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Article

Mulching and drip irrigation to mitigate soil salinity on tomato (*Lycoperscon esculentum* L.) production in coastal area

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Abstract: Bangladesh's coastal regions are rich in saline water resources. The majority of these resources are still not being used to their full potential. In the southern Bangladeshi region of Patuakhali, research was conducted to investigate the effects of mulching and drip irrigation on tomato yield, quality, and blossom-end rot (BER) at different soil salinity thresholds. There were four distinct treatments applied: T_1= drip irrigation with polythene mulch, T_2 = drip irrigation with straw mulch, T_3 = drip irrigation without mulch, and T_4 = standard procedure. While soil salinity was much greater in treatment T_3 (1.19–8.42 dS/m) fallowed by T_4 (1.23–8.63 dS/m), T1 treatments had the lowest level of salinity and the highest moisture retention during every development stage of the crops, ranging from 1.28–4.29 dS/m. Treatment T_3 exhibited the highest soil salinity levels (ranging from 1.19 to 8.42 dS/m), followed by T_4 with a range of 1.23 to 8.63 dS/m. In contrast, T_1 treatments consistently maintained the lowest salinity levels (ranging from 1.28 to 4.29 dS/m) and the highest moisture retention throughout all stages of crop development. In terms of yield, drip irrigation with no mulch treatment (T_3) provided the lowest output (13.37 t/ha), whereas polyethylene mulching treatment (T_1) produced the maximum yield (46.04 t/ha). According to the study, conserving moisture in tomato fields and reducing soil salinity may both be achieved with drip irrigation combined with polythene mulch. The research suggests that employing drip irrigation in conjunction with polythene mulch could effectively preserve moisture in tomato fields and concurrently decrease soil salinity.

Keywords: *Lycoperscon esculentum*; mulching; drip irrigation; salinity; coastal area

1. Introduction

Lycopersicon esculentum, commonly known as the tomato, holds substantial global importance as a key horticultural crop and an integral component in diverse cuisines, offering a nutrient-rich source of vitamins, minerals, and antioxidants [1].

The tomato, scientifically known as *Lycopersicon esculentum*, is a very significant horticultural crop worldwide. As a significant part of many meals, tomato fruit is a good source of vitamins, minerals, and antioxidants [1]. Tomatoes' aroma volatiles, sugar, and acid content are primarily responsible for their organoleptic quality, while their mineral, vitamin, carotenoid, and flavonoid content determine their nutritional quality [2]. Consequently, it is a vegetable crop of commercial significance. The most often consumed vegetable is the tomato, which has excellent nutritional value and is a strong source of potassium, vitamins A and C, and other nutrients. Few cultivars are somewhat salt resistant, and they are only moderately susceptible to salinity. According to Mass [3], EC 2.5 dS/m is the threshold value for saline rooting media. Tomato is cultivated as an important and popular vegetable as well as a salad crop with a wide range of varieties all over the country, but due to the unfavorable ecosystem, its production area is limited in the southern part of Bangladesh. In this area, traditionally, tomatoes are cultivated on homesteads rather than in crop fields, due to drought and salinity problems simultaneously.

Tomatoes are produced in Bangladesh from September to April, when there is little rainfall and evapotranspiration uses up the soil's moisture content (250 mm). The only thing that directly affects tomato production is water. Careful use of manures and fertilizers, effective use of available soil moisture, planting spacing, timing, weed control, and other factors are critical to successful tomato growing [4,5]. Utilizing soil moisture effectively is crucial among these aspects. In Bangladesh, producers must rely on irrigation or natural precipitation because of the sparse rainfall from September to April. Many farmers also lack the financial means to pay for irrigation. In this case, native mulching can be a suitable irrigation-saving option. Crop waste, straw, rice husk, and water hyacinth are examples of native mulches that are typically used in horticultural crop cultivation [6,7]. Different types of mulch play an important role in conserving soil moisture [4]. There is a large amount of arable land in Bangladesh's southern region that might be used for agriculture [8]. Adequate vegetables are necessary to overcome the significant obstacle presented by coastal locations damaged by salt. Given the significance of tomatoes as a food in Bangladesh, a great deal of study is required to create growing conditions with moderate salinity that would yield strong vegetative development. On the other hand, a limited number of research studies have examined the impact of salt stress on tomato fruit development, production, and quality. According to the Sign et al. [9] report, out of all vegetables, tomatoes are moderately sensitive to salinity. On the other hand, considerable genetic heterogeneity in tolerance to salt levels exists across tomato genotypes [10].

