EFFECTS OF BUNCHING ONION CRUDE EXTRACT AND IRRIGATION LEVELS ON GROWTH AND YIELD OF TOMATO

E. M. Shikoli[1], J. O. Ogweno[1], S. Mwanarusi[1#]and F. O. Wayua[2]

[1] Department of Crops, Horticulture and Soils, Faculty of Agriculture, Egerton University. P.O. Box 536-20115, Egerton, Kenya.

[2] Kenya Agricultural and Livestock Research Organization Kakamega- Non Ruminant Research Institute. P.O Box 169-50100, Kakamega, Kenya.

ABSTRACT

Tomato (***Solunum lycopersicon* L.)** which belongs to solanaceae family is the second most important vegetable in Kenya. The objective of this study was to determine the effects of Bunching onion (*Allium fistulosum)* crude extract concentrations and irrigation levels on growth and yield of tomato. Greenhouse experiment was conducted in a completely randomized design (CRD) with three replications and employed a single factor treatment design with combinations of different levels of *Allium fistulosum* crude extract and different levels of irrigation treated as distinct treatments. The treatments consisted of combinations of *Allium fistulosum at* 20% and 15% with 4 levels of irrigation at 0.5 l, 1 l, 1.5 l and 2 l/pot/week and negative and positive control (green cop) combined with 2 l/pot/week. The results from the study showed that tallest plants and thickest stems were obtained under 20% combined with 2 l and 1.5 l of water. Tomato plants flowered early when treated with under 20% diluted in 1 l of water treatment. Highest number of tomato fruits and fruit weight were obtained under 20% combined with 2 l of water while the lowest number of fruits and fruit weight were obtained under the negative control treatment. From this study *Allium fistulosum* crude extract in combination with irrigation levels improved tomato growth and yield. It was clear that, concentration 20% of *Allium fistulosum* crude extract combined with in 2 l of water improved tomato growth and yield.

Key words: Tomato, Flowering, Internodes, Irrigation, *Allium fistulosum*

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) belongs to solanaceae family and is produced worldwide. In Kenya, tomato is the second most important vegetable crop after potato (*Solunum tuberosum*). Production of the crop is carried out by both small and large scale farmers under field and greenhouse conditions (Mbaka *et al*., 2013). Tomato for domestic market is mostly grown under irrigation and rain fed conditions. Tomato enterprise creates employment opportunities, generate income and foreign exchange earnings for the country (Sigei *et al*., 2014). Nutritionally, tomato fruit contains lycopene, vitamins A (retinol), B and ascorbic acid and minerals such as potassium (K), phosphorous (P), calcium (Ca) and iron (Fe) (Kelley and Boyhan, 2014). According to Horticultural Crop Directorate (HCD) (2019), in the year 2018 and 2017, yields realized under an area of production of 14,595 ha were 283,000 and 410,033 tonnes respectively.

Despite these benefits of tomato fruit, production of the crop is faced with biotic and abiotic constraints among them bacterial wilt disease caused by *Ralstonia solanacearum* pathogen (Sigei *et al*., 2014). The pathogen is both soil and waterborne. It can survive in soils and water that facilitate its further spread especially in irrigated fields (Fajinmi and Fajinmi, 2010). The pathogen hosts include crops such as potato, eggplant (*Solanum melongena* L.), geranium, and surface water, infected planting material, soil and plant debris (Mwanikemwa, 2015). *Ralstonia solanacearum* pathogen penetrates the crop through the root system thus causing wilting and finally death of the plant (Kinyua *et al*., 2014). Mbaka *et al*. (2013) reported that the disease caused over 64% tomato crop loss for open field production and up to 100% loss in greenhouse production systems in Kenya.

