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Yield and Fruit Quality of Tomato as Influenced by Calcium and Mulching in Rooftop Cultivation

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Abstract

The experiment conducted in containers known as pot placed on rooftop of a building using noncalcareous grey terrace soil was carried out from October, 2012 to March, 2013 at Kazla, Motihar, Rajshahi, Bangladesh to investigate the influences of calcium and mulching practices on yield and fruit quality of tomato. The study was laid out in a split-split plot design with three replications. The trials comprised three factors: 1) three tomato varieties viz, BARI F_1Tomato-5, BARI F_1Tomato-6 and BARI F_1Tomato-7; 2) four levels of calcium (Ca) treatment (40 ppm, 60 ppm, 80 ppm, 120 ppm) and 3) mulching practices. Results of the experiment revealed that fresh yield of tomato was significantly increased by applying mulching practices due to conservation of soil moisture by mulches and therefore, reduced Ca-deficiency symptoms. The highest number of fruits per plant and fresh yield were obtained from the variety BARI F_1Tomato-5. The same trend of yield and yield contributing parameters were likely to be better by using T_3 treatment (80 ppm) than those of other treatments. In contrast, BARI F_1Tomato-7 variety in control treatment without mulching practice gave poor quality and yield of tomato. Results suggested that BARI F_1Tomato-5 variety receiving 80 ppm calcium treatment with mulching condition exposed better quality, yield and yield contributing characters of tomato. However, the T_3 treatment (80 ppm) with mulching would be recommended as the best combination to grow BARI F_1Tomato-5 for the farmers in Bangladesh.

Keywords

Tomato Varieties, Calcium Treatment, Rice Straw, Mulching Practices and Yield

1. Introduction

Tomato (*Lycopersicon esculentum* Mill.) is herbaceous plant and a member of

the solanaceae family. Tomato is one of the most important vegetable crops grown throughout the world under field and greenhouse conditions. Global production of tomato is over 120 million metric tons [1]. The average yield of tomato in Bangladesh is 7.42 t/ha, which is very low compared to other tropical countries. At present 6.10% area in Bangladesh is under tomato cultivation both in winter and summer [2]. In terms of human health, tomato is a major component in the daily diet in many countries, and constitutes an important source of minerals, vitamins, and antioxidants [3].

Container gardening is the practice of growing plants in containers instead of planting them in the ground. This gardening may also be known as pot cultivation. This type of cultivation reduces the risk of soil-borne diseases, virtually eliminates weed problems, and gives gardeners more control over moisture, temperature, and sunlight. The method of cultivating food on the rooftop is referred to as rooftop farming. Rooftop cultivation can also provide more opportunities for growing fresh produce for populations that have little ground area for crops, which can help reduce food shortages in poor, urban areas.

For high yield and good fruit quality, three plant nutrients such as Ca, Mg, and K must be in sufficient supply due to their functions in plant metabolism [4]. Blossom-end rot (BER) is a physiological disorder in tomato fruit that may reduce the marketable yield [5]. A high rate of BER occurrence has often been associated with low calcium (Ca) content in the fruit tissue [6]. Increasing fruit Ca uptake has been shown to effectively reduce the incidence of BER in tomatoes [7] [8] [9]. Yield of tomato is related with mulching. In winter or dry season mulching conserve soil moisture and modify the soil physical environment which causes nutrient availability for the plant and ultimately improve the yield of tomato. The experiment focuses to examine three varieties of tomato interacting with different calcium treatments and mulching to differentiate results on total number of fruits, defective fruits and weight of fruits per plant, and fresh yield per plant and per hectare. The objective of this study is to determine the best combination accomplishing suitable variety, treatment and mulching for better quality and yield of tomato and therefore recommend for Bangladesh.

2. Materials and Methods

The research work was designed for rooftop cultivation at Kazla, Motihar, Rajshahi city corporation Bangladesh during the period from October 2012 to March 2013 with an attempt to evaluate the effect of calcium and mulching on yield and yield contributing characters of tomato. Geographically the experimental field was located at 24˚21'41.85"N latitude and 88˚37'42.34"E longitude. The site was characterized by moderately high temperature and heavy rainfall during the kharif season and scanty rainfall with moderately low temperature during the Rabi season. The average temperature, humidity and rainfall were recorded as 22˚C, 75% and 7 mm respectively during the experiment. The experimental soil was collected from Godagari terrace area, Rajshahi Bangladesh

which was categorized as noncalcareous gray terrace soil. It was silty clay loam in texture (sand 10%, silt 60%, clay 30%) with pH 6.0 and calcium content was 20.08 ppm. The soil was well drained with moderately high permeability. Soils were collected from a depth of 0 to 15 cm for making samples and then analyzed for determining physical and chemical characteristics before setting the experiment. The soils were analyzed at the Soil resource development institute (SRDI), Regional station, Shyampur and BCSIR Rajshahi.

