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Research Article

Comparative effects of potassium chloride (KCl) as osmotic stressor on various growth parameters of *Lycopersicon esculentum* L.

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Abstract

Lycopersicon esculentum L. is one of the most important crop and used as a source of vitamins. The present study was carried out to investigate the osmotic effect of KCl on tomato growth and productivity. The experiment was conducted under two different conditions i.e. tomato plants were cultivated in fields as well as in pots. In order to investigate the difference among plant cultivated under different conditions. The plants were provided with various concentration of KCl treatment i.e. 0.1 M KCl, 0.2 M KCl and 0.3 M KCl and keeping one line as control. However, the completely randomize design (CRD) with 4 replicates was used. Various agronomic characters of plants such as plant height, number of brunches per plant, number of leaflets per plants, size of branch, terminal leaflet length, terminal leaflet width, Plant fresh weight, dry weight and number of fruits per plant were studied. The results showed that with increasing concentration of potassium chloride, the plant various growth parameters increase. The plant showed maximum growth, when provided with 0.3M KCl. Similar, type of results was obtained from the tomato plants cultivated in pots. However, in case of tomato plant cultivated in pots, showed less growth as compare to field in general.

Keywords: Fruits; KCl (Potassium Chloride); *Lycopersicon esculentum*; Treatments; Vegetative growth

Introduction

Tomato (*Lycopersicum esculentum* L.) is one of the most popular vegetable crops of Pakistan, after wheat and other economically important cereals. It is mostly cultivated in all provinces of Pakistan [1]. In Pakistan, Khyber Pakhtunkhwa tomato is one of the major crops, grown around 4230 hectares

with annual production of 51,062 tons. Tomato is generally characterized by presence of trichomes and when broken emit strong aroma. It usually bears deep tap roots, that extends up to 3 meters containing extensive network of secondary roots [2]. The fruits are mostly red in color however, in some cases its also found in yellow color. However, there is great amount of variation among cultivars, in size and shape of fruits, in placenta development as well as in fleshy mesocarp [3].

More than 50% of crop yield is lost due to various abiotic stresses and limiting the agricultural land [4]. Abiotic stresses such as salt stress and osmotic stress affect plant via fluctuation the capacity of water extraction in roots. The salt stress primarily affect germination, plant growth, water relation, plant yield, nutrient balance, photosynthesis, in some cases even cause death of plant [5]. This drastic situation calls for development of drought tolerant varieties with maximum yield potential best suited to rainfed hot climate [6]. Osmotic stress is one of the major components of salt stress, mostly occurs due to lower osmotic potential of water content inside the cell. Water deprivation and salt stress alter the osmotic balance inside the cells, and considerable crosstalk is known to exist between responses to both conditions [7]. The osmotic stress in plant tissue developed during, high concentration of Na^+ ion is found in the surrounding of plant root. For normal physiological and biochemical process, plant required proper amount of water and solutes. For this purpose, plant absorbs water continuously from the soil. These absorptions of water are highly depending on the osmotic gradient of cell, because water movements occur from higher osmotic gradient to the lower osmotic gradient. Osmotic pressure of cell increases when solute concentration of different ions like Na^+ and Cl^- etc. found in the soil increases in tissue of plant, those the cell accumulates higher concentration of these ions, the cell absorb water and normally water flow inside the cell [8].

Potassium (K^+) play important role in plant tissue like, the regularity of enzyme and build be involved in the mediation of turgidity, growth, osmotic adjustment, cell movement, and mineral nutrition [9]. Plants require two types of molecules, micro-and macro molecules, which perform all the activities and act as an important constituent of living protoplasm. These molecules are required in various proportion depends on the nature of plants. K^+ (potassium) are one of these macromolecules play a vital role in plant growth and other related parameter of life [10].

Na^+ competes with potassium (K^+) for an uptake via transport system and do it effectively. However, the concentration of Na^+ is greater than K^+ in saline environment that effect the turgidity of cell [11]. Potassium (K^+) amount is decrease at high salinity or ion toxicity like Na^+ and Cl^- which reduce the productivity of plants [12]. Potassium K^+ also play a key role in photosynthesis. According recent study of plant physiologist the carbohydrates translocation and plant metabolism are mostly depends on K^+ concentration [13]. Furthermore, through sunlight interruption, potassium also control photosynthesis. The leaf area and sunlight interruption are dramatically reduced when potassium concentration becomes low then the required rate [14]. The present study was carried to investigate the effect of various concentration of KCl on the growth parameters of tomato plants. For this purpose, tomato was cultivated in 2 different set of environments.

