The Effects of Different Organomineral Fertilizer Doses on Forage Yield and Quality Traits of Second Crop Silage Maize Under Eastern Mediterranean Conditions

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Abstract: This research was carried out during the 2020 growing season to investigate the effects of different organomineral fertilization doses on forage yield and quality traits of second crop silage maize under Eastern Mediterranean conditions. In the study, a total of 7 different fertilizer treatments were used, including the control (0 kg ha^{-1} N), the recommended inorganic fertilizer N dose (300 kg ha^{-1} N), and 5 different organomineral fertilizer N doses (100, 150, 200, 250, and 300 kg ha^{-1} N). Inorganic fertilizer treatment (INORG) exhibited the highest dry matter yield (13.21 t ha^{-1}), followed by 300 kg ha^{-1} (13.10 t ha^{-1}), 200 kg ha-1 (12.19 t ha^{-1}), 250 kg ha^{-1} (12.16 t ha^{-1}), and 150 kg ha^{-1} (12.01 t ha^{-1}) organomineral fertilizer doses, with slight differences. INORG provided also the highest crude protein content (6.75%), followed by 250 kg ha-1 (6.46%) and 300 kg ha-1 (6.34%) organomineral fertilizer doses with slight differences. On the other hand, there was no significant difference between fertilizer treatments in terms of ADF, NDF, and RFV values. These results showed that 300 and 250 kg ha^{-1} organomineral fertilizer treatments may be used successfully in silage maize cultivation as an alternative to INORG under Eastern Mediterranean conditions.

1 INTRODUCTION

Maize is the most preferred crop for silage production all over the world because it has a high forage yield potential, energy, nutrient and DM contents, and low buffering capacity. When growing silage maize, the primary source of nutrients is inorganic fertilizers. In many parts of Turkey, silage maize typically needs 250–300 kg ha^{-1} of nitrogen (N) to produce the optimum forage yield and quality. Given that the soils in Turkey have a low amount of organic matter and nutritional minerals, this could be one reason for the considerable increase in yield (Nazli et al., 2014). However, excessive application of inorganic fertilizers leads to environmental pollution, increases greenhouse gas emissions and production costs, damages soil structure, and decreases crop yield and quality (Khan et al., 2008; Nazli et al., 2020).

Within the framework of sustainable agriculture, raising the amount of organic matter in soils is essential to improving the soil's structure and crop yield as well as its quality. As a result, the use of organomineral fertilizers on agricultural land has received significant attention in an effort to restore soil sustainability and fertility and prevent any environmental problems caused by the excessive use of inorganic fertilizers. Organomineral fertilizer is a type of fertilizer produced by combining the minerals needed by the plant with organic matter produced from natural resources. Organomineral fertilizer includes organic matter and humic acid sources, which regulate and improve soil structure, prevent soil compaction, provide better aeration, increase the water retention capacity of the soil, prevent pollution from chemical fertilizers, and increase crop productivity (Abdulraheem et al., 2023). In this context, the aim of this study was to examine the effects of different organomineral fertilizer doses on forage yield and quality of silage maize.

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2 MATERIAL AND METHODS

The field experiment was conducted throughout the 2020 growing season at the Çukurova University Faculty of Agriculture Research and Implementation Farm. The soil had a sandy clay loam texture with the following characteristics: low calcareous content (5.69%), low organic matter content (1.96%), low available P_2O_5 (40.7 kg ha^{-1}), high available K_2O (1763 kg ha^{-1}), low salt concentration (0.14 mmhos/cm), and neutral soil pH (7.88). The Çukurova Region has hot, dry summers and mild, humid winters, which are indicative of a Mediterranean climate. The average temperature and total rainfall throughout the growing season were 28.4 °C and 55.7 mm, respectively. The research employed two distinct cultivars of silage maize (Kws-Kilowatt and SY-Inove) as plant material. The chemical composition of fertilizers used in the study is presented in Table 1.

Table 1: The description and chemical composition of fertilizers used in the study.

Fertilizer	Type	N (%)	P (%)	Organic matter (%)	Humic + Fulvic Acid (%)
20-20-0	CBF	20	20	-	-
Urea	CTF	46	-	-	-
Triple superphosphate (TSP)	CBF	-	42	-	-
(10-10-0+12SO_3)+0.1 Zn	OBF	10	10	15	5
30+5SO_3	OTF	30	-	20	5

CBF= Chemical basal fertilizer, CTF= Chemical top fertilizer, OBF= Organomineral basal fertilizer, OTF= Organomineral top fertilizer.

In the experiment area, the soil was prepared by medium-depth (20–25 cm) plowing and harrowing with a cultivator. Considering that the fertilizer treatments were the sub-plots and the cultivars were the main plots, the field experiment was set up using a split plot design with three replicates. Each plot was 21 m² (4.2 x 5 m), and inter-row spacing and distances between the rows were 16 and 70 cm, respectively. On June 20, 2020, a pneumatic drill was used to plant maize seeds at a depth of around 4 to 5 cm. Table 2 lists the seven distinct fertilization methods employed in the research.

