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The Effects of Nitrogen and Vermicomposts Applied in Different Dosages and Combinations on the Triticale Silage (X *Triticosecale* Wittm.) Quality

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A B S T R A C T

This research was conducted in 2019 and 2020 to determine the effects of different doses of nitrogenous and vermicompost on the quality of triticale in Erzurum arid conditions. In the experimental area, 5 doses of vermicompost (0, 2500, 5000, 7500 and 10000 kg ha $^{-1}$) and 4 doses of nitrogen (0, 40, 80 and 120 kg N ha $^{-1}$) were applied in combination in each block. The research was created with 3 replications according to the factorial arrangement in the Experimental Design of Randomized Complete Blocks. Dry matter ratio 38,30%-42,94%, crude protein rate 9.50%-12,28% by applying different amounts of nitrogen and vermicompost in silage triticale according to the findings obtained. ADF, NDF and RFV ratios varied between 22,44%-39,04%, 41,77-58,23%, 93,42-156,49%, respectively. While the pH of the triticale silage varied between 4,18-5,17, the physical evaluation quality class varied from low value to very good. When the results are evaluated as a whole, it comes to the forefront that vermicompost applications alone do not have a significant effect, especially in terms of the quality of silage, using 80 kg N ha^{-1} of nitrogen together with different doses of worm fertilizers of 2500, 5000, 7500 and 10000 kg ha^{-1}.

1. Introduction

For the advancement of animal husbandry in the Eastern Anatolia Region and to fulfill the need for quality roughage, silage is necessary. However, in the Eastern Anatolia region, corn plant that is a good silage plant under irrigated conditions has issues in terms of high altitude, low temperature, and noticeably short vegetation periods. For all these purposes, alternative products for corn plants should be considered in order to satisfy the watery and green feed requirements that are suitable for the winter of the animals in the area. Triticale, which does not have the competitiveness in irrigated agricultural areas with corn and clover plants, is an alternate forage plant, particularly in non-irrigated areas. The plant triticale, which was formed during the milky stage for the production of silage, was estimated to have a higher silage yield than the grains (wheat, rye, and barley) cultivated under

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certain conditions and to have a yield of 3-3,5 tons per decare (Geren and Ünsal, 2008).

The triticale (*xTriticosecale* Wittmack) which is produced by wheat and rye hybridization, typically produces more than 20 percent feed at an unfavorable environment and soil conditions relative to wheat, and its feed content is better than rye and wheat (Koch and Paisley, 2002). While the crude protein ratio in the grass of the triticale plant is 10,39%, the crude protein yield is 30 kg da^{-1} (Albayrak et al., 2004). Grain production takes place on 1,2 million hectares of agricultural land in the province of Eastern Anatolia and triticale is grown on only 1,34 thousand hectares of agricultural land in that region (Topal et al., 2015). To ensure sustained production in the triticale plant, it is important to provide an adequate quantity of nitrogen ingredients in the soil to recover nutrients that are omitted or washed and lost throughout crop harvesting. Different doses (0, 6, 4, 8, 9, 12, 15, 16, and 18 kg ha^{-1}) were used in studies on the amount of nitrogen fertilizer to be provided to the triticale plant and the optimal dose rate for the plant was calculated to be between 8 and 12 kg da^{-1} (Bali et al., 1991; Taşyürek et al., 1999; Üstünalp, 2010). It should be remembered, nevertheless, that the use of less nitrogen in fertilizers causes economic harm to farmers and the heavy use of fertilizers induces groundwater depletion and environmental issues.

Several unnecessary chemical fertilizers, which have been imported in recent years to feed the rising population of the world and our country, have triggered both nutritional and environmental problems. For this cause, in agriculture production, organic fertilizers have begun to be used rather than chemical fertilizers. Many organic compounds (humic and fulvic acid, compost, leonardite, etc.) and organic fertilizers including numerous varieties of microorganisms (algae and enzyme extracts, etc.) have begun to be produced in our country for this reason. Besides these fertilizers, vermicompost fertilizers are also commonly used for this purpose. Vermicompost strengthens the physical composition of the soil and enriches it with mineral substances such as N, P, Zn, K, Ca, Mn (Azarmi et al., 2008). Vermicomposts which are more effective in plant growth and development than barnyard manure (Atiyeh et al., 2000) are also beneficial in improving the physical properties of the soil.

From this point of view, the aim is to obtain high-quality triticale silage by assessing the required dose of worm and nitrogen fertilizer combinations to minimize the nitrogen dose to be applied.