Methods used to control bacterial wilt in tomato crop includes rotation with non-host crops and use of chemicals. Crop rotation has a challenge because the pathogen can survive in soil in association with weed hosts. In addition, the available land owned by small scale farmers is not enough for practicing crop rotational programmes (Fajinmi and Fajinmi, 2010). On the other hand, cost of application of chemicals is quite expensive and prohibitive

[#]Corresponding author:*edshikoli@gmail.com*

to small scale farmers who rely on tomatoes as a source of livelihood (Fajinmi and Fajinmi, 2010). This has made farmers to look for alternative methods of controlling the disease.

Plant extracts of *Allium fistulosum* have potential of controlling a number of crop pests and diseases. *Allium fistulosum* produces sulphur (S) volatiles upon degradation of *Allium* tissues. *Allium fistulosum* also contains allicin (diallyl-thiosulphinate), which has significant antibiosis effects against a wide range of plant-pathogenic bacteria and fungi. These properties of the plant extract therefore stand to offer a potential eco-friendly alternative for controlling tomato bacterial wilt (Balestra *et al*. 2009). On the other hand, greenhouse agriculture enhances optimized use of water under varying climatic conditions (Impron, 2011). Irrigation water requirement in a greenhouse varies depending on the season and size of the crop cultivated. Transplanted tomato plants require about 0.05 l of water per plant per day while at maturity or during sunny days, plant water requirement may rise to 2.7 l per plant per day (Georgios *et al*., 2018).

Bacterial wilt depends on water for spread and extent of disease while development depends on moisture during the growing season. High soil moisture and prolonged periods of wet weather or rainy seasons are associated with increased bacterial wilt incidence and severity. Besides, the pathogen can survive in extremely diverse environment by moving along water ways (Agather *et al*. 2017). The objective of this study was to determine the effects of *Allium fistulosum* crude extract concentrations and irrigation levels on growth and yield of tomato.

MATERIALS AND METHODS

Experimental Site

The study was conducted in a greenhouse at Kenya Agricultural and Livestock Research Organization (KALRO)-Kakamega, Kenya. KALRO-Kakamega is at (Longitude 34°35′ E and Latitude 0°35′ N) located in the Upper Midland Zone IV (UM_4) Agro Ecological Zone at an altitude of 1585 m above sea level (Jaetzold and Schmidt, 2012).

Variety

The tomato variety used in this study was Sodagar F1 an indeterminate variety that is suitable for greenhouse production as a trellised crop. The variety has a high vigour, but is highly susceptible to bacterial wilt. Tomato seedlings were planted in a nursery until seedlings attained the 3-4 true leaf stage before being transplanted. Prior to transplanting, pots of 22 cm diameter ×36 cm height were each filled with 5kg of sterile soil and NPK 14:28:14 was applied at a rate of 200 kg/ha supplying an equivalent of 28 kg N/ha, 56 kg P/ha and 28 kg k/ha (Oseko and Dienya, 2015). Bunching onion plant parts was used in this study as it has antibacterial properties that have potential for controlling various plant pathogens. The Sodagar F1 variety and bunching onion were sourced from farmers' fields in Kakamega.

Experimental procedure

Soil preparation by steam sterilization and bunching onion extracts

Soil used in this study was obtained from forest. Steam sterilization was done in batches according to Gelsomino *et al*., (2010).

Plant extracts from bunching onions collected from farmers' fields in Kakamega were extracted using water as per the procedure described by Odey *et al*. (2012). The different concentrations of H_2O extracts were prepared by mixing 0 g (0:100), 5 g (1:20), 10 g (1:10), 15 g (1:6.7) and 20 g (1:5) of each plant parts (roots combined with leaves) in 100 ml sterile H_2O to produce extract concentrations of 0%, 5%, 10%, 15% and 20%, respectively. The extracts were then sieved in cheese cloth and stored in clean containers for experimental use.

