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Full Length Research Paper

Enhancing the Tolerance of Eggplant Grown under Salt Stress Conditions via Foliar Selenium Application

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One of the most dangerous effects of climate change in Egypt is sea level rise, which will make the northern Delta more salinized. It is highly desirable for present and future crops to be more tolerant of salinity. In order to assess the impact of selenium foliar treatments (0, 5, 10, 20, 30 µM Na2SeO3) on eggplant cultivated on sandy soil and irrigated with varying concentrations of saline water (0, 30, 60, 120 mM NaCl), the current experiment was conducted in the experimental station at the Agriculture Research Centre in Egypt during the summer months of 2014 and 2015. According to the findings, the Se supplement at a concentration of 20 µM had the greatest effects on eggplant production and vegetative growth over a range of irrigation water salinity levels. N, P, and K contents in eggplant leaves and fruits increased with increasing salinity, but K decreased due to some kind of antagonism with Na. Nevertheless, N, P, and K contents in leaves and fruits increased with increasing Se supplements up to 20 µM to be at higher concentrations, after which they decreased. The lowest value (0.52) for the K/Na ratio in leaves was obtained by treating ECw 13.5 dS m-1 without Se supplementation, while the maximum value (1.71) was obtained from treating Se 30 µM under 0 mM NaCl irrigation water. Additionally, the amount of chlorophyll in plant leaves rose as the salinity of the irrigation water increased, but it fell as the amount of Se supplements increased. The treatment of ECw 13.5 dS m-1 without Se supplements produced the maximum proline content in fresh leaves (51 mg g-1), while the control treatment produced the lowest (30.9 mg g-1).

Key words: Sea level rise; Salt stress; Selenium supplements; Eggplant; Proline content.

INTRODUCTION

Egypt relies heavily on climate change-vulnerable natural resources. The Nile Delta's vast expanse of agricultural land is especially vulnerable to sea level rise. By the year 2100, Nicholls et al. [1] predicted a mean global sea level rise of 1 m, which would result in a 0.37 m rise at the Nile delta. By 2060, this, along with a 0.38-meter non-climate-induced sinking of the Nile Delta, would cause the shoreline to shift to the current 0.75-meter contour and a 5% loss of Egyptian agricultural land, mostly along the Nile Delta's coast. According to El-Raey et al. [2], for every meter of sea level rise, 12 to 15 percent of Egypt's present arable land would be lost. Below one meter in elevation, agricultural activities will be challenging due to salinization and seawater intrusion.

As an abiotic stressor that restricts plant growth [3], salinity is turning into a major agricultural issue, particularly in dry and semi-arid regions where salt severely damages 20–30% of the land [4]. Worldwide, a wide range of plant yields are significantly reduced by high soil salt concentrations [5]. However, one of the primary agricultural waste resources in Egypt is saline and drainage water, which degrades the soil and has a negative impact on plant productivity [6].

A traditional vegetable crop in many tropical, subtropical, and Mediterranean nations is eggplant (Solanum melongena L.). While Bresler et al. [8] classed eggplant as a salt-sensitive vegetable, others classified it as a salt-moderately sensitive vegetable [7]. Variations in the cultivars or types that are used and the environmental conditions under study may be the cause of this discrepancy in its tolerance classification. On eggplant, Unlukara et al. [9] discovered a slope value of 4.4% and a salinity threshold value less than 1.5 dS m-1. These scientists also noted a 2.1% decline in plant water use as a result of salinity.

Numerous plant species may collect proline when exposed to a variety of stressors, including water scarcity, salinity, high levels of light, and harsh temperatures. It is believed that proline is a compatible solute. It acts as a hydroxyl radical scavenger, stabilizes cell membranes through interactions with phospholipids, prevents denaturation of folded protein structures, and provides energy and nitrogen. Nonetheless, there is ongoing debate regarding proline's role in osmotic adjustment and plant tolerance to adverse environmental conditions [10]. However, since stress-regulated changes in proline synthesis and degradation may also affect the expression of other genes, the metabolic effects of osmolyte accumulation may be just as significant as or even more significant than their role in osmotic adjustment, ensuring that the genetic response to stress is appropriate for the current environmental stress conditions [11]. In order to defend against the osmotic pressure during salt stress, proline may build up in leaves and roots [12].

Despite not being regarded as a necessary nutrient for plant growth, trace levels of selenium (Se) are needed for human and animal nutrition [13]. However, as demonstrated by the conducted experiments (becoming toxic for humans and animals fed with these plants), a diet containing 1 mg Se kg-1 dry weight (DW) may cause chronic Se poisoning in humans and animals, and a single ingestion of plant material containing 1,000 mg Se kg-1 DW may cause acute Se poisoning and death [14]. Selenium is a component of selenium-containing proteins, many of which have vital roles in energy metabolism, antioxidant defense, and redox control during transcription and gene expression [15]. By boosting plant antioxidant activity, as seen in rice [17] and tea leaves [16], selenium supplementation improves the yield and quality of edible plant products. Although it is very reliant on the conditions under which it is sprayed, foliar treatment of selenium has been demonstrated to be several times more effective than application in soil fertilizers [18]. Furthermore, [19] demonstrated that foliar spray had a high rate of recovery. Nevertheless, [20] discovered that foliar application was less effective than soil application during planting.

