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Effect of Water Quality and Deficit Irrigation on Tomatoes Yield and Quality in Ethiopia: A Review

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Abstract
Tomato is one of the vegetable crops of worldwide demand because of its various purposes including nutritional and medicinal values. It produced in Ethiopia largely for domestic consumption by small scale farmers and private producers. Tomato production and productivity affected by biotic and abiotic factors. Water quality and deficit irrigation has been considered as factor in its production, yield and quality as reported by many authors worldwide. Salinity, toxicity of heavy metals, and presence of organic matters are some concern of water quality. Irrigation management practices such as amount, time of application and frequency affected tomatoes yield and quality. Hence, based on reports of scientific findings, effects of these two factors reviewed in this paper for further information provision.
Keywords: water quality, irrigation deficit, tomato

Introduction

Tomato (*Lycopersicon esculentum Mill.*) is annual warm-season crop that belongs to Solanaceae family and originated in the South America. It is known with Tomato is one of the important vegetable crops cultivated in the world with high consumption rate and nutritionally important because of its high contents of antioxidants including carotenoids, lycobene, vitamin C and A and phenolic compounds, which offer a lot of health benefits for the consumers (Nahar and Gretzmacher, 2002). In addition Tshiala and Olwoch (2010) reported as tomato has been used worldwide as a fresh vegetable or as a spice in food preparation. It has high demand and plays great role in Ethiopian vegetable marketing. Tomato production has been used as opportunity for employment and used as source of income for producers.

In Ethiopia both fresh and processing tomatoes produced. According to Tefera and Tefera (2013) tomatoes in Ethiopia produced mainly in the northern and central rift valley areas and in recent years, commercial tomato production has significantly expanded because of national agricultural strategies began favoring high value cash crops and based on such opportunities fruit and vegetables are priority sector for the government of Ethiopia which aims to increase production by 47% between 2015 and 2020. Tomato is one of the major priority vegetable crops in the country.

Fresh market tomatoes fruit quality described by physical characteristics such as color, shape, size and defects and by firmness and flavor. In addition, quality attributes of processing tomatoes related with soluble solids, acidity, viscosity and color (Etissa *et al*., 2014). However, tomatoes yield and quality influenced by various production constraints such as variety characteristics, disease, insect and other pest problems, soil factors, climate variability and cultural practices (Van der Ploeg and Heuvelink, 2005; Tshiala and Olwoch, 2010).

Nutrient and water supply affects tomato quality greatly and its highest demand for water is during flowering (Gideon, 2012) unpublished paper quoted (Winter and Rushbrook, 2003). Water quality can be seen from some toxic elements and organic matters that are harmful to humans. This might be the issue when municipal wastewater used for irrigation purposes. Even though municipal waste water used as an alternative for irrigation it contains relatively high amounts of sodium, which can be accumulated in the soil during irrigation with this wastewater and display toxic effects on the plants (Zavadil, 2009).

Besides, Khan *et al.*(2011) reported that tomatoes leaves accumulated higher concentration (with exception of Cu) of heavy metals studied compared to fruit and the concentration of Cr, Fe, Mn, Pb and Zn in leaves was above the permissible limits when irrigated with waste water while waste water supplemented with fertilizers showed reduction in heavy metals uptake. This indicates that tomatoes can be cultivated with the help of phytostabilizing heavy metal agents DAP fertilizer.

Irrigation water plays great role in vegetable crops production as it affects growth, yield and quality of the crops. Water quality and irrigation management practices such as time of application and its application frequencies considered as components of major limiting factors of tomato crops production. According to Rahil *et al.* (2013) water quality has been affected and salinity increased by different means such as uncontrolled discharges of untreated or poorly treated wastewater and the excessive use of fertilizers in agriculture hence, when saline water is used, factors including plant tolerance, irrigation system, water management strategies, irrigation intervals and soil properties have to be considered.

Despite tomato produced in different parts of Ethiopia and the crop has high market demand locally, regionally, nationally and internationally little is known about the influence of water quality and deficit irrigation

on its yield and quality. Therefore, the target of this paper is to review various articles reported worldwide for further information provision concerning effect of water quality on tomato production and quality.

Effect of water quality on tomato yield

Water quality refers to the characteristics of a water supply from any source like large reservoirs, farm dams, rivers, ground water, municipal supplies and industrial effluents that will influence its suitability for a specific use mainly how well the quality meets the needs of the user and it can be defined by certain physical, chemical and biological characteristics (Holmes, 1996). The major concern of water quality for crop production linked with salinity issues and it influence production and yield quality such as tomatoes fruit quality. Besides, presence of heavy metals in water another important factor that cause health problem apart from nutritional value of the crop.