In the southern portion of Bangladesh, the Patuakhali and Barguna regions are unique physiological units [11]. It is distinguished by harsh environmental factors such as heavy clay soil, high soil salinity, and a lack of quality irrigable water during the dry season [12]. The winter period is comparatively shorter in this region than in other parts of the country; therefore, this area is referred to as challenging for agricultural production [13]. Nevertheless, these regions possess substantial arable land, presenting an opportunity to significantly enhance national agricultural output. However, there is a lot of arable land in these areas, which might help boost agricultural output nationally [14]. Among the cultivable areas of this region, roughly 86% of low to medium saline (4–8 dS/m) provides scope for good crop production [15]. Drip irrigation systems allow water and nutrients to be supplied directly to the crop's roots, boosting production and water savings while also improving irrigation efficacy [16]. Mulching also minimizes water loss from the soil surface and improves moisture distribution, hence changing the irrigation schedule [17,18]. The productivity and quality of tomato crops are significantly influenced by water [19]. Increased irrigation enhances tomato productivity despite lowering soluble sugar, organic acid, and dry matter [20]. Deficit irrigation often has the opposite effect on fruit yield as it does on fruit quality. It has been established that deficit irrigation increases tomato titratable acidity, vitamin C content, and total soluble solids [2].

Limited research has investigated the combined impact of varying soil moisture levels and saline water irrigation on the growth, quality, and yield of tomatoes. This stands in contrast to numerous studies that have individually explored the agronomic performance of tomatoes. Few research has examined how different soil moisture levels and salty water irrigation affect tomato growth, quality, and yield in combination, despite the fact that several studies have examined the agronomic performance of tomatoes separately. Furthermore, more research is required to evaluate whether tomato production in the southern region of Bangladesh is threatened by salty water irrigation. The growth responses of tomatoes to saline water and irrigation were examined and studied in the field experiment described here. Regarding crop performance, our hypothesis was that every environmental condition would have an equal impact on tomato growth and development. As a consequence, this experiment was carried out with the following goals in mind: to observe the performance of tomato yield under different salinity levels; to investigate the different salinity levels for tomato growth and yield; and to investigate the influence of drip irrigation schedule, mulching materials, and their interactions on soil salinity mitigation and tomato yield and quality in a coastal environment.

2. Materials and methods

The experiment was conducted at MLT site Kuakata, Patuakhali in the Rabi season of 2015–2016. The trial was laid out in RCBD with 3 compact replications consisting with 4 treatments i.e., T_1: drip irrigation with polythene mulch, T_2: drip irrigation with straw mulch T_3: drip irrigation without mulch T_4: conventional practice. The tomato (BARI Tomato-14) seedlings of 30 days old were transplanted in unit plots of 5 m × 1.2 m on 23 December 2015. For mulching, 10 µm black polyethylene sheet having holes of 50 mm diameter at a distance of 60 cm × 40 cm was spread over the beds and tomato seedlings were transplanted in the holes (**Figure 1**). For straw mulch, paddy straw at 10 t/ha was used after transplanting. Recommended fertilizer doses (N_{100}, P_{100}, K_{80} kg/ha) for fertigation were used for all treatments except conventional one. For irrigation application, plastic water tank with drip system having a capacity of 150 L was installed at a height of 1 m above the ground surface to irrigate 9 plots by gravitational flow. One plant was provided with a dripper of 0.5 L/h discharge capacity. Ripened tomato was harvested 6–8 times starting from the first week to the last week of March 2016. Soil samples were collected at 15 days interval to measure salinity and moisture content of each plot. The climatic information is displayed in **Figure 2**. Data on growth yield and yield contributing characters were collected at different stages of plant growth (**Figure 3**). Collected data were analyzed using Microsoft Excell and R software.