Material and methods

The present study was carried out at botanical garden of Department of Botany, Islamia College Peshawar. The tomato plants were cultivated in two different conditions i.e. in

Pots and in Field. The experiment was conducted using Completely Randomized Block Design (CRBD) with 4 Replicates. The plants were cultivated and treated in following ways.

Plants cultivated in pots

The pots of same size were filled with soil and sand in 3:1 proportion. Tomato seeds under Syngenta To-1057 was sown, each pot contain about 5 seeds. The seeds were sown ½ inch deep. The pots were provided with tap water daily. When germinated seedlings reached to about 6cm, these seedling thinning was done. The pots were provided with one hole at the bottom for leaching purposes. The same method was used [15].

Plants cultivated in field

The field was ploughed, almost 16 sq. Feet for each treatment. The complete field was divided into four main halfs based on treatments design. Each half was further divided into two rows and each row 10 plants. Distance of one plant to another was kept about 30cm with four replicates. The field plugging experiments are modified form of Tamana & Ahmad design [16].

Potassium chloride treatment

After 15 days of sowing, plants were provided with KCl treatments i.e. 0.1 M KCl, 0.2 M KCl and 0.3 M KCl and one line was kept Control, in order to investigate the comparison among different treatments. The KCl treatments were given at interval of 10 days. The plants were harvested after 45 days, the plants were washed and dried, various parameters such as plant height, No. of branches per plant, number of leaflets per plant, Branches size, leaf size, Fresh weight of plant, Root length, Dry weight, Number of fruits, Water contents

Statistical analysis

For analysis of data, MS Excel 365 was used. One-way ANOVA was performed using MS Excel at $P < 0.05$.

Results

The effect of KCl as osmotic stressor on various growth parameters of *Lycopersicon esculentum* was recorded.

Plant's height (Cm)

Plant height of tomato plants provided with various concentration of KCl i.e. 0.1 M, 0.2 M and 0.3 M was analyzed as shown (Figure 1a & b). It was seen that the plant showed maximum height, when provided with 0.3 M of KCl in comparison to control plant. However, the minimum plant height was recorded in plants provided with least KCl i.e. 0.1 M. After the third treatment of KCl it can be concluded that tomato plant cultivated in field have shown a better plant height as compare to pots. Whereas, it was also evident that in both cases field as well as pots cultivated plant showed maximum height at 0.3 M KCl.

Number of branches per plant

The KCl various concentration effect on number of branches/ plants was recorded. It was observed that with increasing concentration of KCl, the number of branches increases (Figure 2a & b). The highest number of branches in pot as well as in field was recorded in plant provided with 0.3 M KCl. However, in case of pot the branches were less than that of field plants among all treatments of KCl. in comparison to control minimum number of branches were recorded in 0.1M KCl.

Number of leaflets

The statistical analysis of data revealed that, with increasing concentration of KCl treatments in fields and Pot cultivated plants showed increase number of leaflets (Figure 3a & b). The lowest number of leaflets after the 3rd treatment of KCl various concentration was recorded in plants provided with 0.1M of KCl in comparison to control. However, the maximum number of leaflets were observed in 0.3 KCl treated plants in field as well as pot experiments.