2. Materials and Methods

The research was performed in 2019 and 2020 years in dry conditions in the experimental area of Atatürk University Plant Production, Application, and Research Center. In the research, high-yielding triticale (Umranhanim) variety, suitable for the climatic conditions of our region, was used (Karabulut and Çaçan, 2018). Ammonium sulphate containing 20-21% nitrogen and triple superphosphate fertilizer containing 43-44% P_2O_5 as chemical fertilizers in the trial were used and the solid vermicompost used in the experiment was purchased from a production company operating in Erzurum. The organic matter content of the vermicompost used in the study is 65,5%, total nitrogen 1,1%, total phosphorus 0,7% and water-soluble potassium content 1,5% and the pH level is 8,1. The experiment was performed in Erzurum province, which is situated in the area of Eastern Anatolia and has an altitude of 1,869 m. In Erzurum province, winters are cold and rainy while the summers are cool and dry.

The closest meteorology station to the research area is located in Erzurum city center. The mean scores of long-term overall precipitation, temperature, and relative humidity values are given in Table 1, as per the data obtained from this station.

The soil from the research area has the following features respectively; soil structure class is clayey-loamy, pH is 7,56, organic matter ratio is 1,01%, the lime ratio is 1,14%, while the phosphorus amount is 4,41 kg da^{-1} and the potassium amount are 171 kg da^{-1}. As a result, it was observed, according to the data collected, that the soils in the experimental area were mildly alkaline, calcareous, with low levels of suitable phosphorus and organic matter and moderate amounts of potassium suitable for use in plants (Özyazıcı et al., 2016). The research was created with 3 replications according to the factorial arrangement of the Randomized Complete Block Design (RCBD). In the experimental area, 5 doses of vermicompost (0, 2500, 5000, 7500 and 10000 kg ha^{-1}) and 4 doses of nitrogen (0, 40, 80, and 120 kg ha^{-1}) were applied in combination for each block. Besides, 80 kg ha^{-1} phosphorus (P_2O_5) fertilizer was provided to each parcel along with plating (Bozkurt et al., 2001). Inter-row planting was performed within 20 cm in the first half of September (Akkaya and Akten, 1990), the sizes of the planted parcel as follows: the length is 3 m, the width of the parcel is 1,6 m (8 row x 0,2 m) and the parcel area is 4,8 m^2. The planting frequency was planned as 400-450 seeds per m^2 and 20-22 kg of seeds per decare (Genç et al., 1989). Harvesting of triticale silage was carried out when the plants reached the dough stage (Can et al., 2004). The results obtained in the study were subjected to variance analysis according to the SPSS randomized complete block design and Duncan multiple comparison tests were used for determining the differences between the means (Yıldız and Bircan, 1994).

Table 1. Some climatic values of Erzurum province for 2019 and 2020 and long-term average

Months	Monthly Total Precipitation (mm)			Monthly Average Temperature (^{0}C)			Monthly Average Relative Humidity (%)		
	2019	2020	Long Term Average	2019	2020	Long Term Average	2019	2020	Long Term Average
January	13,9	2,8	17,9	-8	-8,8	-10,6	80	79,3	81
February	26,9	14,8	20	-8,4	-6,2	-8,2	84,9	78,3	80,5
March	24,7	46,2	34,3	-3,1	2,3	-0,9	79,3	77,1	74,4
April	68,9	49,2	58,6	4,2	5,5	5,8	73,4	65,4	67,8
May	63,8	118	70,6	11,9	10,9	10,5	60,3	61,1	67,2
June	23,6	34,6	45,1	17,8	15,7	14,9	57,2	55,6	61,5
July	3	30	22,3	19	19,8	19,5	49,4	51,6	53,5
August	11,6	-	18,8	20,3	-	19,9	46	-	49,6
September	28,4	-	20	14,5	-	14,5	51,7	-	52,5
October	11	-	56,9	9,8	-	8,1	56,3	-	67,8
November	14,8	-	25,3	0,1	-	0,4	65,9	-	75
December	23,2	-	19	-3,5	-	-7,2	85,8	-	81,5
Total/Avg	313,8	295,6	408,8	6,2	5,6	5,6	65,9	67,0	67,7

3. Results and Discussion

Dry matter and crude protein rates

The effect of nitrogen, vermicompost, and NxVC applications on dry matter rate was found to be significant at the level of 1% on triticale silage (Table 2). In the study, the dry matter rate in nitrogen applications varied between 40,35-41,88%, while the dry matter rate in vermicompost applications varied between 39,87-42,00% (Table 2).

