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Effect of Liquid Organic Fertilizer (Nitro-Benzene) on Fruit Yield of Field Tomato in Central Rift Valley of Ethiopia

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Abstract: Three levels of liquid organic fertilizer (Nitro-Benzene) integrated with inorganic fertilizers were evaluated in the Central Rift Valley of Ethiopia on the yield of Tomato (*Solanum lycopersicum* L.) in Melkassa and Merti areas from 2014–2017. Full dose of nitrogen (64 kg N ha^{-1}) and phosphorous (20 kg P ha^{-1}) from mineral fertilizer sources was also included as a control. The treatments were laid out in randomized complete block design with four replications. The product solutions were prepared as per the factory Boom Flower® recommendations and applied as foliar spray at five different growth stages of tomato. The results revealed that foliar application of 2 L ha^{-1} liquid organic fertilizer(LOF)-Nitro-Benzene (Boom Flower) together with recommended rate of nitrogen (64 kg N ha^{-1}) and phosphorous (20 kg P ha^{-1}) (RNP) from inorganic fertilizers significantly increased marketable yield of tomato by 47% compared to the use of RNP alone at Melkassa. Partial budget analysis also indicated that the application of 2 L ha^{-1} Boom Flower with RNP gave the highest net benefit of 238, 116 ETB ha^{-1} with maximum marginal rate of return of 3217% in Melkassa. Thus, the foliar application of 2 L ha^{-1} LOF integrated with 64–20 kg N–P ha^{-1} is recommended for tomato production in Melkassa and Merti areas as well as other similar agro-ecologies.

Key words: Liquid Organic Fertilizer · Foliar Application · Fruit Yield And Tomato

INTRODUCTION

Vegetable crops are the third major food crops in Ethiopia in terms of the area they are covered next to cereal and pulse in a belg season. Out of the total crop area, 3.43% was under the vegetables. Ethiopian Cabage and Tomato took up 77.16 % and 8.83% of the vegetable crop area respectively [1]. Among these tomato was the second vegetable crop produced in the 2014/2015 cropping season. According to the CSA [1] report, the average total fruit yield of tomato was 6.20 Mt ha^{-1}.

Ethiopia has shown dramatic growth in fertilizer use since the end of 1990s. Currently, the national mean fertilizer consumption reached up to 14.4 kg ha^{-1} (https://knoema.com/atlas/Ethiopia/Fertilizer-consumption). However, the fertilizer use per nutrient base does not exceeded 12 kg ha^{-1}. The country has consistently invested at least 10% of agriculture input since 2003. This strong support has resulted in an average growth rate of over 7% per year in the sector [2]. Fertilizers increase crop productivity while replenishing the soil with essential plant nutrients. The country's fertilizer use efficiency will show dramatic improvement if and only if the demand and supply of fertilizers is fulfilled to the farming community by appropriate nutrients concentration through the right plant nutrient formulation and fertilizer pricing policy. Moreover, access to alternate types or forms of fertilizer sources enables farmers to enhance soil fertility and ensure good crop production in the country.

Combining organic and mineral inputs has been advocated as a sound management principle for smallholder farming in the tropics because neither of the two inputs is usually available in sufficient quantities and hence both inputs are needed in the long term to sustain soil fertility and crop production [3].

Promotional effects of humic acid on fruit weight have been reported in several studies. Foliar or soil application of humic acid has led to significant increases in mean fruit weight and total yield in peppers [4]. [5] investigated that

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foliar application of fulvic acid have been increased marketable yield in tomato production. [6] also indicated that foliar humic acid application have been an advisable treatment in terms of producing better quality and yield of tomato.

The foliar application of liquid organic fertilizer to tomato and other crops generally shows beneficial effects on growth and yield parameters. Similarly, foliar and soil application of liquid organic fertilizer has resulted in an increase of early yield and total yield in tomato [6]. Furthermore, studies explaining the effects of liquid organic fertilizer suggested that its effect is demonstrated through increasing enzyme catalysis, enhancing respiration and photosynthesis and stimulating nucleic acid metabolism [7-10].