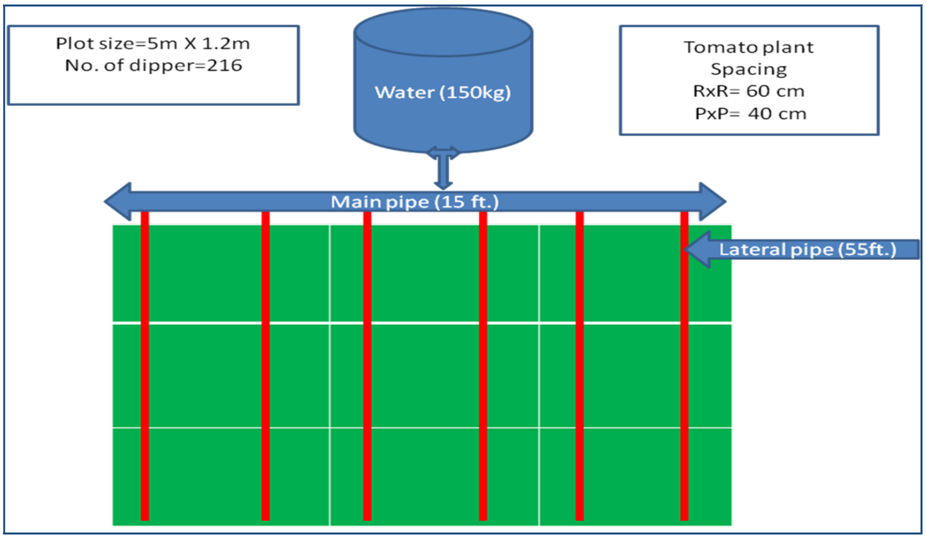


Figure 1. A typical layout of drip irrigation system.

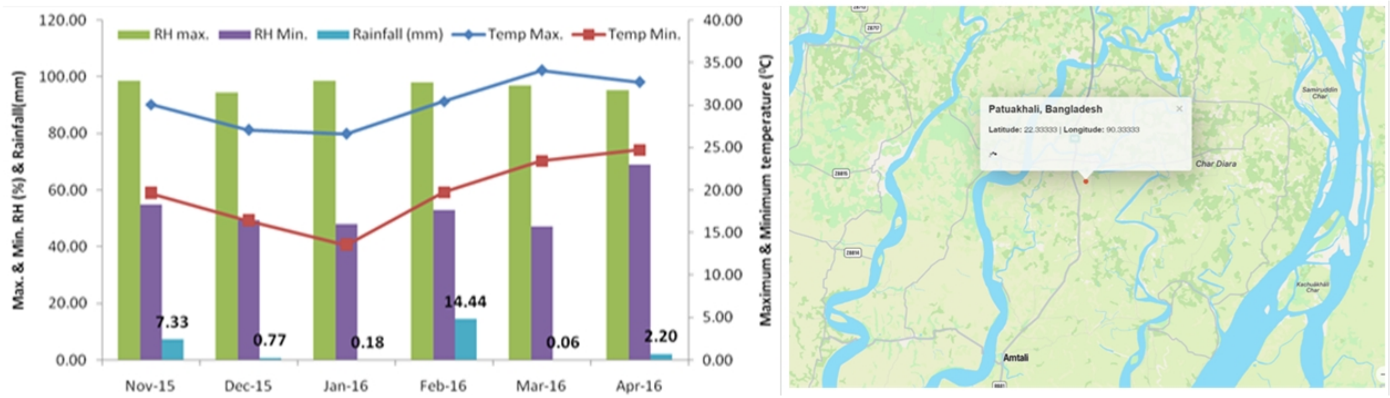


Figure 2. Meterological data and GPS location of experimental site (source: meteorological station, Kalapara, Patuakhali).

Figure 3. (*Continued*).

