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FERTILIZATION OF TOMATO WITH EFFECTIVE MICROORGANISMS, FARM YARD MANURE AND NITROGEN

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Abstract

Objective: This study was conducted to investigate the effect of effective microorganisms (EM), farm yard manure and nitrogen on yield and quality of tomato. Methodology: A factorial experiment was carried out at the Research Farm of Gezira (Medani), Shendi and Hudieba in 2009/10. The factors studied were N (0 and 2N as urea), farm yard manure (0 and 10 t/ha) and EM (- or +). The treatments were arranged in RCBD with four replicates. The data collected involved tomato marketable yield and quality in term of fruit firmness and total soluble solids. Results: The results revealed that 2N application significantly increased the yield at Medani and Hudieb but not at Shendi. EM improved the yield of the control and manure by 12-31 and 7-18%, respectively, but these increments were not significant. The highest yield of tomato was recorded at Medani and Hudieba in manure integrated with 2N. However, the yield obtained by the use of manure alone was not significantly different from that of manure with 2N but significantly the highest among the other combinations at Shendi. Each of N and manure significantly improved the firmness of tomato at Medani. Hence, manure applied separately or integrated with 2N could be used for the organic production of tomato and yield maximization, respectively, at Medani and Hudieba. Separate use of manure was suggested for both yield maximization and organic tomato production at Shendi. Conclusion: It could be concluded that the integrated use of manure and nitrogen fertilizer significantly resulted in the highest tomato yield when the total soil N is low as in Medani and Hudieba. Application of manure alone showed comparable yield to that of combined manure and 2N but significantly higher than that of 2N when the total soil N is high as in Shendi.

Keywords: EM, FYM, Nitrogen fertilizer, Lycopersicon esculentum Mill, total soil N, tomato yield, organic tomato.

I. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetables grown in Sudan. In 2009, it produced 453000 MT of fruits from a harvested area of 28042 ha (FAOSTAT,http://faosta.fao.org/site/339/default.aspx). Tomato is a healthful vegetable providing a rich source of minerals, vitamins and antioxidants. It plays an important role in human diet particularly during the time of high production.

The concept of effective microorganisms (EM) was developed by Dr. Heruo Tiga, a professor of horticulture at the University of Ryukyus in Okinawa, Japan, in 1971. Its application began in 1989. EM is a mixture of a group of beneficial microorganisms that can coexist with each other; it is concluded lactic acid bacteria, yeast, actino bacteria and photosynthetic bacteria These microbes were blended in molasses or a sugar medium maintained at low pH. EM application was known to improve soil properties, increase the efficiency of organic fertilizers, suppress plant pathogens and pests and enhance crop yield and quality. For example, the use of EM increased the yield of peas, sweet potato and onions

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by 31, 23 and 29%, respectively[5]. Furthermore; the effect of EM on yield was more profound when it was integrated with the use of organic materials[8].Similarly, the use of organic fertilizers was found to improve soil properties and crop yield and quality. Addition of farm yard manure significantly increased the yield of tomato and also improved its quality [11, 7]. Maximum yield of tomato was obtained when organic manure was combined with mineral fertilizers[3].

In order to have an increase in food production to meet the increased demand expected by 2050, the necessarily large increases in fertilizer use will create not only soil fertility problems but also ecological imbalances[6]. Unfortunately, excessive use of chemical fertilizer has caused many problems as soil degradation leading to the reduction of tomato yield and quality. To reverse these trends, EM technology has been adopted as an alternative solution[4]. In Sudan, the available published data showed that EM and farm yard manure had not yet been used for boosting up tomato yield. Not only that but also there was only one study of EM effect on tomato yield and quality[14]. Also there is urgent need to investigate the EM application in interactions with fertilizers and farm yard manure in all of the soil amendments. Thus, the Government of Sudan has taken actions by investigating on the use of EM technology and farm yard manure instead of chemical fertilizer. Accordingly, the objective of the present study was to investigate the effect of EM, farm yard manure and nitrogen as well as their interactions on tomato yield and quality.

