International Journal of Applied Agricultural Sciences
2024, Vol. 10, No. 5, pp. 234-241
https://doi.org/10.11648/j.ijaas.20241005.15

Research Article

Effects of Mela Organics' New Liquid Fertilizer on Tomato Yield in Semi-Arid Areas of Ethiopia

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Abstract

Soil organic matter depletion is mainly caused by crop residue removal, and low or no application of organic fertilizers often results in nutrient exhaustion and low crop yields. This challenge requires the evaluation of different organic fertilizer resources to provide new alternative fertilizer products to an Ethiopian production system. Based on this fact, an experiment was conducted to evaluate the effects of mela organic fertilizer as a supplementary fertilizer to improve the yield of tomatoes under irrigation in the Central Rift Valley of Ethiopia from 2020 to 2021. The experiment consisted of eight treatments (Control, 100% recommended fertilizer, 100% recommended fertilizer + 30 L/ha Mela, 100% recommended fertilizer + 45 L/ha Mela, 75% recommended fertilizer +30 L/ha Mela, 75% recommended fertilizer + 45 L/ha Mela, 50% recommended fertilizer +30 L/ha Mela and 50% recommended fertilizer + 45 L/ha Mela) laid out in randomized complete block design with three replications. The results revealed that the highest agronomic yield was obtained by applying the 100% recommended fertilizer + 30 L/ha Mela. However, based on the partial budget analysis, the highest marginal rate of return was obtained from 50% recommended fertilizer + 45 L/ha Mela. Thus, it can be concluded that the application of Mela Organics up to 45 L/ha, integrated with chemical fertilizer applications, can increase tomatoes' economic yields and reduce fertilizer costs.

Keywords

Liquid Organic Fertilizer, Mela Organics, Organic Fertilizer, Semiarid Regions, Tomato Yield

1. Introduction

The decline in soil fertility is a significant constraint to increasing food production in Ethiopia [4]. One of the main factors contributing to low agricultural productivity is the decreasing level of organic matter in soil. Organic matter is crucial for the physical, chemical, and biological characteristics of soil. A well-structured soil enhances water availability and air distribution and stimulates root activity. Nutrients must be added to the soil to boost soil fertility in the short term. Although chemical fertilizers are commonly used, their efficiency is low in the absence of organic matter. Therefore, it is essential to test new organic fertilizer technologies and application methods to maintain soil fertility and ensure agricultural productivity. In some areas of Ethiopia, the application of Mela Organics liquid organic fertilizer has been tested and found to be effective.

Liquid organic fertilizers contain various macro-and micronutrients and amino acids, which are required by plants. In addi-

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Received: DD MM 2024; **Accepted:** DD MM 2024; **Published:** DD MM 2024

tion, liquid organic fertilizers contain microorganisms that improve soil fertility to support plant growth and development. Microbes are added to organic fertilizers in addition to increasing nutrient availability, and they can also increase the efficiency of nutrient uptake by plants, thereby increasing fertilization efficiency [12, 13, 18]. The synthesis of amino acids and proteins is believed to be accelerated by the application of liquid organic fertilizers, thereby promoting plant growth. Liquid organic fertilizers contain potassium, which plays a vital role in the metabolic processes of plants, specifically in the synthesis of amino acids and proteins from ammonium ions [7, 11]. Potassium is essential for maintaining optimal turgor pressure, facilitating smooth metabolic processes, and promoting consistent cell elongation. Liquid organic fertilizers offer even distribution during fertilization, preventing the buildup of fertilizer concentrations in a single area due to their complete solubility.

Liquid organic fertilizers are advantageous because they increase nutrient uptake and quickly overcome deficiencies due to readily absorbable nutrients. Several studies have demonstrated that using organic fertilizers in both solid and liquid forms can also promote robust plant growth and high yields. Research results by Darwin et al. [3], demonstrated that using liquid organic fertilizer at a concentration of 60 ml/L or a dose of 100 L/ha can serve as a cost-effective alternative to traditional inorganic fertilizers for sweet corn. This organic fertilizer has been proven to produce comparable growth and yields to the recommended inorganic fertilizers. Maintang et al. [10] reported that providing liquid organic fertilizer can reduce the use of inorganic fertilizers by 25% for growth and yield variables of maize. Ramesh [14] also concluded that the application of 50% nitrogen (N) from urea along with 50% N from vermicompost resulted in higher rice grain yield and also superior for nutrient uptake and conserved N under rice cultivation. A study conducted in Ethiopia found that the highest marketable pod yield of hot pepper was achieved by using a combination of NPS blended fertilizer and cattle manure at a rate of 150 NPS Kg/ha + 3.75 t/ha of CM [1].