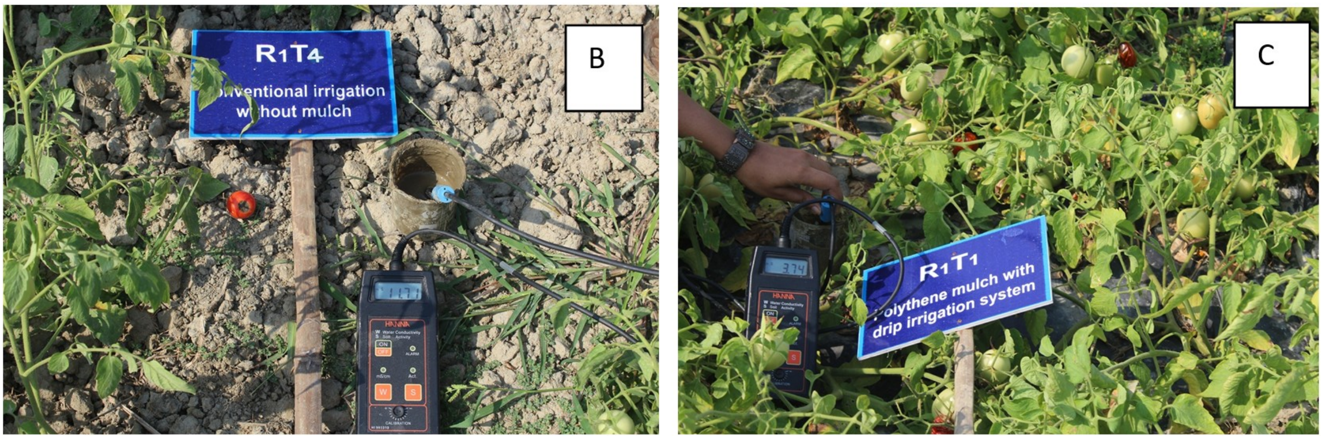


Figure 3. Setting experiment and recording data **(A)** Bed preparation with polythene mulch, **(B)** Irrigation without mulch, **(C)** Polythene mulch with drip irrigation.

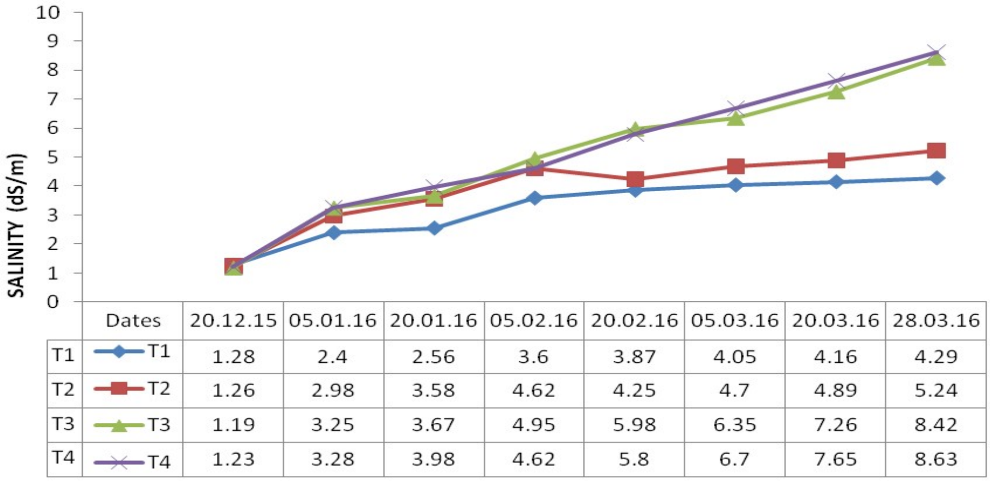
3. Results and discussion

Irrigated agriculture will remain the primary source of the world's food supply. Only 16 percent of the world's agricultural land is made up of irrigated farmlands, however they produce 30% to 40% of the food that is consumed globally [21]. A very effective use of water resources is necessary for irrigated agriculture to remain viable. There are yet to be any widely recognized design standards for managing salt water in humid environments [22]. Research has indicated that using too much salty water for irrigation might cause a large build-up of salts in the layer that has been ploughed, which would negatively impact the growing conditions for crops [23]. In order to address the issue of a sustainable irrigated agriculture that conserves water resources and has a minimal influence on crop growth and development, it is imperative to create novel management techniques for the exploitation of saline water [24]. It has been demonstrated that, in comparison to crops that are irrigated directly with saline water, the present practice of alternating irrigation between saline and non-saline water reduces the harm caused by salt to crops.

