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Review on the Effect of Climate Change on Tomato (Solanum Lycopersicon) Production in Africa and Mitigation Strategies

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Abstract
The tomato (Solanum lycopersicon) is one of the member of the Solanceae, or nightshade family, originated in South America and growing as a commercial crop around the world. Despite of its importance, tomato production has been confounding by many biotic and abiotic constraints. In this review, the effect of climate change on tomato which belongs to under abiotic factors and their mitigation strategies reviewed. The possible changes in the context of climate changes like increasing air and atmospheric temperature, change in precipitation, increasing concentration of CO_2, long-term water shortages, unsuitable soil conditions, increasing disease and pest outbreaks on crops are expected to have significant impact on tomato performance which will have a serious impact on our food security. As approved by different findings, the effect of climate change is ameliorated by different achievable and practicable strategies like selection of growing area and planting time, development of cultivar tolerant to changes in climate though breeding and farm management practice like mulching, shading or growing under protected cultivation, using advanced irrigation technologies and nutrient management. So, it is important to briefly understand the effect of climate change on tomato by researching, then developing and demonstrating the mitigation strategies.
Keywords: Carbon dioxide (CO_2), Drought, Temperature, Tomato leaf miner (TLM)

1. Introduction

The tomato (*Solanum lycopersicon*) is one of the member of the *Solanceae*, or nightshade family, originated in South America and growing as a commercial crop around the world (Deuter *et al.*, 2012). This family also includes other well-known species such as potato, tobacco, peppers and eggplant. The cultivated tomato was brought to Europe by the Spanish conquistadors in the sixteenth century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. More recently, wild tomato has been distributed into other parts of South America and Mexico (Naika *et al.*, 2005).

Itis the second most important vegetable crop next to potato in the world; world production in 2009 was about 152 M tons fresh tomatoes produced on 4.4 M ha. The top ten leading producing countries of tomato are China, USA, India, Turkey, Egypt, Italy, Iran, Spain, Brazil, and Mexico (Desneux *et al.*, 2011). World harvested area increased from 4.5 million hectarein 2010 to 5.02 million hectares in 2014, this showed area covered by tomato increased by 10.4 %; yield from harvested areas were 151.9 million KT (kilotonne) in 2010 and**1.71** billion KT in 2014 with yield per hectare34 MT (metric tonne) in 2014. In Africa, yield decreased from 18.6 million MT in 2010 to 15.9 million MT in 2014 which was decreased by 14.6 %; total yield in terms of (tonne) was 18.2 million in 2010 increased to 19.3 million tonne in 2014. While, in eastern Africa Yield (hg/ha) decreased from 131488 in 2010 to 128239 in 2014 which showed total yield decreased by 2.5% (FAOSTAT 2014). As this report showed, world tomato production per unit area is decreasing. Desneux *et al.* (2011) reported due to climate favorability for expansion and damaging potential of Tomato Leaf Miner (TLM), world tomato production has drastically reduced since 2006.

Tomato production has been confounding by many biotic and abiotic constraints. Abiotic stresses are virtually interrelated; either individually or in combination, they cause morphological, physiological, biochemical and molecular changes that negatively affect plant growth and productivity and ultimately yield. Increasing temperature (heat), drought, cold and salinity are the major abiotic stresses that induce severe cellular damage in wild and domesticated plant species and they considered as the result of climate change (Bita and Gerats, 2013). The possible changes in the context of climate changes like temperature, precipitation, concentration of CO_2, CH_4, nitrous oxide (N_2O), O_3, long-term water shortages, unsuitable soil conditions, drought and desertification, disease and pest outbreaks on crops and livestock, are expected to have significant impact on crop growth. Climate change is predicted to have a direct impact on the occurrence and severity of diseases in crops, which will have a serious impact on our food security. (Gautam *et al.*, 2013; Kurukulasuriya and Rosenthal, 2013; Ali *et al.*, 2017).