II. MATERIALS AND METHODS

This study was conducted at the Research Farm of Gezira (Medani), Shendi and Hudieba in 2009/10 to examine the effect of EM, manure, and nitrogen on tomato yield and quality. Tomato commercial variety named Castle Rock- Sudan has been used. Seeds were sown on both sides of raised beds, 1.4m wide and at an inter-row spacing of 30 cm. Farmyard manure was applied in an open furrow made on both sides of the raised beds and immediately covered back with soil. This was just done prior to sowing. Randomized Complete Block Design (RCBD) with four replications has been used. In this Study the different combinations of two different dose of each of A, B, and C i.e. Nitrogen (0 and 2N), farmyard manure (0 and 10 ton/ha) and EM (- and +) respectively were applied However, N was applied tow times firstly after 21 days from planting and secondly after 60 days from planting. EM was applied according to the protocol supplied by Moroug Factory for Biological and Organic Fertilizers, Khartoum, Sudan. Firstly, tomato seeds were soaked in 1 ml EM/L water for 30 mints. Secondly, soil application at 15 L EM/ feddan once at sowing and then applied at a rate of 10 L EM/ feddan at an interval of 10 days continued for extra four times. Lastly, at the emergence of the first leaves of tomato, spraying of plant thoroughly with 1 ml EM/L water every 10 days continued till harvest. Data collected involved tomato marketable yield and quality in form of fruit firmness and total soluble solids. Also, the analysis of a composite soil sample collected prior to sowing and manure at each site was performed.

III. STATISTICAL ANALYSIS

The data collected were computed using Microsoft Excel and subjected to analysis of variance using MSTAT-C statistical package. Duncan´s Multiple Range Test (DMRT) was used for mean separation at the probability level of 0.05.

IV. RESULTS

Manure and soil sample analysis were shown in table 1 and 2, respectively. The soils of the three sites were non saline and non sodic. The soil at Medani and Hudieba were clayey while that at Shendi was silty. Also, Shendi site had the highest O.C. %, available P and total soil N than the others.

The use of EM increased tomato marketable yield by 30.7, 11.8 and 25.3% over the control at Medani, Shendi and Hudieba, respectively, but these increments were not statistically significant (Table 3). Addition of 2N significantly improved the yield of tomato at Medani and Hudieba but not at Shendi.

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Moreover, significant enhancement of yield at each of the three sites was obtained through the application of manure. It was worth noting that significant interaction between manure and N on yield was evident at each site whereas that between EM and N was only obtained at Medani. No further interaction was noticed (Table 3).

Table1. Some chemical properties of the manure applied to the tested sites

Site	N%	P ppm	O.C.%	C:N
Medani	1.5	0.04	37.4	24.9
Shendi	1.2	0.20	35.5	27.3
Hudieba	1.3	0.04	33.8	27.0

Table2. Some chemical and physical properties of the tested sites

Site	Sand%	Silt%	Clay%	pH	EC dS/m	ESP	N%	O.C.%	Available P ppm
Medani	14	29	57	8.2	0.4	4	0.05	0.39	1.6
Shendi	4	48	48	7.6	1.2	8	0.07	0.86	9
Hudieba	15	29	58	8.0	0.8	10	0.05	0.33	7.5

Bulk density at medani 1.7 g/cm3

Table3. Effect of EM, manure and N on marketable yield (ton/ha) of tomato

treatments	Medani	Shendi	Hudieba	mean
Control	8.8	16.1	16.6	13.8
EM	11.5	18.0	20.8	16.8
M	26.6	26.3	23.1	25.3
M+EM	31.5	29.6	24.7	28.6
N	13.6	21.2	21.6	18.8
N+EM	10.0	20.1	18.5	16.2
N+M	45.4	21.8	35.4	34.2
N+M+EM	40.2	25.3	33.4	33.0
N	1.15***	1.25 ns	1.10**	
M	1.15***	1.25***	1.10***	
N*M	1.62**	1.77*	1.56**	
EM	1.15 ns	1.25 ns	1.10 ns	
N*EM	1.62*	1.77 ns	1.56 ns	
M*EM	1.62 ns	1.77 ns	1.56 ns	
N*M*EM	2.29 ns	2.51 ns	2.21 ns	
C.V.%	19	22	18	

EM: effective microorganisms, M: farm yard manure at 10t/ha and N: nitrogen at 86 kg N/ha
*, ** and *** are statistically significant at 5, 1 and 0.1% probability level, respectively.
ns: not statistically significant at 5% probability level

Table4. The interaction effect of manure and N on tomato yield (t/ha)