Salt in irrigation water, particularly NaCl, often has detrimental effects for crops. These effects include turgor pressure reduction, slowed cell development, and damage to chloroplasts, which lowers photosynthesis and growth rate [22]. In the end, these modifications affect crop production and dry matter buildup. It has been noted that oxidative stress in salinity stress is caused by unchecked production of reactive oxygen species and damage to the antioxidative system [25]. According to research by Alarcon et al. [26], tomato plants might exhibit a drop-in relative growth rate and leaf area ratio within 17 days of exposure to rising osmotic pressure in the nutrient solution. Research by Karin [27] showed that a small amount of salt stress promotes crop development, increases adenosine triphosphatase enzymatic activity, and improves osmotic adjustment.

3.1. Soil salinity

The results of salinity development revealed that irrigation system and mulching created variations in the soil salinity in the treatments (**Figure 4**). Through drip irrigation same amount of water was applied more precisely and uniformly but salinity development was differed among the drip irrigated treatments due use of different kinds of mulch materials. The soil salinity was developed considerably at a lower rate in drip irrigation system that was more influenced by polythene mulch (1.28–4.29 dS/m) fallowed by straw mulch (1.26–5.24 dS/m) compared to non-mulch (1.19–8.42 dS/m). In conventional (flood) irrigation system salinity development (1.23–8.63 dS/m) was similar as drip irrigation without mulch. The results are in agreement with the findings of Tan et al. [28]. They noticed that mulched drip irrigation significantly decreases the soil salinity, the contents of individual salt ions, the pH value, the ratio of Cl^- to SO_4^{2-} and the sodium adsorption ratio (SAR) at a 20-cm depth of soil by controlling the soil matric potential. Hanson et al. [29] also noted that mulched drip irrigation has been widely used to alleviate the deleterious effects of salinity on tomato because it effectively suppresses the upward movement of salt to the plough layer.



	Dates	20.12.15	05.01.16	20.01.16	05.02.16	20.02.16	05.03.16	20.03.16	28.03.16
T1	◆ T1	1.28	2.4	2.56	3.6	3.87	4.05	4.16	4.29
T2	■ T2	1.26	2.98	3.58	4.62	4.25	4.7	4.89	5.24
T3	▲ T3	1.19	3.25	3.67	4.95	5.98	6.35	7.26	8.42
T4	× T4	1.23	3.28	3.98	4.62	5.8	6.7	7.65	8.63

Figure 4. Soil salinity development in different treatments in tomato growing period.

3.2. Tomato yield

The growth, yield and yield attributes and water used by the tomato plants of each treatment are presented in **Table 1** and **Figure 5**. In drip irrigation system each plant of treatment T_1, T_2 and T_3 received 21 liters of water and in conventional irrigation system it was 32 liters (T_4) during their growing period and a significant difference was found in plant height among treatments. It was due to mulch effect because mulch kept the root zone moist preventing evaporation throughout the growing season. In T_1 black polythene mulch prevented evaporation more than straw mulch in T_2. Consequently, taller, and healthy plants were produced by the mulch treated plots than mulch less drip or conventional irrigated plots. The highest plant height (96.0 cm) was found in T_1 fallowed by T_2 (92.33 cm) and T_3 (87.67 cm). Same effects were found in yield and yield contributing parameters. Drip irrigation with polythene much influenced more in yield and yield contributing parameters than other treatments, so fruit yield was also the highest (46.04 t/ha) followed by drip irrigation with straw mulch (26.67 t/ha). The lowest yield (13.37 t/ha) was found from drip irrigation with no mulch treatment. The results are in agreements with the finding of Raina et al. [30]. He explained in his article that mulched drip irrigation has various effects on the nutrient components of tomatoes, and it plays a more significant role in increasing fruit yield than flood irrigation.

Table 1. Yield and its related attributes of tomato.