Tomato seedlings were established in a nursery until they attained the stage of three to four true leaves. Seedlings were hardened off one week before transplanting by reducing watering frequency in the nursery bed. Prior to transplanting, the experimental greenhouse was maintained weed free to avoid competition for nutrients, pest and disease transmission. Pots of 22 cm diameter 36 cm height were filled with 5 kg of sterilized soil. Basal fertilizer (NPK 14:28:14) was applied at a rate of 200 kg/ha to supply an equivalent rate of 28 kg N/ha, 56 kg P/ha and 28 kg k/ha (Oseko and Dienya, 2015). Tomato seedlings were watered to field capacity in the nursery bed 5 hours before uprooting in order to minimize root damage. Inoculation of *Ralstonia solanacearum* pathogen was done during the time of transplanting by dipping of roots in the bacterial inoculum solution. Most vigorous and disease free tomato seedlings dipped in the

bacterial inoculum solution were then transplanted late in the evening to minimize transplanting shock where one seedling was transplanted in each pot. Top dressing fertilizer (CAN 26:0:0) was applied at the rate of 200 kg/ha to supplement an equivalent of 52 kg N/ha in 2 splits (Oseko and Dienya, 2015). Maintenance practices involved gapping, weeding, watering, trellising, staking and flower pruning which were done uniformly in all experimental units. On completion of the experiment, the pots containing infected soil and plants were sterilized and safely disposed of to avoid further spread of the pathogen. This was done by autoclaving the materials at a temperature of 121℃ for 15 minutes in order to kill the pathogen.

The experiment was conducted in a completely randomized design (CRD) with three replications and employed a single factor treatment design with combinations of different levels of *Allium fistulosum* crude extract and different levels of irrigation treated as distinct treatments. The combination were as follows: Negative control WL2, Positive control (Greencop 50g/20l) WL2, A15%WL0.5, A15%WL1.0, A15%WL1.5, A15%WL2.0, A20%WL0.5, A20%WL1.0, A20%WL1.5 and A20%WL2.0.

Allium fistulosum crude extract of 20% and 15% concentrations which were the most effective in the laboratory experiment were used in greenhouse experiment. Irrigation levels were chosen based on the daily water requirement for greenhouse grown tomato plant which is 2.7 l/day at maturity and 0.05 l/day for new transplants.

Before treatment application, 0.05 l H_2O level was applied to the young transplants for a period of one week as recommended for seedlings transplants. Different concentrations (15% and 20%) of the *Allium fistulosum* crude extract were applied by drenching on the soil contained in pots since bacterial wilt disease is soil borne. The *Allium fistulosum* crude extract was applied at an interval of one week (15g and 20g each dissolved in 100ml of distilled water) until the fruits became mature. Irrigation water was applied weekly in every pot (l/week/pot). To take care of the existing inoculum, borehole water was used since pathogenicity tests that were done showed absence of bacterial wilt (Gelsomino *et al*., 2010).

Data Collection and Analysis

Data collection commenced two weeks after transplanting and continued on a 14 days interval until termination of the experiment. Four plants were tagged randomly in every experimental unit for the purpose of data collection. At each instance of data collection, the mean for each variable measured were computed. From a sample of four plants, height was measured from the ground level to the tip of the plant and data obtained used to compute the mean plant height. Stem collar diameter of the four tagged plants was measured using a digital vernier calliper (Model 599-577-1/ USA). Mean stem collar diameter was obtained from the middle part of the stem which was determined by counting the number of internodes divided by two. Days to flowering was determined when 50% of plant had produced flowers.

Harvesting of tomato was done at an interval of seven days from when the first fruits attained breaker stage till termination of the experiment. Mean number of fruits per plant and yield were obtained from a sample of four plants from each experimental unit at each harvest.

Data collected was subjected to analysis of variance (ANOVA) using the general linear model procedure of the Statistical Analysis System (SAS) program, SAS version 9.1 (SAS institute Inc, 2010) based on the following statistical model:

$$Y_{ijk} = \mu + A_i +$$

Where Y_{ij} = observation made in the i^{th} treatment and j^{th} repetition, μ = general mean, A_{i-} = is the effect due to i^{th} treatment, ε_{ij} = random error. Means were separated using Tukey's Honestly Significant Difference (Tukey's HSD) test whenever means at F test are significant at 95 % confidence level.