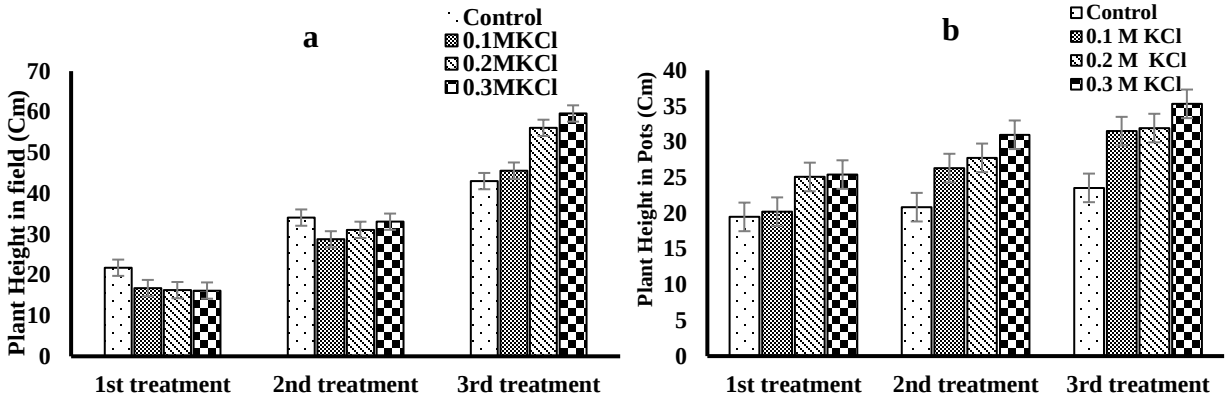

Figure 1. Effect of various concentration of KCl on *Lycopersicon esculentum* height in (a) field (b) Pots

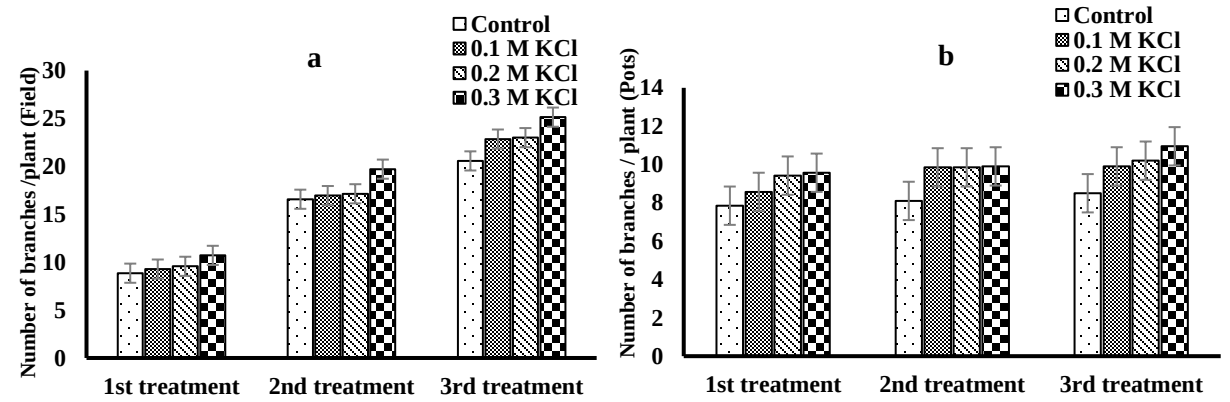

Figure 2. Effect of various concentration of KCl on *Lycopersicon esculentum* number of branches in (a) field (b) Pots

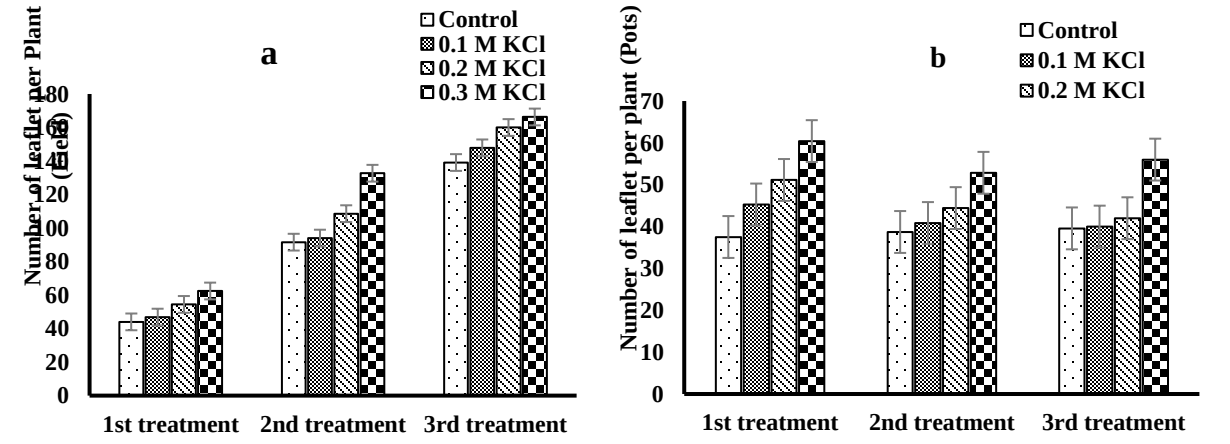

Figure 3. Effect of various concentration of KCl on *Lycopersicon esculentum* number of leaflets in (a) field (b) Pots