Since eggplant is grown on sandy soil and irrigated with varying concentrations of saline water (0, 30, 60, and 120 mM NaCl), the primary goal of this study is to assess the protective effect of foliar application of selenium supplements (0, 5, 10, 20, 30 µM Na_2SeO_3) on eggplant (vegetative growth, yield, proline, and some elements content).

2. MATERIALS AND METHODS

The current experiment was carried out at the Agriculture Research Centre (ARC), Egypt's Central Laboratory for Agricultural Climate (CLAC), during the summers of 2014 and 2015. The Dokki site's climate data for the 2014 and 2015 research seasons are shown in Fig. 1. An automated weather station located at the location provided the data.

2.1 Plant Materials

The seeds of eggplant (Solanum melongena L. cv. Baladi) were planted in polystyrene trays on January 20th, 2014, and January 18th, 2015, respectively. On February 26 and 23, respectively, the eggplant seedlings reached the fifth true leaf stage and were moved into a sandy soil bedding system.

2.2 System Materials

Table 1 lists the physical and chemical properties of the open system of sandy soil from Siwa Oasis in the Matroh Governorate, Typic Torripsamments. Bricks on a cement base made up the system bed, which measured 60 cm in width, 25 cm in height, and 7.5 m in length. In the end, there were 50 cm between each plant and 40 cm between each row. The main gully was made of 1 mm black polyethylene and filled with earth. To facilitate the easy leaching of drainage water, a layer of gravel measuring two to three centimeters is placed in the bottom of the gully bin.

To prevent the effects of organic matter on the salinity impacts under the various treatments under investigation, neither manure nor organic matter was added to the soil.

Using a 110 watt submersible pump, various salinity irrigation water levels were pumped. The nutrient solution and various salinity irrigation water levels were pumped via polyethylene pipe (16 mm) with a 2 liters per hour dripper using a 120 L plastic tank (one per bin system) and a submersible pump (one per tank). Using an EC meter, the nutrient solution [21] was brought to the necessary level (2.5 dS m-1) for each treatment. Fertigation was scheduled to occur two to four times per day, and the length of the irrigation period varied according to the season.

2.3 Investigated Treatments

After two weeks of transplanting the eggplant plants, various treatments were administered. The study examined the effects of foliar applications of varying quantities of selenium (Se) (0, 5, 10, 20, 30 µM Na_2SeO_3) on eggplant grown with varying levels of saline irrigation water (0, 30, 60, 120 mM NaCl) on the soil under investigation. Se supplements and ECw concentrations were applied in accordance with [22–25].

The dates of the 2014 and 2015 eggplant harvests were June 26 and June 17, respectively. After 48 hours of drying at 70°C in an air-forced oven, the obtained samples were digested using an H_2SO_4/H_2O_2 mixture in accordance with the procedure outlined by [26] and stored for the element determination.

2.4 Experiment Design

Three replicates were used in the split plot experimental design. There were ten plants in each experimental plot. As shown in Fig. 2, the saline irrigation levels were designated as main-plots and the Se concentrations as sub-plots.

2.5 Measurements

The vegetative and yield characteristics beside the chemical analysis of eggplants were measured as follows:

- Plant height (cm), before starting the flowering stage
- Number of leaves per plant, before starting the flowering stage
- Fresh weight of total fruits per plant (g/plant)
- Number of fruits per plant
- Chlorophyll content in leaves, SPAD:

Total chlorophyll of the fifth mature leaf from top was measured using Minolta chlorophyll meter Spad-501.

- Proline content in 0.5 g of fresh leaves, at harvest:

When plants are exposed to heavy metals, cold, salinity, drought, or specific diseases, their proline concentration may rise. Proline level measurement is therefore a helpful assay to track physiological condition and evaluate higher plants' ability to withstand stress. Proline content was given as mg g^{-1} fresh weight (FW) and was calculated using the [27] modified [28] method.

- Total N, P, K and Na contents in leaves and fruits, at harvest:

According to the process outlined by [26], the Kjeldahl method was used to identify the total nitrogen in the plant; a spectrophotometer was used to estimate the total phosphorus; and a flame photometer was used to determine the total potassium and sodium in the plant, as explained by [30].

A SAS software application was used to undertake statistical analysis utilizing the analysis of variance [31]. Duncan's method was used to assess treatment significance ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth and Yield of Eggplants

Table 2's data demonstrated that the average plant height varied throughout the course of the two growing seasons under the investigated treatments, declining as the salt of the irrigation water increased. However, when the amount of Se supplements increased, so did the height of the plants. The irrigation with tap water and Se 20 µM produced the highest plant in terms of the interaction between irrigation water salinity and Se supplements; the irrigation with ECw 13.5 dS m^{-1} and Se 0 µM produced the lowest. Additionally, the number of leaves on each plant correlated with the earlier findings about plant height.