RESULTS

Plant Height

Tomato plant height was significantly influenced by the use of *Allium fistulosum* crude extract combined with and irrigation at different levels (Table I). In both the trials, the tallest tomato plants were observed in (20%+2 l) treatment followed by the (20%+1.5 l) treatment in all the sampling

days. Treatments (15%+2 l) and (15%+1.5 l) followed in terms of tomato plant height and the difference amongst them was significant (P<0.05) in both experiments. Among the other treatments, tomato that received 20%+1 l grew significantly (P<0.05) taller than those that were treated with 15%+1 l in both trials. Shortest tomato plants were observed in the negative control (-ve+2 l) treatment followed by positive control (+ve+2 l) treatment.

Stem Collar Diameter

Stem collar diameter of tomato plants was significantly influenced by the use of *Allium fistulosum* crude extract with irrigation at different levels (Table II). In both the trials, the largest stem collar diameter was observed in treatments 20%+2 l and 20%+1.5 l followed by 15%+2 l and 15%+1.5 l.

TABLE I- EFFECTS OF *ALLIUM FISTULOSUM* CRUDE EXTRACT CONCENTRATIONS AND IRRIGATION LEVELS ON TOMATO PLANT HEIGHT (CM)

Treatment	Trial 1			Trial 2		
	28dat	42dat	56dat	28dat	42dat	56dat
20%+2 l	18.0a*	50.0a*	90.0a*	18.0a*	50.0a*	90.0a*
20%+1.5 l	17.0b	48.7a	88.7a	16.3b	50.0a	88.7a
15%+2 l	15.3b	46.3b	80.0b	15.7bc	48.7a	85.7b
15%+1.5 l	15.0b	45.3bc	79.0bc	15.0c	42.0b	75.0c
20%+1 l	15.0b	44.0cd	78.3bc	14.0d	40.0b	75.0c
15%+1 l	13.3c	42.7d	72.3bcd	12.0e	40.0b	75.0c
20%+0.5 l	13.0cd	40.0e	71.7cd	12.0e	40.0b	72.0d
15%+0.5 l	11.7de	40.0e	70.0d	11.7ef	40.0b	70.0de
+ve +2 l	11.0ef	38.3e	70.0d	11.0f	38.0bc	70.0de
-ve +2 l	10.0f	38.0e	70.0d	10.0g	33.7c	69.0e
Mean	13.8	43.3	77.03	13.6	42.2	77.0
MSD	0.45	0.68	2.6	0.32	1.6	0.6
CV%	3.23	1.56	3.3	2.33	3.7	1.0

*Means within column followed by the same letter are not significantly different (P>0.05, Tukey's HSD test)

Dat- days after transplanting; -ve+2 l– negative control + two litres; +ve+2 l– positive control + two litres; 15%+2 l– 15% *Allium fistulosum* + two litres; 15%+1.5 l– 15% *Allium fistulosum* + one and a half litres; 15%+2 l– 15% *Allium fistulosum* + one litre; 15%+0.5 l– 15% *Allium fistulosum* + half a litre; 20%+2 l– 20% *Allium fistulosum* + two litres; 20%+1.5 l– 20% *Allium fistulosum* + one and a half litres; 20%+1 l– 20% *Allium fistulosum* + one litre; 20%+0.5 l– 20% *Allium fistulosum* + half a litre

TABLE II- EFFECT OF *ALLIUM FISTULOSUM* CRUDE EXTRACT CONCENTRATIONS AND IRRIGATION LEVELS ON TOMATO STEM COLLAR DIAMETER (MM)