Branch size

When different concentration of KCl treatments were provided to tomato plants, it was seen that KCl treatment increase the size of branches (Figure 4a & b). The increase in size was more significant in plants provided with 0.3M KCl. However, the minimum branch size was recorded in 0.1 M KCl. After 3rd treatment, it was also observed that the size of branches in tomato was less in pots as compare to field plants. However, the trend of increase in branch size due to increasing concentration of KCl was not affected.

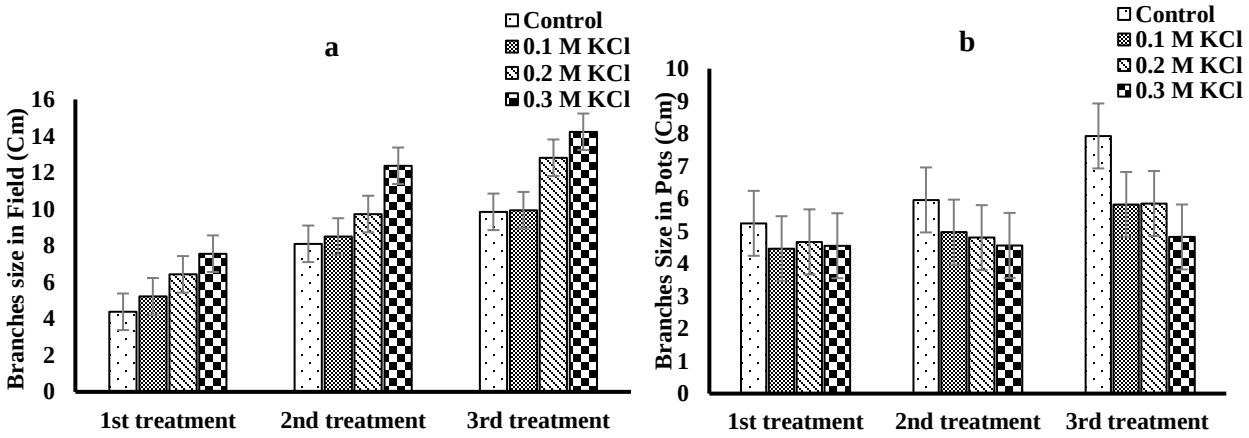

Figure 4. Effect of various concentration of KCl on *Lycopersicon esculentum* branches size in (a) field (b) Pots

Terminal leaflets length

The effect of various concentration of KCl on terminal leaflet of tomato plants were recorded (Figure 5a & b). It was recorded that the terminal leaflet length of 0.3 M KCl was maximum as compared to control plants. This increased among tomato plant was present in both field as well as pots plants. However, the pots plant had relatively less terminal leaflet length as compared to field plant. Moreover, the trend of increasing terminal leaflet length was from 0.1M KCl to 0.3M KCl.