Three tomato varieties viz, BARI F_1Tomato-5, BARI F_1Tomato-6 and BARI F_1Tomato-7 were used as planting materials. Calcium carbonate ($CaCO_3$) was used for supplying Ca, and the doses were 40 ppm, 60 ppm, 80 ppm, 120 ppm and control. Same doses were applied three times interval during the experimental tenure. At the beginning of the experiment calcium doses were mixed with pot soil before the day of transplanting. Secondly, the doses were applied at 20 day after transplanting (DAT) and finally applied at 40 DAT. Urea, diammonium phosphate (DAP) and muriate of potash (MP) fertilizers were applied as basal dose. Rice straw was used as mulching material. The treatments were replicated for three times.

The experiment was laid out in a split-split plot design. Each block was divided into two main plots, one plot was cultivated with mulching and another was without mulching. Each main plot was further divided into three sub-plots and varieties were allocated to these plots. Then each sub plot was again divided into five sub-sub plots and calcium (Ca) treatments were assigned to these plots at random. However, the total number of unit plots in the entire experimental plot was $2 \times 3 \times 5 \times 3 = 90$. Each plot was treated as individual earthen pot in the experiment. The data were analyzed statistically using the analysis of variance technique and the mean differences among the treatments were adjudged by Duncan's Multiple Range Test (DMRT) with the help of MSTAT software.

3. Results and Discussion

3.1. Effect of Mulching

The effect of mulching method on the yield and yield contributing characters were presented in **Table 1**. Number of total fruits up to harvest, number of defective fruits, number of fresh fruits and fresh yield per plant and per hectare were significantly affected by mulching (M_1). Maximum number of total fruits (28.22), fresh fruits (26.38) per plant and fresh yield (1.22 kg/plant or 60.25 t/ha) were recorded when mulch was applied causing conservation of soil moisture and weed control. Similar findings were recorded by Elkner *et al.* [10] in tomato. Alternatively, poor performance was observed in no mulching (M_0) treatment. Fruit yield and yield contributing parameters of tomato also showed the similar trend (**Table 1**). No mulching created soil moisture stress which could lead to flower abortion, fruit drop and resultant low fruit count and low yield. This observation is consistent with the findings of Rowe-Dutton, Rudich *et al.*, and Pill and Lambeth [11] [12] [13] who reported decreased fruit count with increase in

soil dryness. Mulching had significant effect on single fruit weight, lateral length and pH of ripe fruit presented in the Table 1. The highest single fruit weight (46.51 g) was obtained in mulching (M_1) meanwhile the lowest (41.60 g) was in no mulching (M_0) technique. The similar result was reported by Kere *et al.* [14].

Defective fruits were correlated with mulching. Mulches can be used to protect plants against Ca-deficiency because they conserve soil moisture and therefore reduce Ca-deficiency symptoms (BER) and increase fresh fruits. In this study, defective number of fruit was decreased and number of fresh fruit was increased with mulching which ultimately increased fresh or marketable yield. Similar results were found by Streck *et al.*, John *et al.*, Elmer and Ferrandino, and Magnusson [15] [16] [17] [18].

3.2. Effect of Variety

Varietal performance showed significant effect on yield components. The number of fruits, defective fruits, fresh fruits per plant and fresh yield of tomato per plant and per hectare were presented in the Table 1. This table showed that BARI F_1Tomato-5 variety (V_1) gave the highest number of fresh fruits per plant and fresh yield than the other varieties. This might be occurred due to their genetic composition. The variation in yield may also be due to genetic differences among the varieties since they were grown under the same environmental condition.

The result was supported by Olaniyi and Fagbayide [19]. Varietal influence on yield of fruits per plant was reported by Sing and Sahu [20]. Rahman *et al.* [21]

Table 1. Effect of mulching on yield and yield contributing parameters of tomato.