Treatments	plant height (cm)	Fruits/plant	Individual fruit wt (gm)	Yield (t/ha)	Water used (l/plant)
T_1	96.00	21.33	54.0	46.04	21
T_2	92.33	16.00	41.0	26.67	21
T_3	87.67	9.33	35.0	13.37	21
T_4	85.33	10.33	42.0	17.67	32
CV	2.53	14.18	7.97	13.88	5.43
LSD	4.57	4.04	6.91	7.18	7.72

Note: T_1: drip irrigation with polythene mulch, T_2: drip irrigation with straw mulch T_3: drip irrigation without mulch T_4: conventional practice.

Figure 5. Different mulch and irrigation system: **(A)** Polythene mulch with drip irrigation; **(B)** Straw mulch with drip irrigation; **(C)** Drip irrigation without mulch; **(D)** Conventional practices.

3.3. Disease incidence

Blossom End Rot (BER) (**Figure 6**) was observed in all the treatments, but its incidence was severe in non-mulched and conventional treatments (**Table 2**). Blossom end rot is a physiological condition that results in a water-soaked spot which appears at the blossom end of tomato fruits caused by a calcium imbalance within the plant. Fluctuations in soil moisture (too wet or too dry) and salinity induced blossom end rot in the treatments. As the plots of drip with polythene mulched treatment (T_1) were moist throughout the growing season so BER incidence was the lowest. BER was found the highest in drip without mulch plots. A similar claim was made in the context of tomato growing by Biswas et al. [31].

Figure 6. Blossom end rot symptom of tomato fruits.

Table 2. Disease incidence in different treatments.

Diseases	**Disease incidence in different treatments (%)**			
	T_1	**T_2**	**T_3**	**T_4**
Blossom end rot	5	8	17	15

Note: T_1: drip irrigation with polythene mulch, T_2: drip irrigation with straw mulch T_3: drip irrigation without mulch T_4: conventional practice.

3.4. Cost and return

Among the drip irrigated treatments, the highest gross margin (Tk. 236000/ha) equivalent to 2149.30 US$/ha was obtained from polythene mulched plots though variable costs were the highest (**Table 3**). It was due to the highest yield production by the treatment of drip irrigation with polythene mulch. The gross margin was less and even negative in drip irrigation without mulch than conventional irrigation system. The farmers were delighted seeing taller and healthy plants in the plots of drip irrigation with polythene mulch treatment. They showed their interest to grow tomato using drip irrigation with polythene mulch as it is more profitable. They also opined that initial cost of this technology is higher, but system of irrigation is easy and less time consuming. The benefit cost ratio (BCR) was recorded the highest (1.75) for the treatment drip irrigation with polythene mulch. It may be suggested that 75% could be earned additionally by cultivating tomato through drip irrigation with polythene mulch. A similar statement was reported by Biswas et al. [31] in Tomato cultivation.

Table 3. Cost and return analysis of tomato as affected by different mulching and drip irrigation.

Treatments	**Gross return (Tk/ha)**	**Total variable cost (Tk/ha)**	**Gross margin (Tk/ha)**	**BCR**
T_1	552000 (5027.24US$)	316000 (2878.77 US$)	236000 (2149.30 US$)	1.75
T_2	320040 (2915.45 US$)	285000 (2596.02 US$)	35040 (319.11 US$)	1.12
T_3	160440 (1461.55 US$)	255000 (2322.75 US$)	−94560 (861.16 US$)	0.63
T_4	212040 (1931.69 US$)	164000 (1493.69 US$)	48040 (437.49 US$)	1.29

Note: Dripper at 5 tk/piece, pipe at 2tk/ft, tomato at 12 Tk/kg in local market.

4. Conclusion

The use of mulch with drip irrigation is a good option not only for water savings but also for improved yield. The maximum yields of 46.04 t/ha and 26.67 t/ha were obtained under drip irrigation with polythene mulch with water supply and drip irrigation with straw mulch, respectively. The use of mulch with drip irrigation is a good option not only for water saving and mitigating salinity but also for improving tomato yield in coastal saline soils. Compared to the non-mulched control treatment, this technique saved irrigation water and boosted fruit production by 20%–25%. Similarly, drip irrigation systems with mulching economize 40%–45% of irrigation water and reduce salinity levels. Although polythene mulch produced more and used less water, straw mulch provided a greater economic return. Polyethylene mulch may thus be a choice in instances where land and water production are prioritized. However, this finding will be helpful for growers, extension personnel, and researchers growing tomatoes in a similar type of saline environment.