Table 2: Fertilizer treatments.

Treatments	
Control	0 kg ha^{-1} N
OMF-100	100 kg ha^{-1} N in organomineral form
OMF-150	150 kg ha^{-1} N in organomineral form
OMF -200	200 kg ha^{-1} N in organomineral form
OMF -250	250 kg ha^{-1} N in organomineral form
OMF -300	300 kg ha^{-1} N in organomineral form
INORG	300 kg ha^{-1} N in inorganic form (Nazli et al., 2014)

During the harvest, ten randomly selected samples were collected from each plot for post-harvest analysis. These samples were subsequently chopped, oven-dried for 48 hours at 65°C, and then ground to fit through a 1-mm screen. The DM yield was computed by multiplying the DM content by the green herbage yield. The Kjeldahl method was used to assess the samples' N contents. The N content (%) was multiplied by 6.25 to calculate the crude protein content. Acid detergent fiber (ADF) and Neutral detergent fiber (NDF) contents were determined using the Van Soest (1963) method. Relative feed value (RFV) was computed using the method outlined by Rohweder et al. (1978) which included RFV = (DDM × DMI) / 1.29, where DDM is the percentage of DM digestibility and DMI is the percentage of body weight that represents voluntary DM intake.

To estimate the DDM and DMI, the following equations were utilized:

$$DDM = 88.9 - (0.779 \times ADF)$$

$$DMI = 120/NDF.$$

The combined data of the two cultivars presented in the study were analysed by an ANOVA model using the JMP 7.0 statistical software. Significantly different means were separated at $P = 0.05$ using the least significant difference (LSD) test.

3 RESULTS AND DISCUSSION

ANOVA detected that the fertilizer treatments significantly affected plant height, cob length, cob diameter, green herbage yield, and DM yield (Table 3). However, the treatment had no clear effect on the stem diameter of silage maize.

Plant height ranged from 215.7 to 235.2 cm (Table 3). INORG provided the highest plant height, followed by OMF-300 and OMF-250 with slight differences, whereas the lowest was in Control.

Table 3: The effects of fertilizer treatments on the forage yield and yield parameters of silage maize.

Treatments	PH (cm)	CL (cm)	SD (mm)	CD (mm)	GHY (kg ha^{-1})	DMY (kg ha^{-1})
Control	215.7 D	22.7 C	20.4	43.9 D	3057 D	983 C
OMF-100	222.0 C	24.9 AB	22.1	46.5 C	3351 CD	1090 BC
OMF -150	224.0 BC	24.3 B	21.9	47.6 ABC	3525 C	1201 AB
OMF -200	223.5 BC	24.3 B	21.5	47.0 BC	3722 ABC	1219 AB
OMF -250	232.2 AB	24.6 AB	22.3	48.6 AB	3705 BC	1216 AB
OMF -300	233.8 A	25.6 A	22.5	49.2A	4008 AB	1310 A
INORG	235.2 A	25.5 A	22.3	48.7 AB	4162 A	1321 A
Mean	226.6	24.6	21.8	47.4	3647	1192
P-Value	**	**	NS	**	**	**

*= $P < 0.05$, **= $P < 0.01$, NS = not significant, PH = Plant Height, CL = Cob Length, SD = Stem Diameter, CD = Cob Diameter, GHY = Green Herbage Yield, DMY = Dry Matter Yield.

Table 4: The effects of fertilizer treatments on the forage quality parameters of silage maize.

Treatments	LF (%)	SR (%)	CR (%)	CP (%)	ADF (%)	NDF (%)	RFV
Control	19.8	44.8 A	35.4 B	5.2 D	32.9	53.8	109.6
OMF-100	20.1	43.0 ABC	36.9 AB	5.7 CD	33.1	52.4	112.3
OMF-150	19.4	43.7 ABC	36.9 AB	5.9 BC	33.7	52.8	110.7
OMF-200	19.4	43.9 AB	36.7 AB	5.9 BC	33.7	55.1	106.0
OMF-250	19.2	42.3 BC	38.5 A	6.5 AB	33.4	53.3	110.3
OMF-300	19.4	41.9 C	38.7 A	6.3 AB	32.7	53.1	111.4
INORG	19.5	42.1 BC	38.5 A	6.89 A	32.1	52.0	114.7
Mean	19.5	43.1	37.4	6.06	33.1	53.2	110.7
P-Value	NS	*	*	**	NS	NS	NS

*= *$P < 0.05$*, **= *$P < 0.01$*, NS = not significant, LF = Leaf ratio, SF = Stem ratio, CR = Cob ratio, CP = Crude protein, RFV = Relative feed value.

Cob length ranged between 22.7 and 25.6 cm (Table 3). Cob length was found to be highest with OMF-300, followed by INORG and OMF-250 with slight differences, while Control showed the significantly lowest value in the study.