Zhai *et al*. (2015) emphasized as water is an important impact factor influencing yield and quality of tomato and indicated as yield decreased with increased salinity and recommended that salinity of irrigation water should be controlled under 4 dS/m. In addition, Rahil *et al.* (2013) and Maga´n *et al.,* (2008) reported that total and marketable fruit yield reduced with increasing salinity level. Furthermore, Wahb-Allah and Al-Omran (2012) reported that irrigation with saline water significantly reduced total dry biomass (31%) and total fruits yield (21%) of tomato compared to irrigation with non saline water and indicated as knowledge of irrigation water quality is critical in understanding the management changes that are necessary for long-term productivity. Studies on industrial waste effluents for tomatoes and okra resulted significant yield reduction because of high concentration effects of heavy metals such as Pb, Cd and Hg available in the wastes (Fatoba *et al*., 2012). Similarly Khan *et al*., (2011) reported as concentration of Cr, Fe, Mn Pb and Zn in leaves was above the permissible limits when irrigated with waste water.

Similarly according to Noshadi *et al*. (2013) tomato yield was increased and then with increasing salinity yield was decreased. Other finding on tomato yield under salinity indicated that unitary increase of water salinity above 1 dS m-1 reduced the commercial and total yield by 11.9 and 11.0%, respectively, and increased the concentration of soluble solids and the titratable acidity of the fruits by 13.9 and 9.4%, respectively and the increase of the proportion of sodium reduced the total and marketable yield, the number of marketable fruits and pulp yield hence, water of moderate salinity, with low concentration of sodium, can be used in the irrigation of the industrial tomato, without significant yield losses (Campos *et al*., 2006).

On the other hand, Leogrande *et al.* (2012) reported that tomato crop irrigated with 50, 75 and 100% of the crop evapotranspiration with two water quality namely fresh water with EC 0.9ds/m and saline water with EC 6ds/m resulted non significant result and elaborated as salinity did not affect yield with the probability that soil salinity in the root zone might be below threshold of tomato salt tolerance. The effect of different salinity level integrated with different irrigation interval was studied and showed that under moderate saline irrigation (3 dS/m) the tomato yield production was not significantly affected by irrigation intervals, while under highly saline irrigation (5, 7 dS/m), the yield production significantly affected by irrigation intervals as a result it was recommended to use short irrigation interval (one day interval) instead of applying irrigation every three or four day (Rahil *et al.*, 2013).

Effect of water quality on tomato quality

Tomato quality is a comprehensive concept and a sum of the interactions among different single quality attributes. Positive relationship between the overall tomato quality and salinity of irrigation water was reported indicating that saline water improved tomato quality, including fruit density, soluble solid, total acid, vitamin C and the sugar-acid ratio (Campos *et al*., 2006; Leogrande et al., 2012; Zhai *et al*., 2015).

Studies on effect of water salinity on tomatoes showed as increasing salinity levels reduced fresh tomato yield, canopy diameter, fruit water content, tomato firmness and calcium and nitrogen concentration were decreased while the texture strength was increased with increasing salinity levels (Noshadi *et al*., 2013).

Besides, 11.1% and 6.9 % increments in tomato fruit total soluble solids and acidity (PH) respectively reported as result of irrigation with saline water (Wahb-Allah and Al-Omran, 2012). This might be because of reduction in water up take and occurrence of active accumulation of solutes. On the other hand, decrease in the size of marketable tomatoes fruits reported with increasing salinity (Maga´n *et al.,* 2008) and water quality affected by salt influence tomato fruit size negatively.

Effect of deficit irrigation on tomato yield and quality

Following world population growth need for agricultural water for irrigation is become increasing but quantity of water with a sufficient quality is declining which can further enhanced by an increasing demand to shift more of the water used in agriculture to higher-value urban and industrial uses. Suitable water utilization in agriculture is critical and has to be practiced. Deficit irrigation is an optimization strategy that allows to some extent of water stress during a certain cropping stage or the whole season without a significant reduction in yield.

Thus, producing more with less such as deficit irrigation has been considered as important option in agricultural crops production. Wahb-Allah and Al-Omran (2012) reported as negative effect of deficit irrigation was more obvious when coupled with salt stress and concerning crop developmental stage it was indicated as fruiting and vegetative growth stages were the most tolerant to deficit irrigation whereas, the reproductive stage was the most sensitive one

Application of deficit irrigation in crop production is an approach to save water in areas of water shortage and longer drought during production period so as to maximize water productivity. Regulated deficit irrigation saves substantial amount of irrigation water and increases water use efficiency (Birhanu and Tilahun, 2010) quoted (kirda et al., 2004). Besides, deficit irrigation reduces production costs, conserves water and minimizes leaching of nutrients and pesticides in to ground water (Nuruddin *et al*., 2003) and mostly practiced in areas where water scarcity exists. According to Nahar and Gretzmacher (2002), glucose, fructose, sucrose, malic acid, ascorbic acid and citric acid content increased significantly with water stress and sweetness of tomatoes and quality enhanced. Another finding suggested as decreased level of irrigation exerted beneficial effects upon fruit quality, mostly with respect to total soluble solid and soluble sugar contents (Shao *et al.*, 2014).