Based on the variance analysis, the different doses of nitrogen and vermicompost at crude protein levels were statistically effective at 1%, whereas the NxVC interaction was considered to be insignificant.

Since the dry matter content of the silage products should be between 30 and 40% (Bolsen, 1995), the dry matter content of the silage produced increased to quite good values, particularly for different applications of vermicompost. The dry matter ratio (Arslanoğlu et al., 2006), which varies based on the substance used and the environmental factors, was significantly increased due to low doses of nitrogen (0,4 and 8 kg da^{-1}) and high doses of vermicompost. This condition may have affected the nitrogen efficiency of the vermicompost applied in high doses in terms of increasing the dry matter ratio. However, this situation, which arises in terms of the effect of different fertilizer combinations on the dry matter rate showed similarities with the study of Kmeťová et al., (2013). Also, several other studies (Naher, 1999; Stalin and Enzamann, 1990; Gutiérrez-Miceli et al., 2007) have noted that nitrogen and vermicompost applications positively affect the dry matter rate. In the study, NxVC interaction was also statistically significant on the dry matter rate. When we look at this result considering the dry matter rate, it probably stems from the applied nitrogen and vermicompost contents that are increasing the efficiency of each other (Figure 1).

Nitrogen, which is the most missing nutrient in agricultural systems, is completely adequate to achieve optimum yield and sufficient protein content from plants. The triticale plant, which is part of the grain community during its growth phase, needs adequate nitrogen compounds to be present in the soil (Mehrotra et al., 1967). It was determined that nitrogen and vermicompost added at different doses resulted in a substantial increase in the crude protein content of the triticale silage. Since vermicomposts contain more nitrate which is one of the important forms of nitrogen (Atiyeh et al., 2000) this may have increased the nitrogen content in the plant. As a matter of fact, these results obtained in terms of crude protein rate were found to be similar to the results of many studies (Domska et al.; 2006; Çelebi et al., 2009; Takıl ve Olgun, 2020) in which different nitrogen and vermicompost doses were applied.

Table 2. Variance analysis results of dry matter and crude protein content in triticale silage where separate doses of nitrogen and vermicompost were implemented

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1})					Mean
	Dry Matter Rate (%)					
	0	2500	5000	7500	10000	
0	40,44	41,51	41,80	41,86	42,08	41,54 A
40	38,30	41,54	41,90	42,25	42,45	41,28 A
80	39,83	41,48	42,32	42,83	42,94	41,88 A
120	40,90	40,02	39,60	40,73	40,50	40,35 B
Mean	39,87 C	41,14 B	41,41 AB	41,92 A	42,00 A	41,27
F values: N: 8,763 *, VC: 11,970 **, NxVC: 3,153 **, ** Those marked with capital letters are significant at the 0.01 level.						
	Crude Protein Rate (%)					
0	9,50	10,77	10,81	11,12	11,29	10,70 B
40	11,02	11,22	11,47	11,51	11,31	11,31 AB
80	11,37	11,64	11,94	12,24	12,28	11,90 A
120	10,46	10,67	10,84	10,99	11,49	10,89 B
Mean	10,59 B	11,08 AB	11,27 AB	11,47 A	11,59 A	11,2

F values: N: 13,851 **, VC: 6,084 **, NxVC: 4,563 ns, **Those marked with capital letters are significant at the 0.01 level. ns: not significant.