Treatments	Total number of fruits/plant	Number of defective fruits/plant	Number of fresh fruits/plant	Average single fruit weight (g)	Total yield (kg)/plant	Weight of defective fruits (kg)/plant	Fresh yield (kg)/plant	Fresh yield t/ha
M_1	28.22	1.84	26.38	46.51	1.30	0.09	1.22	60.25
M_0	18.44	6.28	12.18	41.60	0.76	0.26	0.50	24.69
LS	**	**	**	**	**	**	**	**
V_1	29.47a	5.23a	24.23a	40.37c	1.20a	0.20a	1.00a	49.38a
V_2	22.00b	4.07b	17.93b	49.43a	1.10b	0.20a	0.91b	44.94b
V_3	18.53c	2.87c	15.67c	42.37b	0.80c	0.12b	0.68 c	33.58c
LS	**	**	**	**	**	**	**	**
T_0	21.33c	7.38a	13.94c	44.00	0.94c	0.33a	0.62c	30.62c
T_1	23.67b	3.94b	29.72b	44.67	1.06b	0.17b	0.89b	43.95b
T_2	22.89bc	2.72c	20.17b	44.50	1.02bc	0.12c	0.90b	44.44a
T_3	26.56a	3.39bc	23.17a	44.00	1.17a	0.14bc	1.04a	51.35b
T_4	22.22bc	2.83c	19.39b	43.11	0.96c	0.11c	0.85b	41.98c
LS	**	**	**	**NS**	**	**	**	**

In a column, figures bearing similar letter (s) or without letter are identical and those having dissimilar letters differed significantly as per DMRT. LS = Level of significance, NS = Non-significant, ** = Significant at 1% level, * = Significant at 5% level. M_1 = Mulching, M_0 = Without mulching, T_0 = Control treatment, T_1 = 40 ppm Ca, T_2 = 60 ppm Ca, T_3 = 80 ppm Ca, T_4 = 120 ppm Ca, V_1 = BARI F_1Tomato-5, V_2 = BARI F_1Tomato-6, V_3 = BARI F_1Tomato-7.

also reported that different tomato cultivars behaved significantly different with each other regarding yield per plant.

The maximum defective fruits were observed in BARI F_1Tomato-5 (V_1) compare to other varieties (Table 1) in the same environmental condition. The defectiveness occurred due to blossom end rot (BER), fruit cracking etc. The varietal differences for defectiveness of tomato fruits occurred due to susceptibility to BER and fruit cracking. The obtained results are in partially supported by Adams and Ho [22]. Inspite it, BARI F_1Tomato-5 (V_1) produced the highest number of fresh fruits, resultantly gave the highest total fruit yield. The weight of individual fruit and dry fruit were significantly different as influenced by different varieties. The highest individual fruit weight was found from BARI F_1Tomato-6 (V_2) variety than the other varieties (Table 1). The variation among the varieties in respect of individual fruit weight and dry fruit weight were due to the varietal and genetic characteristics. Varietal influence on individual fruit weight was also reported by Meher *et al.* [23].

3.3. Effect of Calcium

Yield parameters were significantly influenced by calcium treatment, presented in Table 1. The highest fresh yield was obtained with T_3 treatment (80 ppm) due to highest number of fresh fruits and lower incidence of blossom end rot (BER) in comparison to other treatments. Similar results were reported by Hao and Papadopoulos [24]. Calcium treatment with 80 ppm concentration showed the highest fresh fruit yield (1.04 kg/plant or 51.35 t/ha) due to available concentration of calcium into the soil solution. Highly available concentration of calcium has been known to increase the tolerance of plants to stress, and it is conceivable that this may have led to the higher yields in our study. The results obtained from the study are in agreement with those obtained by Fletcher *et al.* [25]. Piva *et al.* [26] reported that increased calcium level in the nutrient solution, increase the calcium level in the fruit. Control treatment (T_0) showed the highest defective

Table 2. Interaction effect of mulching and variety on yield and yield contributing parameters of tomato.

