10	20.23±1.90	25.53±1.71	22.88 ^{A}	0.59±0.83	1.58±2.13	**1.08 ^{A}**
15	19.67±0.56	20.51±1.52	20.09 ^{BC}	0.59±1.45	1.65±2.88	**1.12 ^{A}**
20	19.74±2.27	18.66±3.51	19.20 ^{C}	0.56±1.04	0.82±1.63	**0.69 ^{B}**
Average	**19.68 ^{B}**	**21.26 ^{A}**		**0.51 ^{B}**	**1.24 ^{A}**	

Relative Feed Value			
Residue Doses (t ha^{-1})	**2016-2017**	**2017-2018**	**Average**
Control (0)	142.76±5.11	127.35±5.23	**135.05 ^{B}**
5	144.23±2.31	129.71±3.57	**136.97 ^{B}**
10	137.35±5.90	133.38±3.12	**135.37 ^{B}**
15	147.82±0.45	138.11±3.95	**142.97 ^{A}**
20	137.31±1.99	130.18±2.44	**133.74 ^{B}**
Average	**141.89 ^{A}**	**131.74 ^{B}**	

Captal letters are important according to p<0.01. Lower case letters are important according to p<0.05, ±:standart deviation

CONCLUSION

Increasing production activities as well as increasing use of chemical fertilizers negatively affect the environment and constitute an intensive economic cost. In this respect, biogas residues, which are one of the organic fertilizer sources in developed countries, have been used more intensively in agricultural activities. In this study, the effects of solid biogas fermentation residues on berseem clover were investigated. In regions with Mediterranean climate, there is the potential to reduce the lack of quality roughage with increasing quality of berseem clover. It has been observed that the fertilizer source used has a positive effect on the yield and quality of the plant. However, the use of large amounts of fertilizers has shown toxic effects and reduced yield and quality. It was concluded that the best fertilizer dose would be 10 t ha^{-1} and 15 t ha^{-1}. In addition, the effect of different climates between in twoyears on yield and quality is evidentThis situation shows us the effect of climate factors on yield and quality of forage crops.

ACKNOWLEDGEMENTS

We are very grateful to Efeler Biogas Plant managers and Agricultural Engineer Burak Alp KANTIK who helped us to provide solid biogas fermentation residues. We would like to extend our gratitude to the Eastern Mediterranean agricultural research institute and the field crops department regarding seed supply.

LITERATURE CITED

Abubaker, J., K. Risberg and M. Pell. 2012. Biogas residues as fertilisers – Effects on wheat growth and soil microbial activities. App. Energy. 99: 126–134.

Abogadallah, G.M. and W. P. Quick. 2010. Fast versatile regeneration of *Trifolium alexandrinum* L. Plant Cell Tiss. Organ Cult. 100:39–48.

Acikgoz, E. 2001. Forage Crops. VIPAS publication number 58, 584p. Bursa. (In Turkish)

Alburquerque, J.A., C. de la Fuente and M.P. Bernal. 2012. Chemical properties of anaerobic digestates affecting C and N dynamics in amended soils. Agriculture, Ecosystems & Environment 160:15-22.

Anonymous. 2018. Cakmar Quarter of Kocarlı District climate data for long years, http://en.climate-data.org/location/631889/ , (Accesed September 01, 2018)

AOAC. 2003. Official methods of analysis of AOAC International. 17th Ed. 2nd Rev. Gaithersburg, MD, USA. Association of Analytical Communities.

Arthurson, V. 2009. Closing the global energy and nutrient cycles through application of biogas residue to agricultural land — potential benefits and drawback. Energies 2: 226–242.

Atlas of Energy. 2019. Biogas, Biomass, Waste Heat and Pyrolytic Oil Power Plants, https://www.enerjiatlasi.com/biyogaz/ , (Accesed March 10, 2019)

Bulgurlu, S. and M. Ergul. 1978. Physical, chemical and biological analyses methods of feeds. Izmir, Ege Univ. Agric. Fac. Publish No: 127 (in Turkish).

Caballero Garcfa de Arovalo, R., M. Arauzo Sfinchez and E.J. Hernaiz Algarra. 1994. Response to N-fertilizer of Italian ryegrass grown alone and in mixture with berseem clover under continental irrigated mediterranean conditions. Fertilizer Research 39: 105-112.

Cook, C.W. and J. Stubbendieck. 1986. Range research: basic problems and techniques. Society for Range Management, Colorado. 317

Fouda, S., S. von Tucher, F. Lichti, and U. Schmidhalter. 2013. Nitrogen availability of various biogas residues applied to ryegrass. J. Plant Nutr. Soil Sci. 176: 572–584.

Graves, W.L., W.A. Williams, V.A.Wegrzyn, D.M. Calderon, M.R. George and J.L. Sullins. 1987. Berseem clover is getting a second chance. Calıfornıa agrıculture. 15-18. California. USA.

Gross, C.F. and G. A. Jung. 1981. Season, Temperature, Soil pH, and Mg Fertilizer Effects on Herbage Ca and P Levels and Ratios of Grasses and Legumes. Agr. J. 73(4): 629-634.

Hakyemez, B.H. and C. Sancak. 2005. Adaptation of Some Berseem Clover (*Trifolium alexandrinum* L.) Varieties to the Irrigated Conditions of Ankara and Changes in Yield According to the Cutting Orders. Journal of Agricultural Sciences. 11:(4) 406-410.

Holm-Nielsen, J.B., T. Al Seadi and P. Oleskowicz-Popiel. 2009. The future of anaerobic digestion and biogas utilization. Bioresour. Technol. 100: 5478–5484.