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Conflict of interest: The authors declare no conflicts of interest.

References

1. Dorais M. Effect of cultural management on tomato fruit health qualities. Acta Horticulturae. 2007; 744: 279-294. doi: 10.17660/actahortic.2007.744.29
2. Zheng J, Huang G, Jia D, et al. Responses of drip irrigated tomato (*Solanum lycopersicum* L.) yield, quality and water productivity to various soil matric potential thresholds in an arid region of Northwest China. Agricultural Water Management. 2013; 129: 181-193. doi: 10.1016/j.agwat.2013.08.001
3. Maas EV. Salt Tolerance of Plants. CRC Handbook of Plant Science in Agriculture Volume II. Published online July 18, 2019: 57-76. doi: 10.1201/9780429286735-2
4. Suh JK, Kim YB. Study on improvement of mulching culture method in onion (*Allium cepa* L.), 1; Influence of mulch materials and times on growth and yield. Research Reports of Office of Rural Development (Horticulture). 1991; 33(2): 31-36.
5. Md. MI, Md. Mahmudul HK, Md. Shahidul IK, et al. Fertilizer doses and mulching effect to mitigate soil salinity and maximize yield of watermelon (*Citrullus lanatus* L.) in coastal region of Bangladesh. International Journal of Agricultural Science and Food Technology. 2023, 9(4): 093-097. doi: 10.17352/2455-815x.000198