Dhanush *et al.* (2015)reported International Panel on Climate Change (IPCC)fifth Assessment Report as changes in the climate over the past 30 years have declined global agricultural production by 1 – 5 % per decade relative to a baseline without climate change. Besides, recent studies indicate that even a 2 degrees rise in global temperature will affect agricultural productivity; particularly in the tropics, the effect continually increases with temperature. Kugblenu *et al.* (2013a) suggested among the reason for extremely low production of tomato in

Ghana is the length of the growing season which lastsfor only a few months due to the high temperature influx during the remaining months.

In general, Guodaar (2015) studied by interviewing 378 valid cases, of which majority of the respondents (45.2%) responded climate change resulted poor yield on tomato followed by 102 respondents (27%) who perceived the effects made inadequate tomato supply. Also76 respondents (20.1%), perceived the effect of climate variability on tomato increased incidence of tomato disease with the least respondents (7.7%) perceived climate variability negatively affects the livelihood of farmers. The above results implied the majority of the farmers perceived that climate variability could have some degree of impact on tomato yield with the overall effect on its sustainable supply. Thus, the object of this paper is to review the impact of climate changes on tomato production in Africa and the mitigation strategies.

2. Review on effect of climate variability on tomato production in Africa

2.1. Climate change related factors Affecting Tomato Production

2.1.1. Temperature and Rainfall

Under high temperatures and high concentration of atmospheric CO_2, weed damage to crops in tropical and subtropical semiarid areas is predicted to increase. Global warming was resulting spreading of pests and diseases that are currently found in lowland to highland regions. Temperature also affects the growth of insects, with higher temperatures increasing their growth rate. Thus, continued warming is expected to increase damage to crops from bacteria, fungi, and insects (Johkan *et al.*, 2011).

For tomato, 8 to 13 days period before flower opening is the most critical developmental phase. The optimum temperature varies according to the cultivar tolerance and stage of growth and development. Impact of elevated temperature are complex; mean daily temperature of29^{o}C during the 2 week period up to anthesis has been selected as the critical temperature for successful development phase. This has been confirmed through engaging with producers and researchers by comparing mean monthly maximum temperature data with the commencement and the end of the tomato harvesting season for different locations in Queensland(Deuter *et al.*, 2012)

Guodaar (2015) was studied the effect of temperature on tomato productivity in north district of the Ashanti region of Ghana found maximum temperature had statistically significant negative association with tomato yield. This means that an increase in temperature resulted a significant decrease in tomato yield with some confounding variables such as soil type, application of agro-chemicals, irrigation, tomato variety and regular weeding held constant. Similarly, He also found a statistically significant negative association between rainfall and tomato yield. The implication is that as rainfall increases, it potentially causes a reduction in tomato yield despite tomato needs water, excessive rainfall is detrimental to it.

As cited in La Pena and Hughes (2007), Hazra*et al*. (2007) concluded the failure of tomato to set fruit, bud drop, abnormal flower development, poor pollen production and dehiscence, ovule abortion and poor viability, reduced carbohydrate availability, and other reproductive abnormalities at high temperatures were found in Asia and Sub-Saharan African countries. In addition, considerable inhibition of photosynthesis occurs as temperatures exceeds above optimum level resulting dramatic loss of potential yield(Bita and Gerats, 2013).

High atmospheric temperatures due to elevated concentrations of CO_2 will result heat injury and physiological disorders like photosynthesis in vegetable crops, which will decrease the livelihood of farmers as it reduces the yield. Reproductive development is more sensitive than vegetative development to high temperatures; cultivars even within species varies to heat-sensitivity (Johkan *et al.*, 2011).

For normal germination, growth and development, crop requires optimal temperatures. Therefore, non-optimal temperatures abnormalize growth rate or stop/inhibit germination, growth and development. The temperatures below the minimum and above the maximum requirement limits growth and timely development, and these vary among crops and with different growth stages in the same cultivars. In particular, temperature strongly affects crops during their reproductive period, from pollen formation to fertilization(Table 1)Yamazaki (1985), as cited in(Johkan *et al.*, 2011). In general, under high temperature condition, tomato seedlings grow faster and flower differentiation and development is also promoted. Although, the rate and percentage of fruit set decreases. High temperatures during flowering results flower abscission, malformed flowers, poor flowering, poor fruit quality, color disorder and pollen sterility in tomato plants(Johkan *et al.*, 2011).