Mela Organics, Mela Organics Natural Liquid Fertilizer Producing Plc Product, is a liquid organic fertilizer that contains pH-H_2O (6.59), electrical conductivity (6.22 ms/cm), total nitrogen (5.91%), phosphorus (255.69 mg/L), potassium (1367.07 mg/L), magnesium (329.99 mg/L), calcium (1720.42 mg/L), sulfur (641.99 mg/L), sodium (233.18 mg/L), iron (11.99 mg/L), manganese (7.74 mg/L), zinc (2.56 mg/L), copper (2.05 mg/L), molybdenum (0.96 mg/L) and boron (2.92 mg/L) [9]. It is made from 100% organic sources, with water hyacinth being a major component. This fertilizer is water-soluble and can improve the quality and quantity of crop yield. Its 100% water solubility, free-flowing, and environment-friendly attributes contribute significantly to its wide demand. It also increases the cell wall strength for disease and insect resistance. Moreover, it is easy to use and has no unpleasant smell. According to Mela Organix PLC (nd) [9], liquid fertilizer is safe for humans and the environment. Hence, evaluating the effects of Mela organic fertilizer application as a new fertilizer on tomato yield and yield components under irrigated conditions was important.

2. Materials and methods

2.1. Study Locations

The experiment was conducted for one cropping season (2020-2021) in the East Showa Zone of Oromia at six testing sites (farmers' fields) under irrigated conditions. The locations included the Dugda, Adama, Fentale, and Bora districts in the East Shewa Zone, Oromia Regional State. The organic fertilizer material was tested on the tomato crop hybrid variety, Galilea. The study sites are among the major areas of tomato production in the semiarid area of Ethiopia.

2.2. Treatment Design and Application

The liquid fertilizer was evaluated by integrating it with the recommended chemical fertilizer. It is assumed that liquid organic fertilizers can be used to substitute part of the recommended fertilizer and increase the yield and quality of tomato. The treatment design and applications are described in Table 1.

Table 1. *Fertilization treatments and application.*

TRT	Fertilizer level	Stage of application	Mode of application
1	No inputs control		
2	100% recommended nitrogen and phosphorus fertilizers (RNP)	Mela Organics was applied using 3 split applications of the rate per hectare used.	Mela Organics sprayed slowly on the leaves and stem of the tomato with knapsack sprayer, by mixing one liter in 40 L of water. Sprayed when the leaves of the plants are more active covering all
3	100% RNP + 30 L/ha Mela	The 5, 10 L ha^{-1} applied 25-30 days after transplanting for 30, 45 L ha^{-1} receiving plots, respectively;	
4	100% RNP + 45 L/ha Mela		
5	75% RNP + 30 L/ha Mela	The 10, 15 L ha^{-1} applied 3 weeks after the first application for 30, 45 L ha^{-1} receiving plots respectively; and	
6	75% RNP + 45 L/ha Mela	The remaining 15 and 20 L ha^{-1} applied 3 weeks after the	

TRT	Fertilizer level	Stage of application	Mode of application
7	50% RNP + 30 L/ha Mela	2nd application for 30, 45 L ha^{-1} receiving plots respectively.	the parts of the stem and leaves.
8	50% RNP + 45 L/ha Mela		

Nitrogen, phosphorus and sulfur blended fertilizer (NPS) was used as a source of P and N. All NPS fertilizers were applied as basal application at planting and the N in Urea and Mela Organics were applied in split form. The treatments were replicated three times arranged in a randomized complete block design (RCBD). The plot size for each treatment was 5*4 meter (m), with a spacing of 0.3m between plants and 1m between rows, resulting in 67 plants per plot. Necessary agronomic practices were applied for all treatments as per research recommendations uniformly.

2.3. Soil and Agronomic Data Collection Methods

Soil samples were collected before planting and after crop harvest at a depth of 0-20 cm at randomly marked four sampling points and composited to (0.5 kg). The soil samples were air-dried, ground and allowed to pass through a 0.5 mm sieve for N and organic carbon (OC), and a two mm sieve for the other soil parameters analysis. Some physicochemical properties of soil such as texture, pH, OC, total nitrogen (TN) and available phosphorus (avail. P) were analyzed to determine the initial soil fertility status of soils at the experiment sites.

Plant parameters such as total and marketable tomato fruit yields were collected by harvesting the entire net plot of 12 m^2 and converted into ton per hectare.

2.4. Data Analysis

The collected data were computed and subjected to analysis of variance (ANOVA) using proc GLM procedure using SAS statistical software version 9.2 [15]. When ANOVA shows significant treatment effect, means separation was carried out using Least Significance Difference /Tukey test.