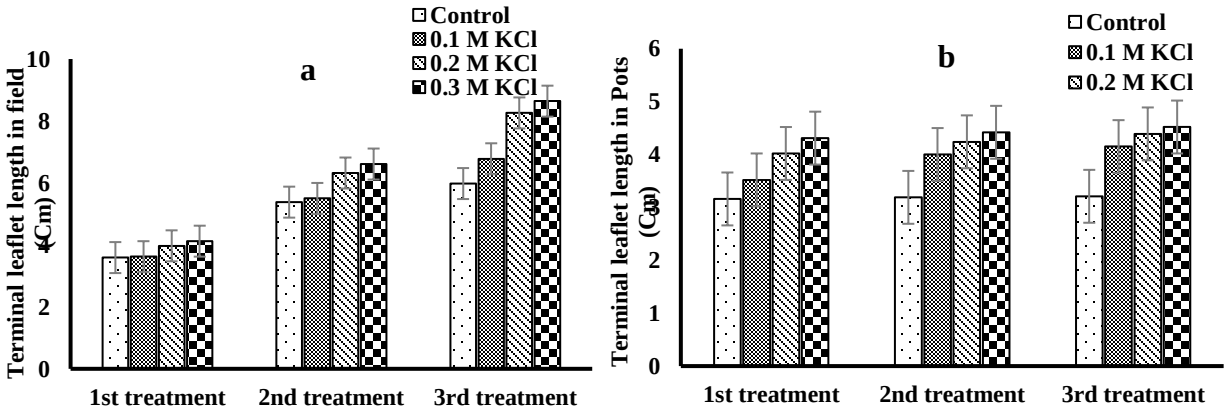

Figure 5. Effect of various concentration of KCl on *Lycopersicon esculentum* terminal leaflet length in (a) field (b) Pots

Width of terminal leaflets

The effect of various concentration of KCl i.e. 0.1 M KCl, 0.2 M KCl, and 0.3 M KCl on width of terminal leaflets of tomato plants was recorded in field as well as pot cultivated plants (Figure 6a & b). It was observed that maximum width of terminal leaflet was shown by 0.3 M KCl treated plants with 4.81 cm and minimum width was shown by control tomato plants with 3.65 cm after 3rd treatment. Similar, trend was shown by the tomato plants treated in pot with these KCl concentrations. It was observed after 3rd treatment that maximum width of terminal leaflet was shown by 0.3M KCl with 3.23 cm and minimum width was observed in 0.1M KCl.

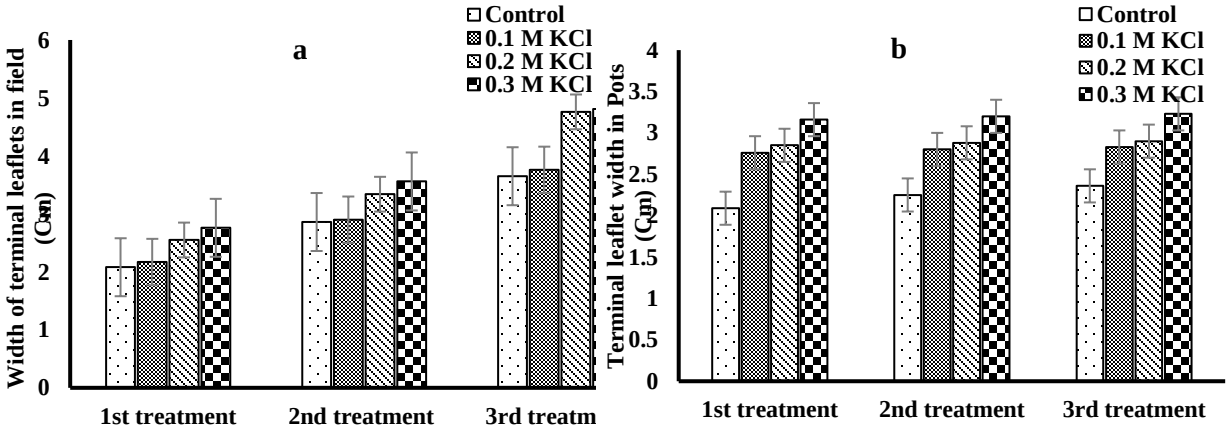

Figure 6. Effect of various concentration of KCl on *Lycopersicon esculentum* width of terminal leaflet in (a) field (b) Pots

Average root length

The effect of various concentration of KCl on average root length of tomato plants was recorded as shown (Figure 7a & b). In field cultivated plants, highest root length was present in 0.3 M KCl with 21.26 cm and lowest root length was shown by the plant treated with 0.1M KCl with root length of 15.9 cm. Similar trend was observed in pot cultivated tomato plants. The maximum root length was present in 0.3 M KCl treated tomato plants with 15.5cm and minimum length of root was present in 0.1 M KCl pots with 11.62 cm.