Treatments	Trial 1			Trial 2		
	28dat	42dat	56dat	28dat	42dat	56dat
20%+2l	4.0a*	6.0a*	6.0a*	3.3a*	5.0a*	5.7a*
20%+1.5l	3.7ab	5.3b	6.0a	3.0a	4.7ab	5.7a
15%+2l	3.3ab	5.0b	5.3b	3.0a	4.7ab	5.3ab
15%+1.5l	3.3ab	4.0c	4.0c	3.0a	4.0ab	4.7abc
20%+1l	3.0b	3.0d	4.0c	2.0b	3.7ab	4.3bc
15%+1l	3.0b	3.0d	4.0c	2.0b	3.3bc	4.0cd
20%+0.5l	3.0b	3.0d	4.0c	2.0b	3.3bc	4.0cd
15%+0.5l	3.0b	3.0d	4.0c	2.0b	3.3bc	3.7cd
+ve +2l	2.0c	3.0d	3.3d	1.7bc	2.0c	3.0d
-ve +2l	2.0c	2.0e	3.0d	1.0c	2.0c	3.0d
Mean	3.03	3.6	4.4	2.3	3.6	4.3
MSD	0.32	0.2	0.26	2.3	3.6	4.3
CV%	10.43	4.9	5.9	11.23	12.4	10.3

*Means within columns followed by the same letter are not significantly different (P≤0.05, Tukey's HSD test)

Duration of Flowering

Duration to flowering of tomato plants was influenced by the use of *Allium fistulosum* crude extract with irrigation at different levels (Table III). In both the experiments, the longest days to flowering were observed in the negative control (distilled water combined with 2l of irrigation water (-ve+2l spray) combined with 2l of irrigation water (+ve+2l). The total number of tomato fruits were significantly influenced by the use of *Allium fistulosum* crude extract combined with irrigation at different levels (Table III). In both the trials, the highest total number of tomato fruits were recorded in treatment 20%+2l followed by that of 15%+1.5l and 20%+1.5l in all the sampling days. Treatments 15%+2l and 20%+1l followed in terms of total number of tomato fruits but the difference amongst them was not significant at 5% in both trials.

TABLE II- EFFECT OF *ALLIUM FISTULOSUM* CRUDE EXTRACT CONCENTRATIONS AND IRRIGATION LEVELS ON FLOWERING, NUMBER AND WEIGHT OF TOMATO FRUITS

Treatments	50% Flowering		Number of tomato fruits		Total tomato fruit weight	
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
20%+2 l	43.0cd	43.0cd	22.0a*	21.7a*	2.35a*	2.31a*
15%+1.5 l	43.0cd	43.0cd	20.7ab	21.3ab	2.25ab	2.19ab
20%+1.5 l	42.0d	42.0d	20.0ab	20.7ab	2.08ab	2.07ab
15%+2 l	43.7bc	43.7bc	20.0ab	19.3ab	2.06ab	2.03ab
20%+1 l	42.3d	42.3d	19.0ab	18.3ab	1.95abc	1.92abc
20%+0.5 l	44.0abc	44.0abc	17.0abc	16.7abc	1.93abc	1.91abc
15%+1 l	43.7bc	43.7bc	16.0abc	16.0abc	1.53bcd	1.50bcd
15%+0.5 l	44.7ab	44.7ab	15.7abc	15.3abc	1.23cd	1.21cd
+ve +2 l	45.0a*	45.0a*	13.0bc	12.7bc	1.1d	1.1d
-ve +2 l	45.0a	45.0a	10.0c	10.3c	0.93d	0.9d
Mean	43.63	43.63	17.3	17.2	1.74	1.74
MSD	0.37	0.26	2.84	2.45	0.26	0.26
CV%	13.1	13.0	16.39	14.21	15.06	15.06

*Means within columns followed by the same letter are not significantly different (P>0.05, Tukey's HSD test)

The total fruit weight was significantly influenced by the use of *Allium fistulosum* crude extract combined with irrigation at different levels (Table III). In both the trials, the highest total fruit weight was noted in treatment 20%+2 l followed by that of 15%+1.5 l but did not significantly differ from those of 20%+1.5 l, 15%+2 l, 20%+1 l and 20%+0.5 l (P>0.05) in both trials. Lowest total fruit weight was obtained in treatments with negative control and positive control.