2.5. Economic Analysis

Partial budget analysis was performed to investigate the economic feasibility of the treatments according to CIMMYT [2]. The yield was adjusted down by 10% to reflect actual production conditions [2]. The variable costs applied in the analysis were chemical fertilizer, liquid fertilizer, and fertilizer application. The farm gate price of tomato used for gross benefit calculation was Ethiopian birr (ETB) 13 kg^{-1}. The cost of fertilizer Urea and Blended (NPS) were ETB 16.47 and 17.57 kg^{-1} with the current market price. The cost of Mela organics was ETB 50 litter^{-1}.

3. Result and Discussion

3.1. Characterization of Initial Soils

Table 2. Chemical properties of the experimental soil.

Sites		Soil pH (water)	Organic matter%	Total Nitrogen (%)	Available P (Olsen) mg/kg	Texture (%) Silt	Clay	Sand
Wonji	Value	7.15	1.55	0.146	22.5	29	32	39
	Rating	Neutral	Adequate	Medium	Adequate			
Dugda-farmer 1	Value	7.06	1.73	0.070	21.7	27	6	67
	Rating	Neutral	Adequate	Low	Adequate			
Dugda-farmer 2	Value	7.0	3.00	0.068	21.9	37	40	23
	Rating	Neutral	Adequate	Low	Adequate			

Sites	Soil pH (water)	Organic matter%	Total Nitrogen (%)	Available P (Olsen) mg/kg	Texture (%)		
					Silt	Clay	Sand
References	[17]	[17]	[8]	[17]			

3.2. Marketable and Total Tomato Yields

Initially, six test sites were used in the study. However, the data from the two sites was not added. Fentale site was dropped due to farmers' mismanagement. A second site was also dropped at Alem Tana because of severe disease attack on the crop. Hence, only four sites were considered in this analysis. The results and discussion are based on data from two sites in the Adama Wonji and Dugda districts. The treatment effects on mean marketable yield (MY) and total yield (TY) were highly significant (Table 3). The location effect is also highly significant for both measured parameters. The mean marketable yield of four sites, as can be seen in Table 3, is 41.2 t/ha for a total of four to five round harvest yields.

The mean MY and TY of all the treatments (treatments 2–7) differed significantly from that of treatment 1 (negative control) (Table 4). A comparison of yields among all fertilized plots showed that the highest MY and TY were obtained from the application of 100% RNP + 30 L/ha Mela and 100% RNP + 45 L/ha Mela, respectively, and the negative control provided the lowest (28.8 t/ha MY).

Table 3. *Analysis of variable of mean MY and TY over 4 sites and 2 districts.*

Sources	DF	MY	TY
Loc	3	***	***
TRT	7	***	***
REP	2	NS	NS
Model	12	***	***
CV		16.3	15.7
RMSE		6.75	7.2
Mean		41.2	46.2
LSD		5.48	5.87

Table 4. *Mean marketable yield (MY) and total yield (TY) of tomato per treatment.*

Treatment	Fertilizer level	MY	TY
1	Negative control	28.8^{c}	32.1^{c}
2	100% recommended nitrogen and phosphorus fertilizers (RNP)	42.4^{ab}	47.3^{ab}
3	100% RNP + 30 L/ha Mela	46.4^{a}	52.1^{a}
4	100% RNP + 45 L/ha Mela	45.8^{a}	51.3^{a}
5	75% RNP + 30 L/ha Mela	42.2^{ab}	47.5^{ab}
6	75% RNP + 45 L/ha Mela	42.8^{ab}	48.7^{ab}
7	50% RNP + 30 L/ha Mela	38.4^{b}	43.4^{b}
8	50% RNP + 45 L/ha Mela	42.5^{ab}	47.5^{ab}