Interactions	Total number of fruits/plant	Number of defective fruits/plant	Number of fresh fruits/plant	Average single fruit weight (g)	Total yield (kg)/plant	Weight of defective fruits (kg)/plant	Fresh yield (kg)/plant	Fresh yield t/ha
M_1V_1	34.53	2.06d	32.47a	42.80	1.48	0.09c	1.38a	68.15a
M_1V_2	26.73	1.87d	24.87b	52.13	1.39	0.11c	1.30a	64.20a
M_1V_3	23.40	1.60d	21.80c	44.60	1.04	0.08c	0.97b	47.90c
M_0V_1	24.40	8.4a	16.00d	37.93	0.92	0.32a	0.60c	29.63b
M_0V_2	17.28	6.27b	11.00e	46.73	0.81	0.29a	0.52c	25.68c
M_0V_3	13.67	4.13c	9.53e	40.13	0.55	0.17b	0.38d	18.77d
LS	**NS**	**	**	**NS**	**NS**	**	**	**

In a column, figures bearing similar letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT. LS = Level of significance, NS = Non-significant, ** = Significant at 1% level, * = Significant at 5% level. M_1 = Mulching, M_0 = Without mulching, V_1= BARI F_1Tomato-5, V_2 = BARI F_1Tomato-6, V_3 = BARI F_1Tomato-7.

fruits for insufficient calcium supply to the plant and produced the lowest fresh yield (0.62 kg/plant or 30.62 t/ha) (**Table 1**). Similar result was obtained by Bangerth [27].

3.4. Interaction Effect

3.4.1. Mulching and Variety (M × V)

Interaction between mulching and variety had significant effect in respect of yield parameters presented in **Table 2**. The highest number of total fresh fruit and fresh yield per plant and per hectare were observed having the interaction effect of $M_1 \times V_1$ due to mulching which conserve soil moisture and reduce moisture stress. Similar observation was found by Sharma *et al.*, [28].

The combination effect between mulching and variety exhibited significant variation in some yield components and yield of tomato observed by Kayum *et al.,* [29]. Number of defective fruits and weight of defective fruits per plant were lower in $M_1 \times V_1$ interaction. In contrast, the highest number of defective fruits and defective fruit weight were observed in the interaction of $M_0 \times V_1$ due to absence of mulching which caused moisture stress. However, BARI F_1Tomato-5 (V_1) variety was found to be as a mulching sensitive variety.

3.4.2. Mulching and Calcium (M × T)

Calcium absorption problems can be prevented by mulching the soil around the tomato plants when it is damp, using straw, plastic or newspapers to keep the soil moisture level consistent. Tomato plants need available soil moisture during the period when they are most vulnerable to calcium deficiency, which is from the time they begin to set fruits until the time those fruits are at least one-half their mature size [30].

Significant effect was found in yield and yield contributing parameter of tomato with the interaction of mulching and calcium (**Table 3**). The highest number of fresh fruit and fresh yield were observed in the interaction of $M_1 \times T_3$ due to moisture availability and optimum calcium concentration. Similar results were observed by Saeed and Ahmed in applying organic mulches with gypsum (for supplying Ca) to soil increased the growth and yield of tomato [31]. Uniform soil moisture must be maintained during the growth of tomato plant for easily up taking of calcium, soil should be kept moist, but not wet [32]. The highest number of defective fruits and defective fruit weight were found in the interaction of $M_0 \times T_0$ due to no mulching and no calcium application. Similar observation was found by Jhon *et al.* [16].

3.4.3. Variety and Calcium (V × T)

Yield contributing parameters of tomato were found significantly affected with the interaction of variety and calcium (**Table 4**). The maximum total number of fruits and fresh fruits per plant were greater with the interaction of $V_1 \times T_3$. The highest single fruit weight and fresh yield per plant and per hectare were observed in the interaction of $V_2 \times T_3$. However, calcium treatment at the dose of

Table 3. Interaction effect of mulching and calcium on yield and yield contributing parameters of tomato.

Interactions	Total number of fruits/plant	Number of defective fruits/plant	Number of fresh fruits/plant	Average single fruit weight (g)	Total yield (kg)/plant	Weight of defective fruits (kg)/plant	Fresh yield (kg)/plant	Fresh yield t/ha
M_1T_0	26.11	6.56b	19.56c	45.78	1.20	0.32ab	0.89c	43.95c
M_1T_1	28.44	2.22d	26.22b	47.33	1.33	0.11e	1.23b	60.74b
M_1T_2	27.78	0.44e	27.33b	47.11	1.29	0.02f	1.27b	62.72a
M_1T_3	31.67	0.00e	31.67a	46.56	1.46	0.00f	1.46a	72.10b
M_1T_4	27.11	0.00e	27.11b	45.78	1.23	0.00f	1.23b	60.74b
M_0T_0	16.56	8.22a	8.33f	42.22	0.69	0.35a	0.35f	17.28f
M_0T_1	18.89	5.67bc	13.22de	42.00	0.78	0.23cd	0.55de	27.16de
M_0T_2	18.00	5.00c	13.00de	41.89	0.74	0.21d	0.53de	26.17d
M_0T_3	21.44	6.78b	14.67d	41.44	0.88	0.28bc	0.61d	30.12b
M_0T_4	17.33	5.67bc	11.67e	40.44	0.69	0.23cd	0.47ef	23.21f
LS	**NS**	**	**	**NS**	**NS**	**	**	**