Table 1. High temperature injury of crops

Crop	High-temperature injyury
Wheat	Male serarity (over 30 °C)
Tomato	Male serarity (over 30 °C)
Cucumber	Male serarity (over 30 °C)
Pumpkin	Abnormal differentiation of male and femal flower (over 30°C)
Potato	Poor potatp formation (over 21°C), No potato formation (over 29°C)

Source: Yamazaki, 1985 as cited in Johkan *et al.* (2011)

Optimum temperature of tomato for Seed germination (16-29°C), Seedling growth (21-24°C), fruit set (20-24°C) and red colour development (20-24°C), while pollen viability and release are adversely affected by high temperatures and causes poor fruit set (Naika *et al.*, 2005).

Kugblenu *et al.* (2013b) evaluated tomato cultivars in a greenhouse located in the Sinna's garden of the Crop Science Department of the University of Ghana (UG), Legon, Accra; 97 meters above sea level. A total of 19 tomato cultivar were evaluated with the objective of to identify tomato genotypes with a high degree of tolerance to heat stress. Average high day and night temperatures (33.88C and 25.98C, respectively) prevailed especially during the early reproductive stage of plant growth. The study showed that, the significant lowest mean values for fruit yield per plant were found in 5C (Roma) (26.7 g per plant) followed by F1Ninja, Selected SM1 and Wosowoso, respectively. This result indicated that these cultivars were more sensitive to heat stress since they recorded the least yield under this condition. On the other hand, the significant highest mean value for yield per plant was reported in Nkansah, King 5, 18I (CLN 2318 F) and DV 2962 cultivars, showing that they may be better adapted to heat stress as compared to the others. The other 11 cultivars (Improved Petomech, Queen, Caracoli, 17 I (CLN 2443B), Tropimech, Moneymaker, 14IR Island Red, Rio Grande, Tomato Rockstone VF, Petomech and Champion) showed intermediate values and therefore, they may be regarded as moderately adapted to heat stress (Table 2).

Table 2. Percentage flower drop, number of fruit per plant, total fruit yield per plant (g) and weight per fruit (g).

Cultivar	Percentage flower drop	Number of fruit per plant	Total fruit yield per plant (g)	Weight per fruit (g)
1 Petomech	66.2	3	128.5	67.4
2 Rio Grande VF	69.8	5	134.6	53.7
3 Tomato Rockstone VF	80.5	2	132.9	71.1
4 Caracoli	51.4	3	189.3	75.1
5 F1 Ninja	72.9	1	44.4	44.4
6 Tropimech	63.3	5	171.2	60.3
7 Petomech VF II Improved	42.4	6	203.9	73.3
8 Moneymaker	32.4	4	159.2	52.9
9 King 5	46.9	13	379.8	36.8
10 Queen	58.2	4	202.9	93.6
11 18I CLN 2318 F	57.4	6	322.7	76.4
12 14IR Island Red	58.1	2	146.1	54.5
13 8S Selected SM 1	35.5	3	71.1	38.9
14 5C Roma	61.4	1	26.7	26.0
15 17I CLN 2443 B	74.7	5	186.5	45.2
16 Nkansah	13.6	27	571.8	25.2
17 DV-2962	41.8	7	316.9	82.3
18 Champion	67.1	2	120.9	60.4
19 Wosowoso	79.8	2	99.9	81.2
Mean	56.5**	5**	189.9**	58.9*
LSD ($P<0.05$)	13.9	3	69.5	7.8

*$p<0.05$, **$p<0.01$*

Source: Kugblenu*et al*. (2013b)

2.1.2. Drought

A period of dry weather which is injurious to crops is referred as drought and it is related to changes in soil and meteorological conditions and not with plant and tissue hydration. Drought stress occurs when the humidity of the soil and relative humidity of the air are low and the ambient temperature is high (Lipiec *et al.*, 2013).