The yield gain from application of 100% RNP is 13.6 t/ha, a 47% increase. The high yield gain clearly shows that fertilization is critical for increasing tomato production at all locations. The RNP was 130 kg of N and 76 kg of P2O5 /ha. The additional fertilizer applied for treatments 3 and 4 (30 and 45 L/ ha Mela) increased the MY from 42.4 to 46.4 and 45.8 t/ha (Table 4), with MY gains of 9.4 and 8.0%, respectively. When the RNP was decreased by 25% while keeping the additional 30 and 45 L/ha Mela (treatments 5 and 6), MY was at par with 100% RNP, indicating that the contribution of Mela Organic to yield increments is as important as that of chemical fertilizer. In line with this research, Maintang et al. [10] showed a reduction in the use of inorganic fertilizers (NPK+ Urea)) by up to 25% with the use of liquid organic fertilizers on maize plants. Research result by Shi et al. [16] also concluded that under film mulching with drip irrigation, organic liquid fertilizer combined with chemical fertilizer reduced by 20% could sustain normal growth, promote reproductive organ biomass accumulation rate, and lead to efficient cotton production. The combined use of organic and inorganic fertilizers is expected to improve soil conditions, enhance plant productivity, and reduce the reliance on inorganic fertilizers. In addition, when the RNP was decreased by 50% while keeping the additional 30 L/ha Mela Organics, MY lowered to 38.4 t/ha. While maintaining the RNP at 50%, the increase in Mela Organics from 30 to 45 L/ha increased the MY to 42.5 t/ha. This indicates that further yield increments can be obtained by increasing the rate of Mela Organic while maintaining the rate of chemical fertilizers as low as 50% of RNP.

Table 5. Combined analysis of variance per district.

	Wonji Adama			Dugda		
Sources	DF	MY	TY	DF	MY	TY
Site	1	***	***	1	NS	**
TRT	7	NS	NS	7	***	***
REP	2	NS	NS	2	*	*
Model	10	***	***	10	***	***
CV		14.5	13.1		13.4	12.0
RMSE		5.6	5.7		5.8	5.9
Mean		38.8	43.7		43.6	48.8
LSD		6.6	6.7		6.8	6.9

3.3. Marketable and Total Fruit Yield Performance Across Districts

Data from Dugda district (Farmers 1 and 2) and Adama Wonji (Farmers 1 and 2) were analyzed separately. The combined analysis of the variance of Wonji showed that the treatment effects on both MY and TY were non-significant (alpha = 0.05). However, the combined ANOVA for the two sties of Dugda showed that the treatment effects for MY and TY were highly significant (Table 5).

The difference in MY between the negative control and RNP at Dugda was 22.2 t/ha, while at Wonji the measured difference was 3.9 t/ha only. A comparison of the ANOVA results for the two locations indicates that Dugda is highly responsive to applications of both chemicals and Mela Organics, but less responsive at Wonji. One of the reasons for the difference in the responses of tomatoes to the application of both chemical and organic fertilizers is their previous management history (Table 2). Most irrigated farmlands in Wonji use high amounts of chemical fertilizers. Thus, a high amount of residual fertilizer can decrease the response of crops to fertilizer addition [5]. Nevertheless, the effect of Mela Organics on RNP was clearly observed. Although the treatment effects from the combined analysis of two sites at Wonji are non-significant, the yield increment due to application of 100% RNP + 30 and 45 L/ha Mela relative to the negative control is 7.2 t/ha, which is economically important.

The results of the analysis of variance for the Dugda district clearly show the importance of Mela Organics in increasing tomato yields. As can be seen from Table 6, the MY increments from the application of 100% RNP + 30 L/ha Mela and 100% RNP + 45 L/ha Mela as compared to the positive control (100% RNP) are 6.0 and 4.6 t/ha, respectively. A similar comparison with respect to the negative control, there were yield increments of 28.2 and 26.8 t/ha equivalent to a 125 and 118% increase, respectively. Based on agronomic data of Dugda and combined analysis of two districts, Dugda and Wonji Adama, integrated application of Mela Organics with chemical fertilizer can increase the economic yield of tomato.

The combined application of liquid organic and inorganic fertilizers on tomato plants in this study had a significant effect on the marketable and total yield (t/ha). This suggests that liquid organic fertilizers can be utilized as a source of nutrients to promote plant growth and production. As mentioned earlier, liquid organic fertilizers contain both macro- and micronutrients. The results of this study are consistent with the points made by Gina and Liferdi [6], who showed that the application of 75% organic manure + 20 mL/L liquid organic fertilizer improved tomato yield by 83%. Martinez et al. [11] reported that the application of liquid organic fertilizer obtained from maize residues (vegetal-based) and faeces sheep manure (animal-based) promoted biomass production and nutrient concentration in citrus plants. Darwin et al. [3] also concluded that liquid organic fertilizer could be applied as an additional supplement to inorganic fertilizers used for sweet corn organic farming in the tropics.

Table 6. Mean MY and TY of tomato per treatment combined across districts.