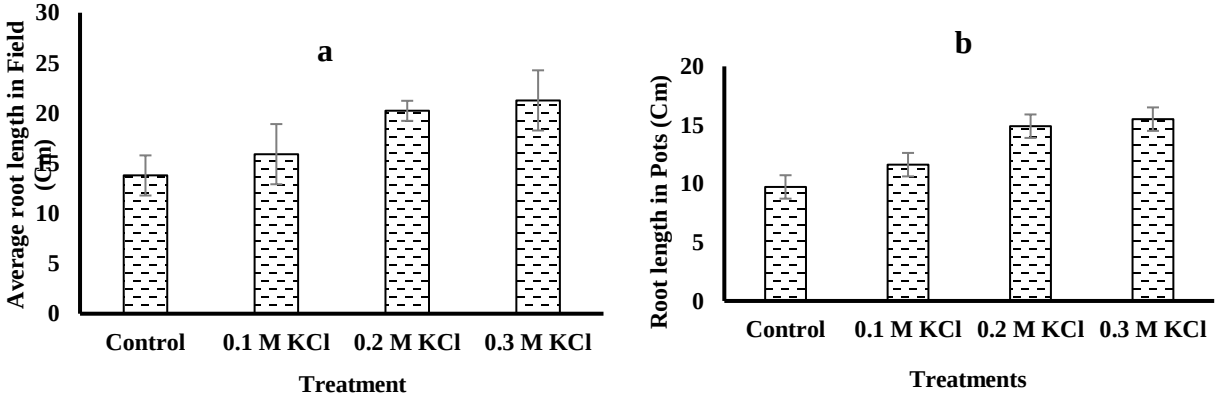

Figure 7. Effect of various concentration of KCl on *Lycopersicon esculentum* root length in (a) field (b) Pots

Fresh and Dry weight

The effect of various concentration of KCl on fresh weight, dry weight of tomato plant was recorded (Figure 8a & b). In field, it was observed that the highest value for fresh weight, dry weight was present in 0.3 M KCl with 113.6 grams, 43.96 grams. The lowest value for fresh weight, dry weight and water content of plant was recorded in 0.1 M KCl i.e. 101.22 grams, 32 grams. Similar, trend was recorded in pot cultivated tomato plant provided with various concentrations of KCl. It was observed that highest value of fresh weight, dry weight was present in 0.3 M KCl with 51.02 grams, 6.54 grams. The minimum fresh weight, dry weight was recorded in pot containing 0.1 M KCl tomato plants with 36.92 grams, 4.11 grams.

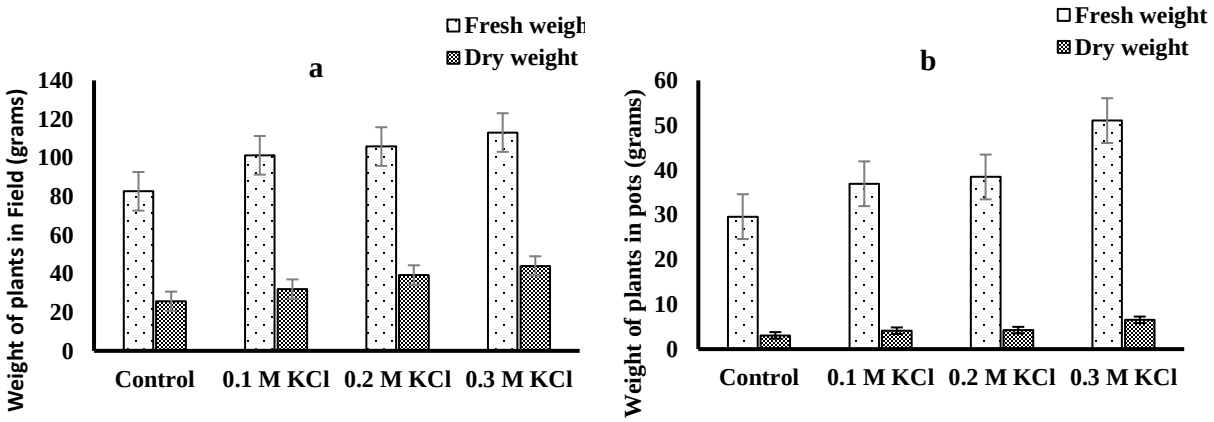

Figure 8. Effect of various concentration of KCl on *Lycopersicon esculentum* fresh and dry weight in (a) field (b) Pots

Numbers of fruit per plant

The effect of different concentration of KCl i.e. 0.1M, 0.2M KCl and 0.3M KCl treatment on number of fruits/ plants was analyzed. It was seen that 0.3 M KCl having an average of 9.2 fruits per plants. In 0.1 M KCl and 0.2 M KCl it was average number of fruits per plant was recorded as 6.6 and 7.4. However, in controlled field 3.6 fruits per plant was recorded (Figure 9a & b). Similar, trend was observed in pot cultivated tomato plants. Maximum number of fruits were present in 0.3 M KCl treated plants with 3.4 per plant. However, in control pots have only 3.4 average fruits/ plant.