Plants fundamentally rely on adequate fresh water, and agricultural water accounts for 70 of water use world-wide. Shortage of water caused by global warming will be the greatest problem for crop production. As temperatures increase evaporation from water source and decrease precipitation arid regions will become further desertified. Particularly in semiarid regions, the cultivatable area will decrease because of drought, and this could results famine and mass migration. As well, it is likely that there will be human conflicts over irrigation water and food (Johkan *et al.*, 2011). Drought is by far the leading environmental stress in agriculture that constricts the global productivity of major crops by directly reducing plant potential yield, but also by indirectly influencing their interactions with biotic factors, as a consequence, playing a critical role on the world´s food security(Mishra *et al.*, 2012).

As temperature increases, there will be increased evaporation from the earth's surface and from plants. Even 1°C temperature increase would increase the amount of evaporation from the earth. Likewise, increased temperatures result in more concentrated, heavy rainfall which results decreased rainfall use efficiency(Johkan *et al.*, 2011). Drought is the result of global warming and one of the segment of climate change. In dry areas, water moves from subsurface to surface layers of the soil. Therefore, when capillary water reaches the ground water evaporates, the soluble salts that dissolved into the water in the lower layers are concentrated on surface of the soil. As a result, salt accumulates at the soil surface, where it negatively effects or prevents plant growth. In dry regions, more water will evaporate as temperatures increase, turning these areas into deserts (Johkan *et al.*, 2011).

2.1.3. Carbon dioxide (CO_2) concentration

Carbon dioxide is a key molecule for photosynthesis. The chemical reaction driven by solar energy involves the reduction of CO_2 to create carbohydrates necessary for plant growth and release oxygen. Under normal conditions, the atmospheric CO_2concentration is very low. Photosynthetic reactions under high temperatures and high light intensities are limited by the CO_2 concentration. Even if CO_2 concentration is very high, photosynthetic rate does not exceed a certain value. An increase in concentration of CO_2 significantly affects photosynthesis. In general, if the concentration of CO_2 is doubled, the photosynthetic rate of many C_3 plants increases by 30–60%, but in most C3 plants these increment of photosynthetic rates are temporary; there are no promotion effects in the long term, the photosynthetic rate decreases over an extended period of exposure to high CO_2 concentrations which is manifesting currently and it is directly linked to climate change(Figure 1)(Johkan *et al.*, 2011).

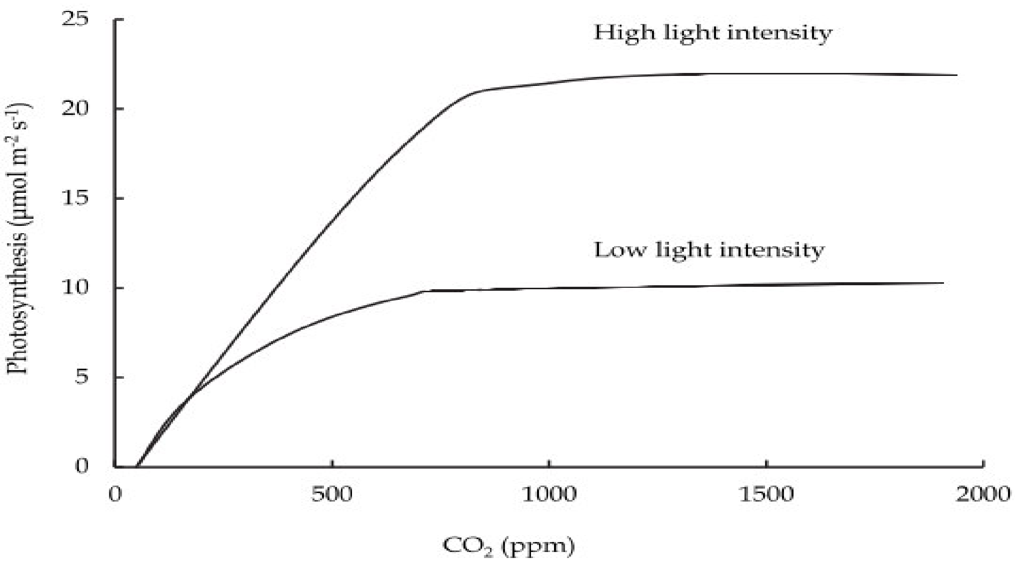

Figure 1. Photosynthetic curves at high and low light intensities.
Source: Johkan*et al.* (2011)