The country has been importing and testing different types of liquid, granular and blended fertilizers in order to boost crop yield. Most of the newly introduced fertilizer types showed positive influences on different crops tested across different soil types in the country. In this regard, the effectiveness of the new liquid organic fertilizer called (Boom Flower), which has been in use across different countries in the world was not known in Ethiopia. Therefore, this study was initiated to evaluate the effect of liquid organic fertilizer (LOF) as a supplementary nutrient for stimulating and boosting yield of tomato in different areas of the Central Rift Valley of Ethiopia under irrigation condition.

MATERIALS AND METHODS

Description of the Study Areas: These studies were conducted on farm at Merti and on station at Melkassa, both are located in the central rift valley of Ethiopia, from 2014 – 2017 cropping seasons. Merti is situated in Merti Jeju district, which is about 210 km away from Adiss Ababa. The study area in Merti is located at latitude of 08°37'15.7" N and longitude of 39°45'33.0" E. The altitude at the site was 1443 meter above sea level (m a.s.l.). Melkassa is found in the Adama district, which is about 107 km away from Adiss Ababa. The experimental site in Melkassa is situated at latitude of 08°25'05.7" N and longitude of 39°19'17.3" E with the altitude of 1540 m a.s.l. The soil type and its textural class in Melkassa is Andosol and loamy, respectively, whereas the soil in Merti is sandy clay loam in texture and slightly alkaline in reaction. The study areas have been continually cropped dominantly with onion, tomato and maize. Irrigation water used for both locations was diverted from Awash River, which is salt free (EC < 0.2 dS/m) [11].

Experimental Design and Treatment Setup: The experiment compared of 3 different levels of liquid organic fertilizer (LOF) integrated with the existing recommendation for the test crop, 64–20 kg N–P ha^{-1} (RNP). The RNP without Boom Flower liquid fertilizer was also included the comparison purpose. The treatments were arranged in randomized complete block design with 4 replications. The treatments description is shown in Table 1.

Boom Flower (LOF) is a new generation fertilizer, which contains 2.2% nitrogen in aromatic form derived from Nitrobenzene. It also contains 27 and 73% w/w total solids and aqueous media, respectively. Heavy metal analysis conducted for the product showed that Boom Flower holds small quantities of cadmium (<1.0 mg kg^{-1}), Total solids -mercury (< 0.2 mg kg^{-1}), molybdenum (< 10 mg kg^{-1}), selenium (< 20 mg kg^{-1}), lead (< 20 mg kg^{-1}) and maximum biuret (<0.1% w/v; not detectable) (Devi Cropscience Pvt. Ltd).

LOF was measured as per the treatment setup, mixed into a 2 liter pressurized hand sprayer with a single applicator nozzle and sprayed to each plant until the surfaces of all laterals leaves were wetted. The LOF application time per crop development stage is indicated in Table 2.

The gross experimental plot size was 3 m by 3.3 m, which had 5 rows and 10 plants per row having a total of 50 plants per plot. The test crop for this study was tomato and the variety used was Melka shola. The central 3 rows were harvested for fruit yield determination. The sources of nitrogen (N) for this experiment were Urea and Diamonium phosphate (DAP) while phosphorous (P) was supplied from DAP. All P and half of N were basal applied while the remaining half of N was top dressed after a month of tomato transplanted. All management practices such as soil and crop management were uniformly carried out for all experimental plots. Foliar application of Boom Flower organic liquid fertilizer to tomato leaves was carried out based on the protocol suggested by manufacturer (Devi Cropscience Pvt. Ltd.).

Data Analysis: Statistical analyses were done by site-season and combined across site-seasons using SAS 9.0 computer program [12], with site-seasons and replicates as random variables and nutrient rates as fixed variables. When significant differences between treatment means were evident from ANOVA, mean separation was computed using the least significant difference (LSD) test at 0.05 level of probability [13].