In a column, figures bearing similar letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT. LS = Level of significance, NS=Non-significant, ** = Significant at 1% level, * = Significant at 5% level. M_1 = Mulching, M_0 = Without mulching, T_0 = Control treatment, T_1 = 40 ppm Ca, T_2 = 60 ppm Ca, T_3 = 80 ppm Ca, T_4 = 120 ppm Ca.

Table 4. Interaction effect of variety and calcium on yield and yield contributing parameters of tomato.

Interactions	Total number of fruits/plant	Number of defective fruits/plant	Number of fresh fruits/plant	Average single fruit weight (g)	Total yield (kg)/plant	Weight of defective fruits (kg)/plant	Fresh yield (kg)/plant	Fresh yield t/ha
V_1T_0	25.67	9.17	16.50de	41.33	1.07	0.38	0.69f	34.07f
V_1T_1	30.67	4.50	26.17ab	40.33	1.25	0.17	1.07ab	52.84ab
V_1T_2	29.50	3.17	26.33ab	40.67	1.22	0.12	1.09ab	53.83ac
V_1T_3	32.50	5.00	27.50a	40.00	1.30	0.18	1.12a	55.31a
V_1T_4	29.00	4.33	24.67bc	39.50	1.16	0.16	1.00bc	49.38bc
V_2T_0	20.50	7.33	13.17fg	49.83	1.03	0.38	0.67f	33.09f
V_2T_1	22.00	4.17	17.83de	49.00	1.09	0.21	0.89cd	43.95bc
V_2T_2	20.67	3.17	17.50de	49.00	1.02	0.15	0.87d	42.96d
V_2T_3	26.00	3.17	22.83c	50.67	1.33	0.15	1.18a	58.27a
V_2T_4	20.83	2.50	18.33d	48.67	1.03	0.12	0.91cd	44.94cd
V_3T_0	17.83	5.67	12.17g	40.83	0.73	0.25	0.50g	24.69g
V_3T_1	18.33	3.17	15.17ef	44.67	0.83	0.14	0.69f	34.07c
V_3T_2	18.50	1.83	16.67de	43.83	0.82	0.08	0.74ef	36.54ef
V_3T_3	21.17	2.00	19.17d	41.33	0.89	0.08	0.81de	40.00de
V_3T_4	16.83	1.67	15.17ef	41.17	0.71	0.07	0.64f	31.60f
LS	**NS**	**NS**	**	**NS**	**NS**	**NS**	**	**

In a column, figures bearing similar letter(s) or without letters are identical and those having dissimilar letters differed significantly as per DMRT. LS = Level of significance, NS = Non-significant, ** = Significant at 1% level, * = Significant at 5% level; V_1 = BARI F_1Tomato-5, V_2 = BARI F_1Tomato-6, V_3 = BARI F_1Tomato-7, T_0 = Control treatment, T_1 = 40 ppm Ca, T_2 = 60 ppm Ca, T_3 = 80 ppm Ca, T_4 = 120 ppm Ca.

80 ppm (T_3) along with the V_2 variety gave the highest fresh yield than the other treatments due to decreasing of fruit defectiveness (**Table 4**). Bangerth [27] reported the same findings.

4. Conclusion

With few exceptions, it can be concluded that the highest fruit yield with lower defective fruits were observed in BARI F_1Tomato-5 in receiving 80 ppm calcium treatment with mulching practices whereas, this variety showed the lowest performance in control treatment without mulching. However, the interaction treatment of 80 ppm calcium with mulching practices would be the best combination for growth and yield of BARI F_1Tomato-5 variety for the farmers in Bangladesh.

5. Limitation of the Study

Indigenous varieties of tomato were not studied and compared to those of newer varieties used in this research. Different times of harvesting were not cited before the final harvest. The time of maturity would be different from each variety which may affect the yield and quality of tomato.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] FAO (Food and Agricultural Organization) (2007) FAO Stat, Core Production 2005. http://faostat.fao.org/site/340/default.aspx65

[2] BBS (2008) Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, 17.