2.1.4. Disease and Insect Pest

The potential impact of climate change on growth and development of crops and pests was investigated by means of computer modeling. Although, little research has been undertaken regarding the effects of climate change on plant diseases compared with other studies. However, a few conducted research finding revealed that the earlier onset of warm temperatures could result in an earlier threat of disease with the potential for more severe epidemics and increases in the number of pesticides applications needed for control (Fahim *et al.*, 2010).

Crop pests are already a major factor influencing farm productivity. Globally about one-sixth of field production is lost due to pests, with further losses in storage. Under climate change the likelihood of the crop pests prevalence, the frequency of new pest introduction, the occurrence of pest outbreaks, the risk of pesticide residues in food will increase; those events are driven by climate change and extreme weather(Dhanush *et al.*, 2015).Late blight of tomato was increased to a mere 6% of its current level of the epidemic in Egypt is due to the projection of climate change. Late blight outbreaks projected to occur from 10 to 15 days earlier in terms of crop susceptible was lengthened by 10 to 20 days during warming conditions(Fahim *et al.*, 2010).

Infestation of insect pests causing pre harvest losses and postharvest spoilage and deterioration in quality that varies with the crop are driven by climate related factors (Oerke, 2006).Tomato is very important vegetable crop of the world; its production is challenging from South American originated pest TLM. This pest has high rate of reproduction and short life cycle; the larval stage is the most damaging stage of TLM (Gebremariamd, 2015). TLM damages tomatoes and other *Solanaceae* crops which may cause significant production losses ranging from 50-100%. TLM infested tomato becomes red and rotten very quickly; some tomatoes even look healthy externally but shrink in size and harden (Figure 2). TLM also changes tomatoes' color to greenish black and makes the tomato fall from the stem prematurely (Tefera and Tefera, 2013; DAFF, 2016).

Figure 2. Infested tomato fruits by TLM
Source: Chidegee*t al*. (2016)

Yet it recently introduced, it has become a major economical pest of both outdoor and greenhouse tomatoes in the Middle East and North and Eastern Africa and causes yield loss of about 80-100% under heavy infestation (Gebremariamd, 2015).

The optimum temperature for TLM development ranged from 19 - 23 °C. At 19 °C, there was 52% survival of *T. absoluta* from egg to adult. As temperature increased beyond 23 °C, developmental time of the moth would appear to decrease. Population development ceases between 7 and 10 °C. Only 17% of eggs hatched at 10 °C but no larvae developed to adult moths; as well as no eggs hatched when maintained at 7 °C (Table 3). Under laboratory conditions the total lifespan of the moth was longest (72 days) at 13 °C and shortest (35 days) at both 23 and 25 °C. Development from egg to adult took 58 days at 13 °C; 37 days at 19 °C and 23 days at 25 °C. High mortality of larvae occurred under all temperatures tested. First instar larvae were exposed on the leaf surface for approximately 82 minutes before fully tunneling into the leaf. Adult longevity was longest at 10 °C with moths living for 40 days and shortest at 19 °C where they survived for 16 days(Table 3)(Cuthbertson *et al.*, 2013).

Table 3. Time-span in days of *Tuta absoluta* life-stages developing at the various temperatures tested (no food supplied for adult moths).