DISCUSSION

Plant Height

In this study, use of *Allium fistulosum* crude extract concentrations in combination with irrigation levels increased the growth parameters of the tomato crop. This could be explained by the fact that these extracts promoted plant growth by decreasing stunting effects of pathogen which is a characteristic of bacterial wilt disease. These findings concurred with those of Alemu *et al*., (2014), who reported that tomato plants treated with different plant extracts at different time of application increased growth parameters of tomato crop.

Plant height significantly increased due to combination of *Allium fistulosum* crude extract and different irrigation levels. Results of current study agrees with those of Tasisa and Fatih (2021) who found out that longest plants were obtained on use of full irrigation throughout the growing season while longer plants on giving optimum amount of water and shorter plants when plants were stressed by skipping irrigation during growing period. This increase in plant height in the current study could be attributed to provision of the right amount of irrigation water which gave better availability of soil moisture that enhanced vegetative growth of plants by increasing cell division and elongation. Furthermore, this could also be attributed to the favourable effects of water in maintaining turgor pressure of cell, which is a major prerequisite for growth (Ramada and Ramanathan, 2017). On the other hand, short plants obtained due to low water level may be explained by the fact that tomato plants experienced partial stomatal closure and reduced CO_2 diffusion and nutrient uptake by the plants hence photosynthesis and other biochemical processes were hampered thus adversely affecting plant growth negatively as also found by El-Noemani *et al*., 2009. This study also agreed with findings of Ramada and Ramanathan (2017), who noted that highest and lowest plant height of shallot were obtained from irrigation levels ranging from 1 to 0.5 ETc respectively. Also higher level of irrigation (1.2lw) was observed by David *et al*. (2016), who reported that it resulted in highest plant height. Plant growth parameters of tomato were significantly increased by increasing soil water supply (Enchalew *et al*., 2016).

Stem Collar Diameter

Stem diameter is an important growth parameter as it serves as a reservoir for the amount of nutrients supplied per unit cross section to developing leaves and for the flow of photosynthates from mature leaves to the rest of plant parts. Tasisa and Fatih (2021) reported that an increase in water level resulted in a significant increase in stem diameter across increasing depth of water application. Plants treated with sufficient water at any growth stage produced widest stem collar diameter while those subjected to deficit irrigation of 25% ETc produced narrow stem collar diameter. In the current study, increase in stem collar diameter with increasing level of irrigation water could be explained by a better supply of plenty of water and less competition for other factors of growth among tomato plants. David *et al*. (2016); Gebregwergis *et al*. (2016) also reported that lowest stem diameter of onion was obtained on application of low level of irrigation water.

Analysis of variance showed existence of significant extract effects differences at p=0.05 level on days flowering of tomato plants on application of different levels *Allium fistulosum* crude extract and irrigation water. Longer days to 50% of plants to flower during growing period could be due to high amount of water applied that promoted more vegetative growth and delayed transition to reproductive period. Results of the current study also concurs with those of Guluma (2009), who reported that length of days to enlargement of onion bulb was due to frequency and amount of water applied and this promoted vegetative growth and delayed development period.

Tomato Yields

In the current study, tomato yields were highly influenced by combination of *Allium fistulosum* crude extract concentrations and irrigation levels. Yield is influenced by traits including number of fruits per plant and total fruit weight. Results agreed with those of Baba *et al*. (2019)