[3] Grierson, D. and Kader, D.D. (1986) Fruit Ripening and Quality. In: Atherton, J.G. and Rudich, J., Eds., *The Tomato Crop*, *The Tomato Crop* (*A Scientific Basis for Improvement*), Springer, Dordrecht, 1389-1393.

[4] Jayaram, D., Allen, V.B. and Shyam, S.M. (2008) Potassium Fractions with Other Nutrients in Crops: A Review Focusing on the Tropics. *Journal of Plant Nutrition*, **17**, 1859-1886. https://doi.org/10.1080/01904169409364852

[5] Taylor, M.D., Locascio, S.J. and Alligood, M.R. (2004) Blossom End Rot Incidence of Tomato as Affected by Irrigation Quantity, Calcium Source, and Reduced Potassium. *HortScience*, **39**, 1110-1115. https://doi.org/10.21273/HORTSCI.39.5.1110

[6] HO, L.C. and White, P.J. (2005) A Cellular Hypothesis for the Induction of Blossom-End Rot in Tomato Fruit. *Annals of Botany*, **95**, 571-581. https://doi.org/10.1093/aob/mci065

[7] Wada, T., Ikeda, H., Ikeda, M. and Furukawa, H. (1996) Effects of Foliar Application of Calcium Solutions on the Incidence of Blossom-End Rot of Tomato Fruit. *Journal of the Japanese Society for Horticultural Science*, **65**, 553-558.

[8] HO, L.C. (1999) The Physiological Basis for Improving Tomato Fruit Quality. *Acta*

Horticulture, **487**, 33-40. https://doi.org/10.17660/ActaHortic.1999.487.1

[9] Schmitz-Eiberger, M., Haefs, R. and Noga, G. (2002) Calcium Deficiency Influence on the Antioxidative Defense System in Tomato Plants. *Journal of Plant Physiology*, **159**, 733-742. https://doi.org/10.1078/0176-1617-0621

[10] Elkner, K., Kaniszewski, S., Gerasopoulos, D. and Passam, H. (1991) Effect of Drip Irrigation and Mulching on Quality of Tomato Fruits. *Acta Horticulturae*, **379**, 175-180.

[11] Rowe-Dutton, P. (1957) The Mulching of Vegetables. Technical Communication No. 24 Commonwealth Bureau of Horticultural and Plantation Crops. East Malling, Maidstone Kent, 183.

[12] Rudich, J., Kalmar, D., Geizenberg, C. and Harel, S. (1977) Low Water Tension in Defined Growth Stages of Processing Tomato Plant and Their Effect on Yield and Quality. *Journal of Horticultural Science*, **52**, 391-399. https://doi.org/10.1080/00221589.1977.11514768

[13] Pill, W.G. and Lambeth, V.N. (1980) Effect of Soil Water Regime and Nitrogen form on Blossom-End Rot. Yield Relations and Elemental Composition of Tomato. *Journal of the American Society for Horticultural Science*, **105**, 730-735.

[14] Kere, G.M., Nyanjage, M.O., Liu, M. and Nyalala, S.P.O. (2003) Influence of Drip Irrigation Schedule and Mulching Materials on Yield and Quality of Greenhouse Tomato (*Lycopersicon esculentum* Mill. 'Money Maker'). *Asian Journal of Plant Sciences*, **2**, 1052-1058. https://doi.org/10.3923/ajps.2003.1052.1058

[15] Streck, N.A., Schneider F.M., Buriol, G.A. and Heldwein, A.B. (1995) Effect of Polythene Mulches on Soil Temperature and Tomato Yield in a Plastic Green House. *Scientia Agricola*, **52**, 587-593. https://doi.org/10.1590/S0103-90161995000300028

[16] John, R.G., Mulungu, L.S., Ishengoma, C.G., Reuben, S.O.W.M., Msolla, S.N., Maerere, A.P., Njau, P.J.R., Ashomogo, G.C., Tiisekwa, T., Mvena, T. and Laswai, H.S. (2005) Effect of Organic Mulch Types on Common Biotic, Abiotic Factors and Components of Yield in Determinate and Indeterminate Tomato (*Lycopersicon esculentum* Mill.) Commercial Cultivars. *Asian Journal of Plant Sciences*, **4**, 580-588. https://doi.org/10.3923/ajps.2005.580.588