Temperature (°C)	Egg hatch	Larvae	Adult	Total life-span
7	-	-	-	-
10	21 [a]	27 [a,*]	-	-
13	7 [b]	51 [b]	14 [a]	72
19	5 [b]	32 [a]	14 [a]	52
23	4 [b]	16 [a]	15 [a]	35
25	4 [b]	19 [a]	12 [a]	35
23/18	3 [b]	31 [a]	10 [a]	44

Different letters denote significant differences ($p < 0.05$).
* Did not survive to adult.
Source: Cuthbertson*et al*. (2013)

Desneux *et al.* (2011)showed the arrival of *T. absoluta* in Senegal was significant in that it has crossed the Sahara Desert in West Africa probably through trade and poses a threat to the rest of Africa. The speed and degree to which this pest has invaded several countries show that it will invade all the African countries. *Tutaabsoluta* is a devastating pest of tomato and yields may be reduced by 80-100% if no control measures are implemented. In similar way Chidege *et al.* (2016) surveyed and reported that the mean plant damage inflicted by the pest in all tomato fields (under open field and greenhouse) was scored between 90 and 100 % in Tanzania and concluded as highest loss for tomato growers who have ever experienced.

Ethiopia's tomato production is being adversely affected by *TutaAbsoluta*, commonly called TLM moth. This pests suspected it came from Yemen and entered into Ethiopia the northern part of the country. TLM is now spreading fast into major tomato producing regions including Oromia and Somali with about 50 to 60% of the country's total tomato production in jeopardy. It started infecting tomato farms in the northern part of Ethiopia and spread over to Somali and Oromia regions, the latter of which accounts for most of the country's tomato production. It is estimated that 29,000 quintals of tomato produced in the Somali region are infected by the virus. Tomatoes produced in this area are suspected to have already been distributed in the local market. The fact that tomato production in Ethiopia is hit by TLM is already impacting local market prices. When compared to price levels three months ago, tomato prices have increased sharply, climbing from 30 percent USD/kg to around 1USD/kg (Tefera and Tefera, 2013).

2.2. Mitigation Strategies of Climate Change

2.2.1. Selection of Location and Planting Time

Among different strategies to ameliorate the effects of climate change include coordination of growing periods and selection of appropriate growing area are considered as temporary solution (Johkan *et al.*, 2011). Abou-Shleel and El-Shirbeny (2014) was conducted study in the context of climate change on tomato fruit setting and yield at different location and different sowing date in Egypt and identified suitable sites and sawing dates for cultivation of tomato in the future and also to adapt with futuristic climate change conditions by using Geographic Information Systems (GIS) techniques. The results showed that the availability of tomato growing in 2009 was very good in the area and time where temperature of the air was conducive although in the year of 2050, the sowing date and time will be changing; July will be not suitable for tomato fruit setting; tomato fruit setting will not be suitable for consecutive three months of the year (June, July and August) at the year of 2100.

Malherbe (2012)suggested that it is very important to optimize planting time in accordance with local climate conditions in order to achieve conditions that compromise tomato yield and quality. However, selecting optimal planting times may be difficult since unforeseen cycles of short-term inter-seasonal climate variation will remain a cause of variation in yield and quality. Despite this, farmers should therefore try to select resilient cultivars that could enable them to plant in potentially hazardous periods of the year, thereby ensuring a continuous supply of produce to markets.

2.2.2. Cultivar Development

Different crop shows numerous adaptive changes in response to drought and heat stresses which are associated to climate change. The decrease in root hydraulic conductivity induced by drought reduces water flux into the plant, but also prevents water losses from the plant to the dry soil, however this ability varies even within species (Lipiec *et al.*, 2013). Development of tomato cultivars which are heat tolerant and perform well in areas and seasons where atmospheric temperature is high is the most important strategies to mitigate the negative impact of climate change particularly in the aspect of temperature beyond the optimum(Johkan *et al.*, 2011; Kugblenu *et al.*, 2013a). Long term climate change will negatively affect rain fed tomato cultivation potential in the Limpopo Province. It will therefore be important to utilize the correct irrigation technology and expertise in the form of advanced resilient cultivars which will result tomato to remain in business in future(Malherbe, 2012).