Table 1: Treatments description

Treatment No	Treatments description
T_1	Existing recommendation (64–20 kg N–P ha^{-1}) (RNP)
T_2	1.0 Liter (L) LOF in 1000 L of water ha^{-1} + RNP
T_3	2.0 L LOF in 1000 L of water ha^{-1} + RNP
T_4	3.0 L LOF in 1000 L of water ha^{-1} + RNP

Table 2: Boom Flower spraying schedule from 2014 – 2017

	Merti			Melkassa		
	Planting date					
Spray schedule	30-Aug-14	1-Oct-15	10-Jul-16	30-Aug-14	5-Oct-15	11-Feb-17
	LOF application schedule					
1st	19-Sep-14	22-Oct-15	30-Aug-16	19-Sep-14	26-Oct-15	4-Mar-17
2nd	4-Oct-14	6-Nov-15	13-Sep-16	4-Oct-14	10-Nov-15	18-Mar-17
3rd	24-Oct-14	20-Nov-15	28-Sep-16	24-Oct-14	25-Nov-15	1-Apr-17
4th	13-Nov-14	17-Dec-15	12-Oct-16	13-Nov-14	25-Dec-15	15-Apr-17
5th	2-Dec-14	4-Jan-16	26-Oct-16	2-Dec-14	9-Jan-16	29-Apr-17

Economic analysis was performed to investigate the economic feasibility of the treatments. Partial budget, dominance and marginal analyses were carried out. The average yields of tomato fruits were adjusted downwards by 10% to account for the yield differences between the experimental plot and the farmers' fields for the same treatment. The average open market price for tomato fruits was 12.00 ETB kg^{-1}. The farm gate prices of DAP and Urea were 17.00 and 14.00 ETB kg^{-1}, respectively. The official price of Boom Flower (LOF) as obtained from the company was 345.00 ETB L^{-1}. For a treatment to be considered as worthwhile option to farmers, the minimum acceptable rate of return should be greater than or equal to 100% [14].

RESULTS AND DISCUSSION

Total and Marketable Fruit Yields of Tomato: The response of tomato to the applied Boom Flower organic liquid fertilizer combined with recommended nitrogen (64 kg N ha^{-1}) and phosphorous (20 kg N ha^{-1}) (RNP) in Merti and Melkassa area are presented Figures 1 and 2.

The pooled mean analysis over years revealed that application of LOF combined RNP significantly affected the total and marketable fruit yields of tomato in both locations (Fig. 1 and 2). Exception was the marketable fruit yield of tomato in Merti, where the result was non-significant (Fig. 1b). The foliar application of 2 L ha^{-1} LOF together with RNP (64–20 kg N–P ha^{-1}) significantly increased the total fruit yield of tomato (36 Mt ha^{-1}) followed by application of 1 L ha^{-1} LOF combined with RNP (30 Mt ha^{-1}), which were statistically different from the control (RNP; 28 Mt ha^{-1}). Compared to the control (RNP), foliar application of 2 L ha^{-1} LOF + RNP and 1 L ha^{-1} LOF + RNP boosted the total fruit yield of tomato by 28 and 7%, respectively in Merti area (Fig. 1a). In agreement to this finding Bekele and Grumu [15] observed at Merti, tomato total yield was increased significantly due to application of Humic acid with RNPK.

Despite the increment in marketable fruit yield of tomato with the integration of LOF with RNP from inorganic fertilizers, the analysis of variance over years revealed that the changes in fruit yield were not significant (Fig. 1b). The general trend, however, indicated that the application of 64–20 kg N–P ha^{-1} with 2 L ha^{-1} LOF boosted marketable yield of tomato by 31% over the agronomic control (RNP; Fig. 1b). This implies that the application of LOF could boost tomato yield.