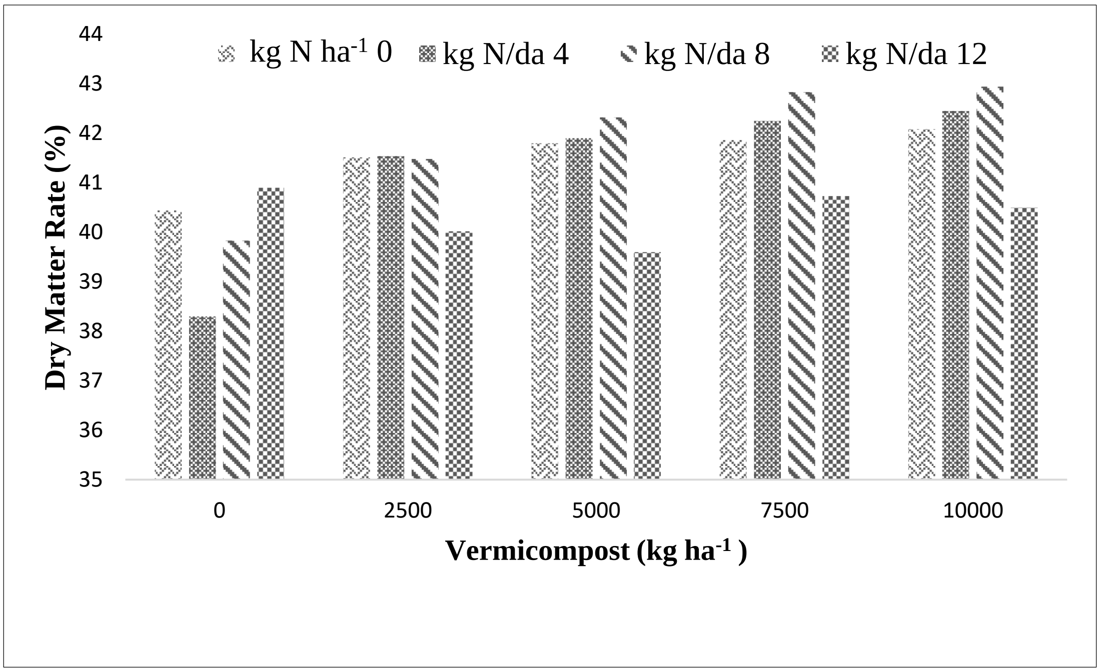

Figure 1. The effect of nitrogen x vermicompost interaction on dry matter ratio

NDF and ADF rates

While the effect of the different nitrogen doses added to the NDF and ADF ratios of triticale silage was statistically differed at a 1% significance level, the effect of the different vermicompost doses varied at a 5% significance level. Besides, the interactions of NDF and ADF rates were statistically insignificant (Table 3).

Table 3. ADF and ADF ratios in triticale silage where various doses of nitrogen and vermicompost were implemented

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1})					Mean
	NDF Rate (%)					
	0	2500	5000	7500	10000	
0	58,23	57,17	56,24	55,29	55,18	56,42 A
40	53,54	52,35	51,01	50,05	50,72	51,53 B
80	47,39	44,84	43,96	42,89	41,77	44,17 C
120	43,96	45,00	45,30	44,31	43,48	44,41 C
Mean	50,78 a	49,84 b	49,13 b	48,13 b	47,79 b	49,13
F values: N: 97,063 **, VC: 3,304 *, NxVC: 0,501 ns, * The mean scores marked with a lowercase letter are significant at the 0.05 level, ** Those marked with a capital letter are significant at the level of 0.01. ns: not significant.						
	ADF Rate (%)					
0	39,04	38,41	37,44	37,30	37,14	37,87 A
40	36,51	33,22	32,22	31,14	31,54	32,93 B
80	28,75	27,22	26,98	25,76	24,31	26,60 C
120	22,70	23,23	23,69	23,27	22,44	23,07 D
Mean	31,75 a	30,52 ab	30,08 ab	29,37 b	28,85 b	30,12

F values: N: 115,370 **, VC: 2,657 *, NxVC: 0,595 ns, * The mean scores marked with lowercase letters are significant at 0.05 level, ** Those marked with capital letters are significant at the level of 0.01 ns: not significant.

It was determined that according to nitrogen and vermicompost content applied in different doses, the NDF rates varied between 44,17% -56,42% and 47,79% -50,78%, respectively, while ADF rates varied between 23,07% and 37,87%, respectively. The ratios of NDF and ADF (Rayburn 2004), an essential cell wall part, vary depending on plant development, leaf/stem ratio, and distinct cultural processes (Lacefield et al., 1999; Ball et al., 2001). In the study, NDF and ADF ratios showed a tendency to decrease due to the increase in nitrogen and vermicompost doses. In particular, low NDF and ADF rates (Budak and Budak, 2014), which are significant quality factors, have been reported to have decreased with increasing fertilizers in studies conducted in various plants (Türk et al., 2019; Atalay and Ateş, 2020; Tobay, 2020).

Relative Feed Value (RFV) and pH

While the relative feed value of triticale silage in the samples taken was statistically very significant (P<0,01) in terms of different nitrogen applications, it showed a significant difference (P<0,05) in different vermicompost applications. In the study, it was determined that different nitrogen and vermicompost combinations do not have a significant effect on the relative feed value of triticale silage (Table 3).

The ADF and NDF values are used in the estimation of the relative feed value and the results of the research showed that the highest NYD value of 156,49 was obtained from the application of 80 kg N + 10000 kg of vermicompost per decare, while the lowest NYD value of 93,42 was observed with the control parcel.