who reported that leaf extracts of *Allium fistulosum* produced longest pod length and high number of seeds per pod. The significant increase in current study could be explained by increased concentration of *Allium fistulosum* crude extract (20%) and availability of nutrients such as calcium and phosphorous essential for plant growth (Baba *et al*., 2019). The results in this study were in agreement with those of David *et al*. (2016); Ramada and Ramanathan (2017) who conducted an experiment to determine yield of various vegetable crops. In their findings, they concluded that low yield was obtained when plants were subjected to water stress (lack or insufficient amount of water) conditions throughout the growing season while deficit irrigation during initial and late stages of growing season did not significantly affect crop yield. Ramesh *et al*. (2016) reported similar findings to those of this study which revealed that highest yield of capsicum crop of 36.17kg was obtained with use of moderate irrigation. In this study, low yield was attributed to water stress (lack of water) during foliage growth and reduced photosynthetic activity that contributed to reduced development and enlargement of fruit. Higher irrigation levels helped to increase vegetative growth of plant which in turn improved assimilates available for storage thus increasing yield.

Baba *et al*. (2019) also observed that leaf extracts of *Allium fistulosum* increased 100 seed weight. In their studies, Enchalew *et al*. (2016); Gebregwergis *et al*. (2016) and Yetagesu *et al*. (2020) found that applying low level of water during fruit development and ripening growth stages produced lower number of fruits thus contributing to low fruit yields and that response of crop is higher under irrigated conditions than non-irrigated conditions. Ramesh *et al*. (2016) reported that highest number of fruits were realized when 0.5cm irrigation was applied. Highest number of fruits obtained in this study could be due to better micro-climate responsible for efficient water utilization at early crop growth stages which ultimately led to more number of flowers hence high number of fruits. On the other hand, lower number of fruits per plant in the control treatment could be due to reduced number of flowers. Increase in yield due to application of high water level could be attributed to increased vegetative growth and increased production of assimilates associated with an increase in average fruit weight. In addition, Yenus (2013); Kenneth *et al*. (2017) reported that highest and lowest yield was obtained on application of 1.2 to 0.5 ETc to tomato crop. Birhanu and Tilahun (2010) also found out that total marketable and unmarketable yield of tomato was lowest in treatments which received reduced amount of water that is 75% water deficit.

Total Fruit Weight

Total weight of tomato fruits was significantly influenced by *Allium fistulosum* crude extract concentrations combined with varying irrigation levels. In this study, weight of fruits increased with increasing irrigation levels. These observations were similar to those of Birhanu and Tilahun (2010) who reported that fruit weight and fruit size was reduced with reduction in amount of irrigation water applied. This is explained by reduced water to support cell division and increase in fruit weight. On the other hand, high fruit weight could be as a result of cell expansion or a larger number of cells and positive effect of water availability for cell division. This effect has also been reported by Ehret *et al*. (2012) who found out that increase in tomato fruit weight was also due to higher level of irrigation. Opiyo *et al*. (2015) also reported that water stress results in lower fruit water content and high fruit weight in well irrigated fruits was most likely be due to high fruit water content. In their study, Ramesh *et al*. (2016) reported that average fruit weight of capsicum was significantly influenced by irrigation levels obtaining highest mean fruit weight of 95.2g. Gupta *et al*. (2010) also reported highest fruit weight of capsicum with moderate irrigation level of 80% of pan evapo-transpiration through drip irrigation combined with surface irrigation. Sezen *et al*. (2011) observed that increase in water deficit (lack of water) in root zone results in loss in turgidity leading to reduction in average fruit weight.

CONCLUSIONS

This study revealed that concentrations of *Allium fistulosum* crude extract and irrigation levels improves growth and yield of tomato crop. In the greenhouse, tallest plants, were observed under 20% concentration of *Allium fistulosum* crude extract combined with 2 l and 1.5 l of water in all days after transplanting. Furthermore, early flowering was achieved under 20% concentration of *Allium fistulosum* crude extract combined with 1 l of water. On the other hand, 20% concentration of *Allium fistulosum* crude extract combined with 2l of water produced highest total number of tomato fruits and total fruit weight while lowest was obtained under negative control combined with 2 l of water. Therefore, greenhouse

tomato farmers should consider using a combination of 20% concentration of *Allium fistulosum* crude extract with 2l of irrigation water as an integrated approach in improving tomato growth and yields.

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