The pooled mean analysis over years also revealed that the foliar application of 2 L ha^{-1} LOF integrated with 64–20 kg N–P ha^{-1} from inorganic fertilizers gave the highest total (24 Mt ha^{-1}) and marketable (22.6 Mt ha^{-1}) fruit yields of tomato in Melkassa area (Fig. 2), which were statistically different from the control (Fig. 2). The application of RNP with the foliar application of 2 L ha^{-1} LOF boosted the total and marketable fruit yields of tomato by 25 and 47%, respectively compared to the agronomic control (20 and 15 Mt ha^{-1} for total and marketable fruit yields of tomato, respectively) in Melkassa (Fig. 2). Similar to this finding Bekele [16] saw at Melkassa, the foliar application of humic acid with RNPK fertilizers significantly influenced onion marketable yield as compared to the highest doses of HFA. In the same line promotion in the nutrients uptake with the application of humic acid has been also reported by various scholars [17-19]. LOF increased the uptake of N, P, K, Mg and Ca over the control [20] and thus improved the bulb yield.

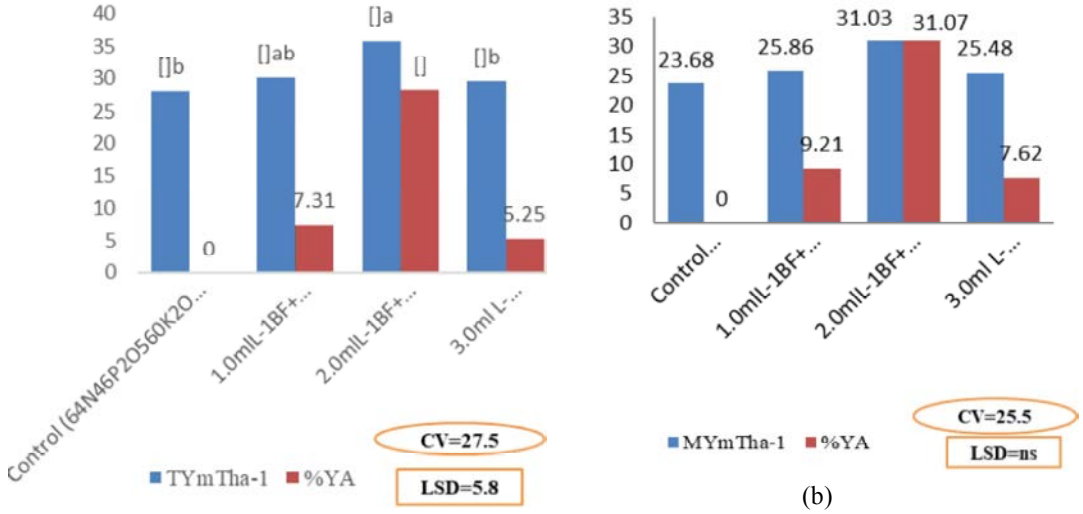

Fig. 1: Total (a) and marketable (b) yields of tomato as influenced by the application of Boom Flower organic liquid fertilizer with or without NPK in Merti.
Note: MY, YA, CV and LSD are marketable fruit yield of tomato, fruit yield advantage of tomato relative the RNP, coefficient of variation and least significant difference at 0.05 level of probability.