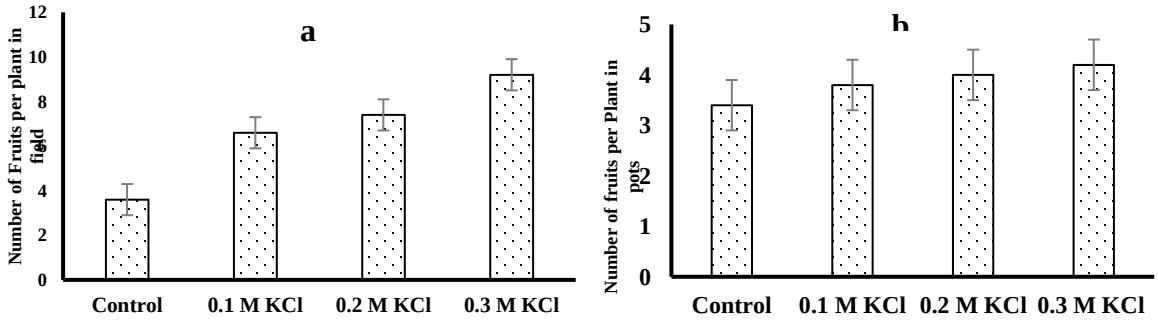

Figure 9. Effect of various concentration of KCl on *Lycopersicon esculentum* number of fruits per plant in (a) field (b) Pots

Discussion

In the present study it was noticed that plant various growth parameters i.e. Plant height, number of branches, number of leaflets, branch size, length of terminal leaflets, width of terminal leaflets, plant fresh weight, plant dry weight, root length and number of fruits have been positively influenced by KCl increasing concentrations (Figure.1-9a and b). KCl show better growth as a Potassium (K^+) source in fertigation solution on growth, yield and quality of tomato (cv. Durinta) as compare to KNO_3 as a source of Potassium [17]. The plant which were subjected to the KCl source showed highest length of stem as compare to control plant [18]. Potassium chloride as potassium source which play a key role in the growth of the plants. The plants in Potassium chloride utilize potassium as a source of macromolecules, which are required for normal growth and metabolic path ways of plants. It was observed that about 65% increase was found in plants, which received Potassium chloride as compare to the normal plants. Significance increase in number of fruits per plant in tomato cv. Money maker with spraying of 10 ppm of Potassium chloride against untreated plants and study that highest number of fruits are found in plant treated with Potassium chloride as compare to other plants like control and untreated plants [19].

The number of fruits per plant increases with the increase in the rate of NPK, which act as a source of potassium chloride [20]. The fruit quality related to the increase concentration of the above nutrients for a potassium source. The plants in open field show positive response to all the agronomical character and the fruit quality color. Little effect of potassium application on flower production, although the proportion of flower that matured into marketable fruit which supported to the present result [21]. The number of flowers showed little response to the potassium level in field plants and maximum number of flowers are found in these plants, which have minimum potassium source. Potassium in fully expanded leaves, tomato fruits were small and green, was related to maximum fruit yield [22]. The leaves with high concentration of Potassium showed expanded lamina as compare to the control plants but the size of the fruits is smaller in plants with higher level of Potassium sources. This showed an agreement with the result we have recorded in our field plants and pots cultivated plants (Table 1 & 2).