On the other hand, decrease in total tomato plant biomass, number and size of tomato fruits as well as increase in fruit dry matter and harvest index (fruit dry matter weight/plant dry matter weight) with irrigation water stress level was reported in Ethiopia (Birhanu and Tilahun, 2010). The authors included as total soluble content was increased with stress level and varies among cultivars while the fruit water content was decreased: Melkassa Marglobe cultivar had higher total soluble solute content than Melka Shola cultivar and the higher total soluble solute content of Melkassa Marglobe might be the reason why this cultivar is preferred by consumers for use as a salad (Birhanu and Tilahun, 2010).

The relation between irrigation timing and water use efficiency is another issue while dealing with irrigation management practices in tomato cultivation. According to Marouelli *et al*., (2004) the highest tomato water use efficiency was observed when the last irrigation occurred between 37 and 45 days after blossom, respectively for fruit and pulp yield and also indicated reduction of fruit number per plant associated with higher number of irrigations performed throughout the maturation stage that might be due to the increase of the rotten fruit rate.

Furthermore, Ismail *et al*. (2007) reported as the lower the amount of water used to produce 1 kg tomato the higher the water use efficiency observed: the results revealed that early morning irrigation for 3-days frequency gave the highest water use efficiency while early morning irrigation for 1-day frequency gave the smallest. It was also indicated that 5-days irrigation interval increased water use efficiency (amount of water required to produce 1 gram dry matter) by 18% and 12 % compared to 1 and 3 days frequencies respectively even though irrigation at every early morning at 3-days interval resulted highest yield that of 1-day interval. This implies that time and frequency of irrigation utilization play great role in tomato production. Thus, identification of final irrigation timing has various merits with respect to tomato production apart from wise use of irrigation water available.

Studies on the amount of water on tomato yield at North West Ethiopia showed that 440 mm/ha water with straw mulch under drip irrigation was recommended for similar agro ecologies as it was found to be economical and agronomical feasible (Berihanu, 2011). Moreover, Tanaskovik V*et al*.(2011) the advantages of drip irrigation over conventional methods for better tomatoes water use efficiency was reported together with the fact that fertigation frequencies longer than four days resulted significant tomato yield reduction due to the increased water deficit and water stress. This implies that duration of deficit irrigation has to be seen carefully. Another interesting finding with respect to tomato water use efficiency evaluation was reported as water potential, water content of the leaf and growth were decreased under partial root drying and regulated deficit irrigation and the plants met stronger water stress under regulated deficit irrigation than under partial root drying regime (Lei *et al*., 2009).

Summary and Future prospects

Tomato is one of the dominant vegetable in Ethiopia. It has been produced in various areas by small scale farmers and commercial private farms. Tomato has high domestic demand. Tomatoes cultivated by both rain feed agriculture and under irrigation. However, tomatoes yield and quality concern was being issue of food security as well as health condition as it largely linked food preparation in the country. It is one of the investment areas in high value vegetable crop in Ethiopia for domestic and foreign currency earning purpose.

Many tomato production problems were being studied in Ethiopia. Water quality and irrigation management particularly deficit irrigation utilization largely influence fresh market tomato fruit yield and processing yield and quality. But no irrigation water quality and irrigation utilization guideline available for tomato cultivation in Ethiopia except few research recommendations. However, some worldwide scientific findings conducted with respect to water quality and irrigation deficit on tomatoes yield and quality included in this paper.

Therefore, even though tomato benefits a lot and world is on the way to develop tomatoes with new traits such as increase in disease and insect pest resistance and environmental stresses in order to enrich tomatoes with substances that may offer health benefit or provide better nutrition, few tomatoes research needs a lot and few works done in Ethiopia and this issue needs further focuses. Tomatoes water requirement has to be analyzed as it might vary from place to place. In addition proper water quality analysis has to be done before using it for irrigation. Tomatoes cultivar oriented salinity threshold level for yield and quality has to be identified and utilized. Irrigation technologies has to be tested in areas where tomatoes produced and irrigation water quantity, quality and its frequency that assist in utilizing deficit irrigation so as to wisely use water for tomatoes production in the county has to be studied and documented.

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