As temperature continue to increase, then the negative impact of high temperature on tomato yields will demand more heat tolerant cultivars which will allow growers to maintain and sustain production (Zekeya *et al.*, 2017). Fruiting percentage was significantly lower in exotic hybrids compared to a local variety, this evidenced that there are variation among cultivars capability to tolerate high temperature (Kugblenu *et al.*, 2013a).Kugblenu *et al.* (2013b) evidenced that, wide variation for tolerance to heat stress exists in tomato for the characters. As the study revealed the cultivar Nkansah retained most of its flowers compared with the rest of the genotypes under high temperature. Based on the fruit yield obtained from the study Nkansah cultivar (Table 2) had high adaptation to heat.

2.2.3. Management practice

Temperature changes associated with global warming have become a major challenge of agricultural output. In order to tackle this problem, a few technical and management adjustments like shading, advanced irrigation technology and sustainable crop management systems may contribute to an increased ability of crops to cope with temperature changes (Johkan *et al.*, 2011; Malherbe, 2012; Driedonks *et al.*, 2016). Mulching, advanced irrigation technology and shading are useful management practices to prevent increases in the soil temperature(Johkan *et al.*, 2011).

The primary objective of providing shade is to control the immediate microclimate of plants by reducing solar insolation and consequently air temperature. Even though air temperature and solar radiation are related such that reducing solar radiation may reduce air temperature, however, the relationship is dynamic and may show variations in different seasons and/or locations(Sandri *et al.*, 2003). Kugblenu *et al.* (2013a) suggested, in order to minimize the negative impact of high temperature, growing tomato under shade is supposed as a good strategies as different studies suggested. Shading decreased final shoot and root biomass by 67 and 47% respectively, whiles fruit yield was not affected. Plants were especially wilted and stressed in the afternoons in the non-shaded plots. Insect pests such as whiteflies stayed constantly on plants even with regular insecticide application in tomato grown without shade.

As Lipiec *et al.* (2013) reviewed form different articles, drought and heat stresses are important threat to plant growth and sustainable agriculture worldwide. From the review he concluded that the adverse effects of drought and heat stress can be mitigated by soil management practices, crop establishment and foliar application of growth regulators by maintaining an appropriate level of water in the leaves due to osmotic adjustment and stomatal performance.

Under protected cultivation, the combination of heat pumps, evaporative cooling, air ventilation and shading can achieve optimum growth conditions and act as counteract the effect of global warming (Johkan *et al.*, 2011). The climate in the greenhouse is regulated by ventilating, heating and cooling and by using screens. The growth and level of production of plants largely depends on the amount of sun that the crop gets per day. Inside a greenhouse the intensity of light is lower than outside. Screens can be used to prevent too much sunlight entering the greenhouse and to reduce evaporation somewhat, so that the crop requires less water. A movable screen can be very useful when the weather changes between sunny and cloudy weather. High RH (relative humidity) encourages fungal diseases, because condensation can easily occur on the crop in the early morning, creating the ideal conditions for fungal spores to germinate rapidly. Thus, ventilation under such growing condition is advisable to overcome the problem (Naika *et al.*, 2005).

3. Summary and Conclusion

Climate change which (the differences in the mean and/or the variations in its properties from the usual and continues for a lengthy period) is the biggest threat of the present century and causing significant negative impact on tomato with some beneficial effects, particularly in temperate regions. Thus, this paper is designed to review the effect of climate change on tomato and mitigation strategies. Rises in temperatures, drought, increased pest outbreak and increasing concentration of atmospheric CO_2 are the major climate change related factors that causes heat injury, physiological disorders like photosynthesis and growth and development in tomato and other vegetable crops; finally decrease the livelihood of farmers as it reduces the yield. Because of the adverse effects of climate change locally and globally, various strategies like selection of growing /planting time and selection of appropriate growing area, development of heat and drought tolerant cultivar through breeding, management practice like mulching, shade provision, advanced irrigation technologies and nutrient management are considered as important and practicable methods to mitigate negative impact of climate change.

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