[17] Elmer, W.H. and Ferrandino, F.J. (1991) Early and Late Season Blossom End Rot of Tomato Following Mulching. *HortScience*, **26**, 1154-1155. https://doi.org/10.21273/HORTSCI.26.9.1154

[18] Magnusson, M. (2002) Mineral Fertilizers and Green Mulch in Chinese Cabbage [*Brassica pekinensis* (Lour.) Rupr.]: Effect on Nutrient Uptake, Yield and Internal Tipburn. *Acta Agriculturae Scandinavica*, *Section B*, *Soil and Plant Science*, **52**, 25-35. https://doi.org/10.1080/090647102320260017

[19] Olaniyi, J.O. and Fagbayide, J.A. (1999) Performance of Eight Fl Hybrid Cabbage (*Brassica olerácea* L.) Varieties in the Southern Guinea Savanna Zone of Nigeria. *Journal of Agricultural*, *Biological and Environmental Statistics*, **1**, 4-10.

[20] Singh, D.N. and Sahu, A.A. (1998) Performance of Tomato Cultivars in Winter Season on Entisol of Orissa. *Environmental and Ecological Statistics*, **16**, 766-762.

[21] Rahman, M.A., Rashid, M.A., Rahman, A.K.M. and Hossain, M.M. (2000) Screening of Wild Rootstocks Brinjal Lines and Tomato Varieties against Bacterial Wilt. Review of Progress. Activity-II. IPM-CRSP (Integrated Pest Management Collaborative Research Support Program), HRC, Bari, Gazipur, 17 p.

[22] Adams, P. and Ho, L.C. (1992) The Susceptibility of Modern Tomato Cultivars to

Blossom-End Rot in Relation to Salinity. *Agronomy Journal*, **57**, 189-192.

[23] Meher, B.B., Lawande, K.E. and Joshi, V.R. (1994) Effect of Different Varieties and Planting Seasons in Seed Yield and Yield and Quality of Tomato. *Journal of Maharashtra Agricultural Universities*, **19**, 393-395.

[24] Hao, X. and Papadopoulos, A.P. (2003) Effects of Calcium and Magnesium on Growth, Fruit Yield and Quality in a Fall Greenhouse Tomato Crop Grown on Rockwool. *Canadian Journal of Plant Science*, **83**, 903-912. https://doi.org/10.4141/P02-140

[25] Fletcher, R.A., Gilley, A., Sankhla, N. and Davis, T.D. (2000) Triazoles as Plant Growth Regulators and Stress Protectants. *Horticultural Reviews*, **24**, 55-138. https://doi.org/10.1002/9780470650776.ch3

[26] Paiva, E.A.S., Sampaio, R.A. and Martinez, H.E.P. (1998) Composition and Quality of Tomato Fruit Cultivated in Nutrient Solution Containing Different Calcium Concentrations. *Journal of Plant Nutrition*, **21**, 2653-2661. https://doi.org/10.1080/01904169809365595

[27] Bangerth, F. (1979) Calcium-Related Physiological Disorders of Plants. *Annual Review of Phytopathology*, **17**, 97-122. https://doi.org/10.1146/annurev.py.17.090179.000525

[28] Sharma, N.K., Singh, P.N. and Tyagi, P.C. (2001) Effect of Application of Leucaena Mulch on Soil Moisture Conservation and Productivity of Rainfed Wheat. *Indian Journal of Soil Conservation*, **29**, 143-147.

[29] Kayum, M.A., Asaduzzaman, M. and Haque, M.Z. (2008) Effects of Indigenous Mulches on Growth and Yield of Tomato. *Journal of Agriculture & Rural Development*, **6**, 1-6. https://doi.org/10.3329/jard.v6i1.1650

[30] Stallsmith, A. (2018) What Is the Amount of Calcium to Add to Tomato Plants? https://homeguides.sfgate.com/amount-calcium-add-tomato-plants-102281.html

[31] Saeed, R. and Ahmed, R. (2009) Vegetative Growth and Yield of Tomato as Affected by the Application of Organic Mulch and Gypsum under Saline Rhizosphere. *Pakistan Journal of Botany*, **41**, 3093-3105.

[32] Grarnham, P. (2017) Calcium for Tomato Plants. https://www.gardenguides.com/99257-calcium-tomato-plants.html