Whereas the various nitrogen dosage applications in the study had a statistically significant effect (P <0.01) on the pH values of triticale considered to be silage, the interaction between the different vermicompost and NxVC did not have a significant effect (Table 3). While pH values of nitrogen varied between 4,32 and 5,03 at 0, 40, 80 and 120 kg ha^{-1}respectively, the pH values of vermicompost varied between 4,50 and 4,72 at 0, 2500, 5000, 7500 and 10000 kg doses.

Research has shown that nitrogen and vermicomposts have induced a decrease in the rate of ADF and NDF of triticale and an increase in the rate of crude protein and NYD, and this case can imply that the nitrogen and vermicomposts applied had a positive impact on the quality of triticale silage. The NYD value, which is agreed as 100 based on the clover plant, increased in parcels where separate doses of nitrogen and vermicompost were used in the study. In terms of relative feed value, this condition has led to an increase in quality as it is above 100 which was also reported by Richardson (2001). Several studies (Demirel ,2016; Türk and Alagöz, 2019; Ertekin et al., 2020) support this situation.

According to the results, nitrogen fertilizer applications caused a significant decrease in pH values. As it happens, previous studies (Kandi et al., 2011; Salehi et al., 2015) that indicate fertilizers provided to plants in certain amounts increase the soluble sugar ratio in the plant, and this, in turn, causes the pH of the soil to decrease (Sadigfard, 2016) confirms the results of our research.

Table 3. RFV and pH values in triticale silage treated with different doses of nitrogen and vermicompost

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1}) RFV Rate (%)					Mean
	0	2500	5000	7500	10000	
0	93,42	95,97	98,78	100,65	101,07	97,98 C
40	105,13	111,97	116,35	120,33	117,95	114,35 B
80	130,67	140,53	143,92	149,95	156,49	144,31 A
120	151,08	148,87	144,61	148,58	152,98	149,23 A
Mean	120,08 b	124,34 ab	125,92 ab	129,88 a	132,12 a	126,47

F values: N: 115,403 **, VC: 3,445 *, NxVC: 0,649 ns, * The mean scores marked with lowercase letters are significant at 0.05 level, ** Those marked with capital letters are significant at the level of 0.01. ns: not significant.

	pH					
0	5,17	5,12	5,10	4,89	4,85	5,03 A
40	4,79	4,73	4,73	4,58	4,65	4,69 B
80	4,52	4,42	4,25	4,18	4,22	4,32 C
120	4,40	4,37	4,39	4,36	4,38	4,38 C
Mean	4,72	4,66	4,62	4,50	4,53	4,61

F values: N: 16,264 **, VC: 1,033 ns, NxVC: 0,160 ns, ** Those marked with capital letters are significant at the 0,01 level. ns: not significant.

Physical Quality Features

We have determined that the color, structure, and smell characteristics of triticale used as silage varied between 1-2, 3-4, and 5-14, respectively**.** As a result of the physical evaluation, while the highest scores were obtained from the parcels where 8 kg N + 0 and 250 kg vermicompost per decare and 12 kg N + 750 and 1000 kg vermicompost per decare were applied**,** the lowest scores were obtained from parcels with no nitrogen application + 0 kg N and 250 kg vermicompost. That is being said, there is no absolute homogeneity between the physical properties in Table 4, which are subject to physical assessment following the tests made in the study.

Table 4. Evaluation of the physical quality features of triticale silage applied with different doses of nitrogen and vermicompost

Nitrogen (kg N ha^{-1})	Vermicompost (kg ha^{-1})	Color	Structure	Smell	Total	Quality class
0	0	1	3	5	9	Poor
	2500	2	3	9	14	Good
	7500	2	4	11	17	Good
	10000	2	4	12	18	Very Good
40	0	1	3	13	17	Good
	2500	1	4	11	16	Good
	7500	2	3	13	18	Very Good
	10000	2	4	12	18	Very Good
80	0	1	4	14	19	Very Good
	2500	2	4	13	19	Very Good
	7500	2	4	11	17	Good
	10000	2	4	12	18	Very Good
120	0	1	3	13	17	Good
	2500	2	3	13	18	Very Good
	7500	2	4	13	19	Very Good
	10000	2	4	13	19	Very Good

When all results are analyzed together, the various doses of vermicomposts used for environmental degradation and sustainable agriculture have both positively impacted the measured properties of triticale, which is generally deemed as silage and has a beneficial impact on the reduction of the nitrogen dose used. The results suggest that it would be more appropriate to use an 80 kg ha^{-1} dose of nitrogen used together with different doses of 2500, 5000, and 7500, and 10000 kg of vermicompost. It will, however, be more useful to carry out a study for another year to provide more accurate and comprehensive guidance on this.

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