6. Khan MMH, Talukder ZH, Uddin MN, et al. Tracking of Diversity among a Wide Local Collection of Bitter Gourd (*Momordica charantia* L.) Landraces in Bangladesh. International Journal of Environmental & Agriculture Research. 2018; 4(8): 29-41. doi: 10.5281/zenodo.1407417
7. Khan M, Bhuiyan S, Saha K, et al. Variability, correlation and path co-efficient analysis of bitter gourd (*Momordica charantia* L.). Bangladesh Journal of Agricultural Research. 2016, 40(4): 607-618. doi: 10.3329/bjar.v40i4.26936
8. Hasan GN, Khan MH, Anik RH, et al. Inter-Cropping of Soybean within Maize for Increasing the Crop Productivity and Cropping Intensity in the Coastal Region of Bangladesh. International Journal of Botany and Horticulture Research. 2023, 1(1). doi: 10.33140/ijbhr.01.01.04
9. Singh VK, Singh AK, Kumar A. Disease management of tomato through PGPB: current trends and future perspective. 3 Biotech. 2017; 7(4). doi: 10.1007/s13205-017-0896-1
10. USDA. USDA National Nutrient Database for Standard Reference, Release 25, Errata for Caffeine value for NDB No. 14627, Energy Drink, Monster. Agricultural Research Service, Nutrient Data Laboratory; 2012.
11. Khan MH, Kundu BC, Uddin MS, et al. Yield potency assessment and characters association of promising lines of mustard (Brassica rapa L.) in southern region of Bangladesh. Advances in Modern Agriculture. 2023, 4(2). doi: 10.54517/ama.v4i2.2216
12. Khan MH, Kundu BC, Ali MM, et al. Insight into Genetic Variability and Association Studies of Some Yield Contributing Characters in Advance Lines of Winter Rapeseed (*Brassica Napus* L.). Journal of Biotechnology & Bioresearch. 2023. 5(2). doi: 10.31031/JBB.2023.05.000607
13. Md Mahmudul HK, Kundu BC, Suprio G, et al. Genetic variability, traits interactions, and principal component analysis of broad-leaf mustard group (*Brassica juncea* L.) to focus on the yield improvement. International Journal of Agricultural Science and Food Technology. 2023, 9(4): 104-110. doi: 10.17352/2455-815x.000200
14. Numan A, Khan M, Uddin R, et al. Risk assessment of commonly used major pesticides for tomato (*Solanum lycopersicum* L.) cultivation in Bangladesh. Advance in Nutrition and Food Science. 2018; 1(2).
15. Bangladesh Rice Research Institute (BRRI). Annual Research Report. Soil Science Division. 2012.
16. Phene CJ, Howell TA. Soil Sensor Control of High-Frequency Irrigation Systems. Transactions of the ASAE. 1984; 27(2): 392-396. doi: 10.13031/2013.32798
17. Brown JE, Ogburn CB, Early BC. Effect of latex spray mulch on the production of watermelon and muskmelon Proc. Nat. Agric. Plastics Congr. 1991; 23: 17-20.
18. Wien HC, Minotti PL. Response of Fresh-market Tomatoes to Nitrogen Fertilizer and Plastic Mulch in a Short Growing Season. Journal of the American Society for Horticultural Science. 1988; 113(1): 61-65. doi: 10.21273/jashs.113.1.61
19. Ariful MI, Al-Numan A, Khan MMH, et al. Purity analysis of carbofuran used in tomato (*Solanum lycopersicum* l.) In Bangladesh. Adv in Nutr Fd Sci.
20. Cui N, Du T, Kang S, et al. Regulated deficit irrigation improved fruit quality and water use efficiency of pear-jujube trees. Agricultural Water Management. 2008; 95(4): 489-497. doi: 10.1016/j.agwat.2007.11.007
21. Shao GC, Deng S, Liu N, et al. Effects of controlled irrigation and drainage on growth, grain yield and water use in paddy rice. European Journal of Agronomy. 2014; 53: 1-9. doi: 10.1016/j.eja.2013.10.005
22. Zhai Y, Yang Q, Hou M. The Effects of Saline Water Drip Irrigation on Tomato Yield, Quality, and Blossom-End Rot Incidence—A 3a Case Study in the South of China. PLOS ONE. 2015; 10(11): e0142204. doi: 10.1371/journal.pone.0142204
23. Li C, Lei J, Zhao Y, et al. Effect of saline water irrigation on soil development and plant growth in the Taklimakan Desert Highway shelterbelt. Soil and Tillage Research. 2015; 146: 99-107. doi: 10.1016/j.still.2014.03.013
24. Chen W, Hou Z, Wu L, et al. Evaluating salinity distribution in soil irrigated with saline water in arid regions of northwest China. Agricultural Water Management. 2010; 97(12): 2001-2008. doi: 10.1016/j.agwat.2010.03.008
25. Manai J, Gouia H, Corpas FJ. Redox and nitric oxide homeostasis are affected in tomato (Solanum lycopersicum) roots under salinity-induced oxidative stress. Journal of Plant Physiology. 2014; 171(12): 1028-1035. doi: 10.1016/j.jplph.2014.03.012
26. Alarcon JJ, Sanchez-Blanco MJ, Bolarin MC, et al. Growth and osmotic adjustment of two tomato cultivars during and after saline stress. Plant and Soil. 1994, 166(1): 75-82. doi: 10.1007/bf02185483

27. Karin HA. Effect of Arbuscular Mycorrhizal Fungi and *Fusarium oxysporum* f. sp. *lycopersici* on Tomato and/or its Exudation in Single and Intercropping Settings [Master’s thesis]. University of Natural Resources and Life Sciences Vienna; 2013.
28. Tan J, Kang Y, Jiao Y, Sun ZQ. Characteristics of soil salinity and salt ions distribution in salt-affected field under mulch-drip irrigation in different planting years. Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering. 2008; 24(6): 59-63.
29. Hanson BR, May DE, Simünek J, et al. Drip irrigation provides the salinity control needed for profitable irrigation of tomatoes in the San Joaquin Valley. California Agriculture. 2008; 63(3): 131-136. doi: 10.3733/ca.v063n03p131
30. Raina JN, Thakur BC, Verma ML. Effect of drip irrigation and polyethylene mulch on yield, quality and water-use efficiency of tomato (*Lycopersicon esculentum*). The Indian Journal of Agricultural Sciences. 2013; 69(6): 114-121.
31. Biswas SK, Akanda AR, Rahman MS, et al. Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. Plant, Soil and Environment. 2015; 61(3): 97-102. doi: 10.17221/804/2014-pse