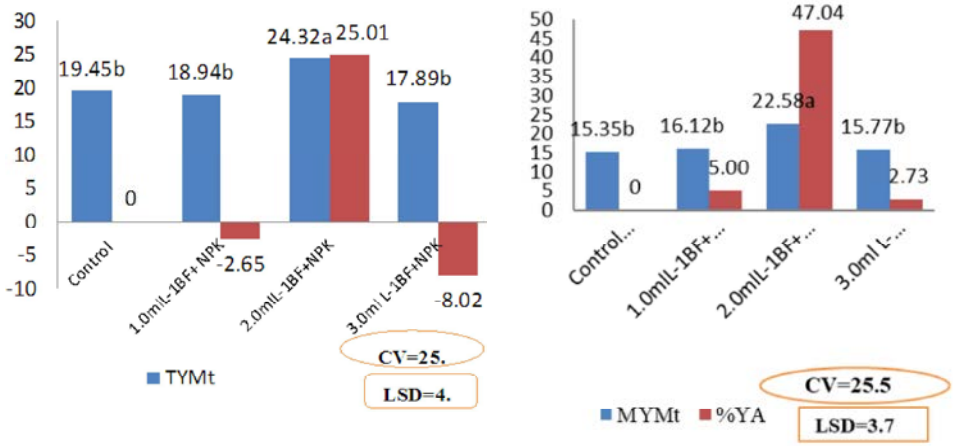

Fig. 2: Total (a) and markatable (b) yields of tomato as influenced by the application of LOF with and without NP in Melkassa.
Note: MY, YA, CV and LSD are marketable fruit yield of tomato, fruit yield advantage of tomato relative the RNP, coefficient of variation and least significant difference at 0.05 level of probability.

Table 3: Partial budget analysis for LOF with NP on tomato production in Melkassa

	Adjusted marketable yield	Total variable cost	Net benefit (ETB ha^{-1})	MRR
Treatments	kg ha^{-1}	ETB ha^{-1}		%
64–20 kg N–P ha^{-1} (RNP)	13815	0.00	165, 780.00	
1.0 L ha^{-1} LOF + RNP	14508	3, 540.00	170, 556.00	135
2.0 L ha^{-1} LOF + RNP	20313	5, 640.00	238, 116.00	3217
3.0 L ha^{-1} LOF + RNP	14193	7, 740.00	162, 576.00 D	-

Partial Budget Analysis: Partial budget analysis was carried out to identify the rewarding treatment(s) for economically feasible production of tomato in Melkassa area. Accordingly, the foliar application of liquid organic fertilizer (LOF) at a rate of 2 L ha^{-1} combined with 64–20 kg N–P ha^{-1} from inorganic fertilizers (RNP) provided the highest net benefit of 238, 116 ETB ha^{-1} with the highest marginal rate of the return of 3217% (Table 3). This implies that for every birr investment on the purchase and integrated application of 2 L ha^{-1} (LOF) with RNP, farmers can earn addition 32.17 birr, which showed great economic return. The economic benefit agreed well with the agronomic response of tomato for the integrated application of nutrients from liquid and granular fertilizers. The application of 1 L ha^{-1} (LOF) together with RNP also provided a net benefit of 170, 556 ETB ha^{-1} with a MRR of 135%, which was still highly profitable [14].

CONCLUSION AND RECOMMENDATIONS

The results of this study revealed that the marketable fruit yield of tomato was significantly boosted by the foliar application LOF together with recommended rate of nitrogen (64 kg N ha^{-1}) and phosphorous (20 kg P ha^{-1}) (RNP) in Melkassa area. The highest total (24 Mt ha-1) and marketable (23 Mt ha-1) fruit yields of tomato in Melkassa area were attained from the application of 2 L ha^{-1} LOF along with RNP from inorganic sources. On top of the enhanced fruit yield of tomato, the highest net benefit of 238, 116 ETB ha^{-1} with a marginal rate of return of 3217% was also obtained from the same treatment. Given the boosted marketable fruit yield of tomato and higher economic return, the foliar application of 2 L ha^{-1} LOF integrated with 64–20 kg N–P ha^{-1} is recommended for tomato production in Melkassa and Merti areas as well as other similar agroecologies. Boom Flower organic liquid fertilizer (LOF) consists of small amount of heavy metals like lead, cadmium, molybdenum and mercury. The residual effects of these ions in long term were not studied in this study. Thus, these effects on soils and plants and their consequences to the higher tropic level need to be monitored.

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