No	Treatment	Wonji Adama		Dugda	
		MY	TY	MY	TY
1	Negative control	35.0	39.8	22.6 c	24.8 c
2	100% RNP	39.9	43.8	44.8 ab	50.8 ab
3	100% RNP + 30 L/ha Mela	42.1	47.0	50.8 a	57.2 a
4	100% RNP + 45 L/ha Mela	42.3	46.9	49.4 a	55.6 a
5	75% RNP + 30 L/ha Mela	38.6	43.6	45.9 ab	51.5 ab
6	75% RNP + 45 L/ha Mela	37.1	42.9	48.6 a	54.4 a
7	50% RNP + 30 L/ha Mela	36.4	41.7	40.5 b	45.2 b
8	50% RNP + 45 L/ha Mela	38.7	43.7	46.4 ab	51.4 ab

Based on the description, the liquid organic fertilizer utilized in this study is composed of 100% organic material and can be directly applied as foliar fertilizer for food crops, plantations, and horticulture. Foliar fertilization ensures that nutrients are evenly distributed and readily absorbed by the plants during their development. [11]. Organic fertilizers contain low macronutrients but sufficient micronutrients, which are necessary for plant growth. The micronutrient elements present in liquid organic fertilizers contribute to the enhancement of plant metabolism. Foliar fertilizer is commonly used as a supplement to soil fertilization to improve crop yield and quality [3, 7]. This study highlights the benefits and advantages of liquid organic fertilizers and suggests their use as viable nutrient sources for sustainable agriculture at the farm level. The findings of this study can serve as additional information to promote the expansion of organic fertilizers, particularly liquid organic fertilizers, in sustainable agriculture.

3.4. Marginal Economic Benefit

The results of the marginal economic benefit of the use of Mela Organics for tomato production in the East Showa Zone are presented in Table 7. The highest MRR% was 6300, obtained from plots treated with 50% RNP + 45 L/ha Mela. It was economically superior and more profitable than the rest of the treatments suggesting that for every 1.0 birr invested in 50% RNP and 45 L/ha Mela Organics for tomato production, the producer could earn an additional birr of 63 (Table 7). The plots treated with 100% RNP + 30 L/ha Mela and 50% RNP and 30 L/ha Mela also provided the farmers with birr 43.2 and 19.4 for every birr investment on these inputs, respectively (Table 7). Based on the MRR, the treatments with 50% RNP + 45 L/ha Mela and 100% RNP + 30 L/ha Mela were economically feasible.

Table 7. Economic analysis for effect of Mela Organics on yield of tomato.

Treatment	Adj. MY (kg ha^{-1})	Gross field benefit (Birr ha^{-1})	TVC (Birr ha^{-1})	NB (Birr ha^{-1})	MRR (%)
Negative control	25920	336960	0	336960	-
50% RNP + 30 L/ha Mela	34560	449280	5505	443775	1940
50% RNP + 45 L/ha Mela	38250	497250	6255	490995	6300
100% RNP	38160	496080	6810	489270	D
75% RNP + 30 L/ha Mela	37980	493740	7208	486533	D
75% RNP+ 45 L/ha Mela	38520	500760	7958	492803	240
100% RNP + 30 L/ha Mela	41760	542880	8910	533970	4320
100% RNP + 45 L/ha Mela	41220	535860	9660	526200	D

4. Conclusions and Recommendations

This study was conducted to evaluate the effect of the integrated use of Mela Organics with chemical fertilizer on the economic yield of tomatoes in the tomato-producing areas of the central Rift Valley of Ethiopia. Based on data from the test sites, the application of fertilizer combined with 30 L/ha Mela Organics increased tomato yields. The highest agronomic yield was obtained with the application of 100% RNP + 30 L/ha Mela. However, based on the partial budget analysis, the highest marginal rate of return was obtained for 50% RNP + 45 L/ha Mela. Thus, it can be concluded that the application of Mela Organics up to 45 L/ha, integrated with chemical fertilizer applications, can increase tomatoes' economic yields and reduce fertilizer costs. Based on this conclusion, it is recommended that 45 L/ha Mela Organics be used with 50% of the recommended chemical fertilizer.

Abbreviations

RNP	Recommended Nitrogen and Phosphorus
TVC	Total Variable Cost
NB	Net Benefit
MRR	Marginal Rate Return
REP	Replication
CV	Coefficient of Variation
RMSE	Root Mean Square of Error
LSD	Least Significant Difference
DF	Degree of Freedom
MY	Marketable Yield
TY	Total Yield
TRT	Treatment

Acknowledgments

We thank the Ethiopian Agricultural Research Institute and Mela Organics Liquid Fertilizers Production PLC for their support.

Author Contributions

Getinet Adugna: Conceptualization, Data curation, Formal Analysis, Methodology, Software, Validation, Visualization, Writing – original draft

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Conflicts of Interest

The authors declare no conflicts of interest.

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