Various sources of potassium showed different response to the plant's productivity and yield [23]. The murate (MOP) which used as a source of potassium are highly impact the fruit production as compare to the sulphate (SOP), which also act as a source of potassium. The plants leaf which act as a photosynthetic organ are highly affected by the potassium level. The leaf which are more expanded show high level of photosynthesis process as compare to the other leaf and greater the Potassium chloride in the soil greater will be the leaf surface area and light interruption take place with high level of potassium chloride KCl Similar type of result were obtained, by applying potassium chloride on wild tomato and study high differentiation in the fruit productivity of tomato plants [24]. The plants which subjected to high level of potassium chloride produce more fruit than the other plants, but the size of fruit are smaller as compare to KCl untreated plants. Tomato plants under salts solution induced several physiological changes such as sugar and organic compound accumulates in the ion in leaves and roots, the seedling length decrease but the fresh weight and dry weight increase under such condition [25]. All these previous researchers have found similar results which i have recorded in my research.

Table. 1 Effect of different concentration of KCl on *Lycopersicon esculentum* L. various growth parameters present in field

Treatment	Plant Height (Cm)	No. of branches Per Plant	Leaflets Per Plant	Branches size (cm)	Terminal Leaflet (cm)	Width of terminal leaflet (cm)	Root length (cm)	Fresh weight (g)	Dry weight (g)	No. of fruits per plant
Field Experiment										
Control	21.74	8.85	44	4.38	3.59	2.08	13.78	82.58	25.66	3.6
	34.05	16.57	91.57	8.1	5.38	2.86				
	43.01	20.57	139.1	9.85	5.98	3.65				
0.1 M KCl	16.75	9.28	46.85	5.23	3.62	2.17	13.9	101.22	32	6.6
	28.71	16.95	94	8.5	5.5	2.9				
	45.58	22.85	147.85	9.94	5.78	3.76				
0.2 M KCl	16.24	9.57	54.42	6.43	3.97	2.55	20.22	105.76	39.28	7.4
	31.05	17.14	108.57	9.73	6.32	3.34				
	56.08	23	160	12.81	8.26	4.76				
0.3 M KCl	16.14	10.71	62.42	7.56	4.12	2.76	21.26	113	43.96	9.2
	33.04	19.71	132.71	12.37	6.61	3.56				
	59.61	25.14	168.28	14.23	8.64	4.81				

Table. 2 Effect of different concentration of KCl on *Lycopersicon esculentum* L. various growth parameters present in pot

Treatments	Plant height (cm)	No. of branches per plant	Leaflets per plant	Branches size (cm)	Terminal leaflet (cm)	Width of terminal leaflet (cm)	Root length (cm)	Fresh weight (g)	Dry weight (g)	No. of fruits per plant
Pot Experiment										
Control	19.48	7.85	37.51	5.24	3.16	2.09	9.72	20.58	3.07	3.4
	20.84	8.1	38.71	5.06	3.19	2.25				
	23.54	8.5	39.57	7.03	3.21	2.36				
0.1 M KCl	20.21	8.57	45.28	4.46	3.52	2.76	11.62	36.92	4.11	3.8
	26.31	9.85	40.85	4.97	4	2.8				
	31.48	9.9	40	5.82	4.15	2.83				
0.2 M KCl	25.07	9.42	51.14	4.67	4.02	2.85	14.9	38.44	4.24	4
	27.74	9.85	44.42	4.8	4.24	2.88				
	31.91	10.2	42	5.85	4.39	2.9				
0.3 M KCl	25.4	9.57	60.42	4.65	4.31	3.16	15.5	51.02	6.54	4.2
	30.97	9.9	52.85	4.66	4.42	3.2				
	35.3	10.95	56	4.82	4.52	3.23				

Conclusion

Potassium Chloride various concentration showed increased plant growth with increasing concentration in *Lycopersicon esculentum* L. It is also concluded from the field data that KCl not only influence the vegetative life cycle but also influence reproductive cycle positively. The data revealed that the highest productivity of fruit is formed in plant which have the highest level of Potassium chloride (KCl) but the fruit size was much smaller in plant which exposed to the highest level of KCl. The data also revealed that some extent KCl chloride act as a fertilizer and provide a better chance for growth of various parameter of Tomato plant.

Authors' contributions

Conceived and designed: I Ahmad & F Tariq, Performed the experiment: A Basit, Z Ullah, A Ali & J Ahmad, Analyzed the data: F Tariq, AA Rahim & Syed IU Haq, Wrote the paper: F Tariq, A Basit & MH Iqbal.

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