Stem diameter varied from 20.4 to 22.5 mm (Table 3). OMF-300 exhibited the highest stem diameter, whereas the lowest was observed in Control.

Cob diameter varied between 43.9 and 49.2 mm (Table 3). As with cob length, OMF-300 gave the highest cob diameter, followed by INORG and OMF-250 with slight differences, while the lowest value was observed in Control.

Green herbage yield ranged from 3057 to 4162 kg ha^{-1} (Table 3). As with plant height, the highest green herbage yield was achieved with INORG, followed by OMF-300 with a slight difference, whereas the lowest was in Control.

DM yield ranged between 983 and 1321 kg ha^{-1} (Table 3). As with plant height and green herbage yield, INORG exhibited the highest DM yield, followed by OMF-300, OMF-200, OMF-250, and OMF-150 with slight differences, while the lowest DM yield was obtained from the control.

Plant height, cob length, and cob diameter were generally increased with each increase in N fertilization dose, probably due to the favorable effect of N fertilization on vegetative growth of the crop. Our results were supported by those reported by Demir et al. (2021) in which increasing N fertilization doses positively affected the plant height, cob length, and cob diameter of silage maize in Ankara, Turkey. Additionally, green herbage yield showed a generally increasing trend with each increase in N fertilization dose associated with the increases in plant height, cob length, and cob diameter. On the other hand, organomineral fertilizer treatments significantly increased green herbage and DM yields of silage maize compared to the control treatment, but they gave statistically similar values to the INORG. Our results coincide with those reported by Smith et al. (2015), which suggested that organomineral fertilization doses produced similar green herbage and DM yields in silage maize to INORG in North-western England.

The fertilizer treatments significantly affected stem and cob ratios and crude protein content, while they had no evident effect on leaf ratio, the contents of ADF and NDF, and RFV (Table 4).

Leaf ratios that were achieved from the silage maize were observed to be in the range of 19.2%–20.1% in the study (Table 4). OMF-100 attained the highest leaf ratio, whereas the lowest was in OMF-250.

Stem ratio was in the range of 41.9% - 44.8% (Table 4). Control attained the significantly highest stem ratio, followed by OMF-200 and OMF-100, and OMF-200 with slight differences, whereas the lowest was in OMF-300. Stem ratio generally tended to decrease with each increase in N fertilization dose. These results are supported by those reported by Carpici (2009) and Ugurlu (2017) in that increasing N fertilization rates significantly decreased the stem ratio of silage maize in Bursa, Turkey

Cob ratio ranged from 35.4% to 38.5% (Table 4). The Cob ratio was highest with INORG, followed by OMF-300, OMF-250, OMF-100, OMF-150, and OMF-200, with slight differences, while the control exhibited the lowest value. Unlike in stem ratio, cob ratio exhibited an increasing trend with increased N dose, mainly due to the positive effect of N fertilization on cob length and cob diameter. Our results coincide with those of Kaplan et al. (2016), who reported that increased N doses significantly enhanced the cob ratio of silage maize in Kayseri, Turkey.

Crude protein content ranged between 5.2% and 6.8% in the study (Table 4). As with cob ratio, INORG showed the highest crude protein content, followed by OMF-250 and OMF-300 with slight differences, whereas the lowest value was observed in the Control. Crude protein content was significantly increased by N fertilization doses from 100 to 250 kg ha^{-1}, while an additional N dose (300 kg ha^{-1}) did not cause any further significant increases. These results conflicted with those reported by Karagöz et al. (2019), in which crude protein content significantly enhanced with each increase in N fertilization doses in Kayseri, Turkey.

ADF content varied from 32.1% to 33.7% in the study (Table 4). OMF-150 gave the highest value, whereas the lowest was in INORG.

NDF content varied between 52.0% and 55.1% in the study (Table 4). OMF-200 attained the highest value, whereas the lowest was in the INORG.

RFV ranged from 106.0 to 114.7 in the study (Table 4). As with cob ratio and crude protein content, INORG provided the highest RFV, while the lowest RFV was observed in OMF-200.

ADF and NDF contents and RFV were not significantly affected by fertilizer treatments in the study. Our results are in agreement with those reported by Demir et al. (2021) in Ankara, in which N fertilization had no clear effect on ADF and NDF contents and RFV of silage maize.

4 CONCLUSIONS

Considering the yield parameters examined in the study, OMF-300 provided similar green herbage yield with INORG, and OMF-300 and OMF-250 exhibited similar DM yields with INORG. In terms of forage quality parameters, OMF-300 and OMF-250 achieved similar crude protein content with INORG, while no significant difference was detected between INORG and OMF doses in terms of the contents of ADF and NDF, RFV, and leaf and stem ratios. These results show that OMF-300 and OMF-250 can be successfully applied in silage maize cultivation in order to reduce both environmental problems caused by inorganic fertilizers and production costs under Eastern Mediterranean conditions.

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