Horrocks, R.D. and J.F. Vallentine. 1999. Harvested Forages. San Diego, California, USA. Academic Press, 3-87,

Hupfauf, S., S. Bachmann, M. Fernández-Delgado Juárez, H. Insama and B. Eichler-Löbermann. Biogas digestates affect crop P uptake and soil microbial community composition. Sci. of the Total Env. 542: 1144–1154

Insam, H., M. Gómez-Brandón and J. Ascher. 2015. Manure-based biogas fermentation residues — friend or foe of soil fertility? Soil Biol. Biochem. 84: 1–14.

Islam, R., S Mohammad, E.Rahman, M. Rahman O.H. Deog Hwan and R.A. Chang Six. 2010. The effects of biogas slurry on the production and quality of maize fodder. Turk J Agric. For. 34: 91-99.

Joachim, H.. and G. Jung. 1997. Analysis of forage fiber and cell walls in ruminant nutrition. J Nutr 127: 810–813.

Karslı, M.A., J.R. Russell and M.J. Hersom. 1999. Evaluation of berseem clover in diets of ruminants consuming corn crop residues. Journal of Animal Science. 77: 2873-2882.

Koc, A. 2013. Effect of phosphorus doses and application time on the yield and quality of hay and botanical composition of clover dominant meadow in highlands of Turkey. Turk J. of Field Crops. 18:(2): 205-210.

Ladyman, K.P., M.S. Kerleyl, R.L. Kallenbachl, H.E. Garrett, J.W. Van Sambee and N.E. Navarrete-Tindall. 2003. Quality and Quantity Evaluations of Shade Grown Forages. AFTA 2003 Conf. Proceedings. 175-181.

Mitran, T., R. Swaroop Meena, R. Lal, J. Layek, S. Kumar, and R. Datta. 2018. Role of Soil Phosphorus on Legume Production. Chapter 13. In book: Legumes for Soil Health and Sustainable Mangement. Editor: R.S. Meena, A. Das, G.S. Yadav, R.Lal. Springer. USA.

Moller, J., A. Boldrin and T.H. Christensen. 2009. Anaerobic digestion and digestate use: accounting of greenhouses gases and global warming contribution. Waste Manage. Res. 27: 813–824.

Nkoa, R. 2014. Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: a review. Agronomy for Sustainable Development 34:473-492.

Risberg, K., H. Cederlund, M. Pell, V. Arthurson and A. Schnurer. 2017. Comparative characterization of digestate versus pig slurry and cow manure – Chemical composition and effects on soil microbial activity. Waste Management 61: 529–538.

Rózyło, K., U. Gawlik-Dziki, M.Swieca, R. Rózyło and E.Pałys. 2015. Winter wheat fertilized with biogas residue and mining waste: yielding and the quality of grain. J. Sci. Food Agric. 96: 3454–3461.

SAS Institute. 1998. INC SAS/STAT users' guide release 7.0, Cary, NC, USA.

SPSS Inc. 1999. SPSS for Windows. Release, 10.0 copyright SPSS Inc., Chicago, USA.

Stinner, W., K. Moller and G. Leithold. 2008. Effects of biogas digestion of clover/grass-leys, cover crops and crop residues on nitrogen cycle and crop yield in organic stockless farming systems. Eur. J. Agron. 29: 125–134.

Sullivan, T., M. Stromberger, M. Paschke and J. Ippolito. 2006. Long-term impacts of infrequent biosolids applications on chemical and microbial properties of a semi-arid rangeland soil. Biology and Fertility of Soils 42: 258-266.

Surmen, M., T. Yavuz and N. Cankaya. 2011. Effects of Phosphorus Fertilization and Harvesting Stages on Forage Yield and Quality of Common Vetch, International Journal of Food, Agriculture & Environment – JFAE 9: (1): 353-355.

Stewart, C.B., P.A. Beck and P.K. Capp. 2008. Establishment and Survival of Red,White, and Berseem Clover on a Sandy Soil. Arkansas Animal Science Department Report.

Yavuz, T., M. SUrmen, S. Albayrak and N. Cankaya. 2012. Forage yıeld and qualıty of Gelemen clover (*Trifolium meneghinianum* clem.) lınes. Turk J. Field Crops. 17(1): 46-50.

Yucel, C., I. Inal, D. Yucel and R. Hatipoglu. 2018. Effects of mixture ratio and cutting time on forage yield and silage quality of intercropped berseem clover and italian ryegrass. Legume Research 41(6): 846-853.

Van-Soest, P.J., J.B. Robertson and B.A. Lewis. 1991. Method for Dietary Fiber, Neutral Detergent Fiber, and Nostarch Polysaccharides in Relation to Animal Nutrition. J. Dairy Sci. 74:3583-3597.

Wentzel, S. and R.G. Joergensen. 2016a. Effects of biogas and raw slurries on grass growth and soil microbial indices. J. Plant Nutr. Soil Sci. 179: 215–222.

Wentzel, S. and R.G. Joergensen. 2016b. Quantitative microbial indices in biogas and raw cattle slurries. Eng. Life Sci. 16: 231–237.

Wu-Di, Z. 2002. Utilizing Bases of Methane Fermentative Residues. Kunming, China: Yunnan Science and Technology Press.

Zoghlami Khélil, A., S. Benyoussef, M. Meznı, H. Saïdı Mıssaouı, S. Hanchı, M. Elayed, F. Gouhıs, A. Abdelguerfi, M. Laouar, P. Papastylianou, D. Bilalis, H. Cicek, S. Ates and M. Dost. 2015. Berseem clover (*Trifolium alexandrinum* L.) in the Mediterranean Basin. Legume Perspectives. 10: 27-28.