Factor		Site			Mean
N	Manure t/ha	Medani	Shendi	Hudieba	
0	0	10.1 c	17.1 c	18.7 c	15.3
0	10	29.0 b	28.0 a	23.9 b	27.0
2N	0	11.8 c	20.7 bc	20.0 bc	17.5

2N	10	42.8 a	23.5 ab	34.4 a	33.6
SE±		1.619	1.773	1.564	
Mean		23.4	22.3	24.2	

Means within each column followed by same letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Table5. The interaction effect of N and EM application on tomato yield (t/ha) at Medani

Treatment	0N -EM	0N+EM	2N-EM	2N+EM	SE±
Yield (t/ha)	17.7 c	21.5 bc	29.5 a	25.1 ab	1.619

EM: effective microorganisms

Table6. Effect of EM, manure and N application on some quality parameters, fruit firmness (kgf) and total soluble solids (%TSS) of tomato

Treatment	Firmness (kgf)			%TSS		
	Medani	Shendi	Hudieba	Medani	Shendi	Hudieba
Control	3.23	3.00	3.13	4.3	3.6	4.6
EM	3.51	3.08	3.39	4.4	3.2	4.7
M	3.69	2.88	3.07	4.1	3.5	4.7
M+EM	3.60	3.02	3.27	4.4	3.4	5.1
N	3.66	2.93	2.93	4.2	3.5	4.9
N+EM	3.24	3.12	3.24	4.3	3.7	4.9
N+M	4.10	3.03	2.76	4.3	3.4	4.8
N+M+EM	4.07	2.92	3.06	4.5	3.9	4.8
N	0.081*	0.083 ns	0.156 ns	0.077 ns	0.102 ns	0.083 ns
M	0.081***	0.083 ns	0.156 ns	0.077 ns	0.102 ns	0.083 ns
N*M	0.114 ns	0.118 ns	0.221 ns	0.109 ns	0.144 ns	0.119 ns
EM	0.081 ns	0.083 ns	0.156 ns	0.077 ns	0.102 ns	0.083 ns
N*EM	0.114 ns	0.118 ns	0.221 ns	0.109 ns	0.144 ns	0.119 ns
M*EM	0.114 ns	0.118 ns	0.221 ns	0.109 ns	0.144 ns	0.119 ns
N*M*EM	0.162 ns	0.166 ns	0.312 ns	0.154 ns	0.203 ns	0.169 ns
C.V.%	9	11	20	7	11	7

EM: effective microorganisms, M: farm yard manure at 10t/ha and N: nitrogen at 86 kg N/ha
* and *** are statistically significant at 5 and 0.1% probability level, respectively.
ns: not statistically significant at 5% probability level.

Table7. The main effect of N and manure on tomato fruit firmness at Medani

Treatment	N		Manure (t/ha)	
	0	2N	0	10
Firmness (kgf)	3.31	3.77	3.41	3.87
SE±	0.081*		0.081***	

*, ***: statistically significant at 5 and 0.1% probability level.

In reference to the interaction of manure and N levels, the integrated use of manure with 2N resulted significantly in the highest yield than those of the other combinations at Medani and Hudieba (Table 4). At Shendi, the yield of manure without N exceeded that of manure+2N and was significantly higher than those of the other combinations. Application of manure without N significantly resulted in higher yield than the control at the three sites. It was also significantly better than that of 2N at Medani

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and not statistically significantly different from that of 2N at Hudieba (Table 4). The interaction of EM and N levels demonstrated that addition of EM to 2N did not significantly increase the yield over that of 2N alone but reduced it at Medani (Table 5). Such trend was also noticed at Hudieba

Significant effect on one quality parameter was obtained by addition of N and manure each alone at Medani site only (Table 6). Both of them significantly improved the fruit firmness quality parameter at Medani (Table 7).

III. DISCUSSION

This study showed that tomato yield responded positively and significantly to 2N at Medani and Hudieba but not at Shendi. These differences among the tested sites could be attributed to the level of the total soil N. The total soil N was low at Medani and Hudieb but high at Shendi. [3]reported a significant increase in yield due to N application at sites having 500 ppm total soil N or less and lack of that at a site having 914 ppm. Lack of yield wheat response to N at this site of Shendi had been also recorded[12]. Application of EM increased the yield of tomato by 11.8- 30.7% at the three sites. Similar results were reported by[5] where the yield of peas, sweet potato and onions was enhanced by 31, 23 and 29%, respectively, as a result of EM addition. Since the yields obtained by EM were not significantly higher than those of the control and less than that of 2N, addition of 2N seemed more economical and practical than the use of EM alone.

As in other studies[11, 7] application of manure significantly improved the yield and quality of crops. This was thought to be due to the fact that manure addition improved the soil properties and provided macro and micronutrients for plants. It also supplied substances such as vitamins, hormones, antibiotics and growth regulators[14, 15]. These made the use of manure result in better crop yield and quality. The addition of farm yard manure alone in this investigation significantly improved the yield of tomato over the control at each site. The yield of manure alone was also significantly better than that of 2N at Medani and Shendi and higher than that at Hudieba but not statistically significant. This strongly suggested the use of farm yard manure at a rate of 10 t/ha at the three sites for the organic production of tomato. Of course organic food increasingly gains importance as it is better for human health and environment.

Scientists realized that much more benefits of EM could be obtained when applied with organic manure[8]. This might have been because most of EM microbes are heterotrophic requiring a source of carbon and N for their nutrition. Hence, the EM was expected to enhance the rate of decomposition and in turn improved the efficiency of organic materials as a fertilizer[6, 9]. Although it was not yet well known how EM improved the growth of plants, it was thought that this was through EM production of growth regulators, hormones and antioxidants[16, 17]. In the present study, the use of EM enhanced the efficiency of manure in boosting up the yield of tomato by 18, 12 and 7% at Medani, Shendi and Hudieba, respectively. However, these increments were not statistically significant. Therefore, the addition of EM to the manure for the purpose of improving its efficiency and increasing tomato yield was not justifiable particularly when the cost of EM application was considered. Unexpectedly, application of EM with 2N resulted in yield reduction when compared to that of 2N. [10] attributed the negative effect of EM on yield when combined with mineral fertilizers to immobilization of plant nutrients by the EM microbes. However, this explanation is questioned since the addition of EM in our study increased the yield of plots without N application and decreased it in plots receiving 2N. This also regrets the use of EM integrated with 2N for improving tomato yield.

It is quite good to apply manure in conjunction with the N fertilizers for achieving the maximum yield [2]. The combined use of farm yard manure and 2N gave significantly the highest yield than their other combinations at Medani and Hudieba. The yield increments obtained from the integrated use of manure and 2N were 71 and 53% over those of manure alone at Medani and Hudieba, respectively while those over the 2N were 234 and 63 % at Medani and Shendi, respectively. Similar studies proved that

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the integrated application of manure with N resulted in a better yield than either sources applied alone[1, 2]. At Shendi, the situation was a little bit different where the addition of manure separately resulted in a yield higher than the integrated use of manure and 2N and significantly better than those of the other combinations. This outcome might be due to the high total soil N that masked the significant response to the added 2N alone or in combination with manure.

These findings necessitate the integrated use of manure and 2N for yield maximization at Medani and Hudieba. Also, separate addition of manure could be quite enough for achieving the above mentioned purpose at Shendi. The use of manure alone or in combination with 2N or manure was not statistically significant and not economically feasible. The farmers are, therefore, unlikely willing to adopt this environment friendly technology. This study discovers the significant amount of manure that can be applied as to boost the production of Tomato as well as the nitrogen specially when combine with manure.

IV. CONCLUSION

It could be concluded that EM use improved but not significantly the yield of control and manure by 12-31 and 7-18%, respectively. It reduced the yield when combined with 2N. Significant increments in yield over the control and 2N were obtained by addition of farm yard manure at the three sites. Furthermore, the integrated application of farm yard manure with 2N resulted in the significant maximum yield than the other combinations at Medani and Hudieba. This was succeeded by manure added alone. At Shendi, manure added without N was not significantly different from manure with 2N but significantly better than those of the control and 2N.

V. RECOMMENDATION

The following are recommendation of this study:

1- For organic production of tomato, farm yard manure at 10 t/ha be applied at the three sites, Medani, Shendi and Hudieba.
2- For yield maximaization of tomato, farm yard manure at 10t/ha combined with 2N be applied at Medani and Hudieba and 10 t/ha of farm yard manure be separately applied at Shendi.

Statement on Conflicts of Interest:
The authors declare no conflicts of interest.

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