Throughout the two seasons under study, the results on plant height and number of leaves per plant were consistent with the total fresh weight of the fruits and the number of fruits per plant (Table 2). In general, the 20 µM Se supplement had the greatest effects on eggplant output and vegetative growth under various irrigation water salinity treatments; the effect was greater when tap water was used for irrigation and diminished as irrigation water salinity increased. These results could be explained by: (1) Se 20 µM is effective in combating internal salt issues in plants.

(2) As irrigation water salinity increased, eggplant output and vegetative growth declined. According to Kabata-Pendias and Pendias [32], clay soils' average Se content was 0.29 mg kg^{-1}, 0.17 mg kg^{-1} in coarse mineral soils, and 10 ppm DW of Se is regarded as phytotoxic in plants. According to Yassen et al. [25], the concentration of Se affected how it interacted with plants. Se promoted the growth of ryegrass seedlings at lower rates, while at higher dosages it behaved as a pro-oxidant, lowering yields and causing metabolic problems. Terry et al. [13] discovered that when the salt level rose, there was a little drop in the amount of Se that was accumulated in the shoots. Additionally, Unlukara et al. [9] noted that the eggplants' vegetative dry weight dropped as soil salinity rose and that fruit output became more sensitive.

3.2 N, P and K Contents in Leaves and Fruits of Eggplants

When compared to the control (no treatments) throughout the two seasons under study, the data in Table 3 demonstrated the impact of saline water irrigation on the N, P, and K contents in eggplant leaves under Se supplementation. The leaves' N and P levels rose with increasing salinity, while their K content fell. Up to 20 µM of Se supplementation, the amounts of N, P, and K in leaves nearly increased; at greater doses, however, they dropped. Se 20 µM with all salty water treatments often produced the maximum value of N, P, and K contents in plant leaves when it came to the interaction between irrigation water salinity and Se supplements.

Table 4 presented data on the effects of irrigation water salinity on the N, P, and K contents of eggplant fruits under Se supplementation. These trends are comparable to those observed in plant leaves. Increased amino acids within the plant as a result of increased stress may be the cause of the rising N and P contents in eggplant leaves and fruits as irrigation water salinity rises; amino acids can interact with phospholipids to modify the osmotic potential, per [33]. Additionally, they noted that Se has a strong capacity to balance the plant's hormones and antioxidants. Applying Se topically to potato plants raised the percentage of N, P, K, and protein in the tuber yield, according to Yassen et al. [25]. Conversely, a decrease in K content with increasing irrigation water salinity may be caused by an increase in NaCl concentration; an increase in Na+ content in leaves and fruits suggests that the eggplant, which has a glycophytic response, was unable to regulate its uptake of Na+ [34]. According to Kong et al. [15], soil pH and salinity had the most effects on plants' uptake of Se; Cl-inhibits uptake via altering plant metabolism. Generally speaking, rising leaf N, P, and K contents

and eggplant fruits by increasing foliar Se supplementation when irrigation is done with salty water. This could be because Se helps the plant's antioxidant activity to withstand stress.

3.3 Some Stress Markers in Leaves of Eggplants

According to data in Table 5, the amount of chlorophyll in plant leaves rose as irrigation water salinity rose but fell as Se additions rose. When compared to the other treatments, the control therapy had the lowest significant value. When compared to the control (tap water irrigation), an increase in the amount of chlorophyll in plant leaves suggests that the plant experienced salt stress. High readings with SPAD could be the result of increased leaf thickness and a darker color, which could be caused by a decrease in extension development under salt stress. Khattab [35] studied the metabolic and oxidative responses associated with exposure of rocket plants (Eruca sativa L.) to different levels

Table 2. Effect of irrigation water salinity and selenium supplements on average vegetative growth and yield of eggplants during the two studied seasons

This is a factorial experiment from two factors: salinity levels (A), selenium concentrations (B) in a spilt plot design, letters A B C D among the main factors, letters a b c d … among the interaction between the two factors (A×B), and different letters means significant

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High levels of Se (100 µM and up) exert toxic effects. Germ et al. [36] reported that Se protected chloroplasts during stress. Data on the proline content of fresh plant leaves throughout the two seasons under study also revealed that, in contrast to the control, proline content rose as irrigation water salinity increased (a sign of stress) but fell as Se supplementation increased. The maximum proline content value (51 mg g-1) was obtained from the treatment with ECw 13.5 dS m-1 without Se supplements, whereas the lowest value (30.9 mg g-1) was obtained from the control treatment. Regarding the impact of Se on the proline content in cucumber seedlings cultivated in saline circumstances, our results concurred with those obtained by [33]. By boosting biosynthesis or preventing proline breakdown, they were able to explain why proline accumulated in stressed plants. According to Nowak [22], Se strengthened cucumber seedlings' resistance to salt by shielding the cell membrane from lipid peroxidation. However, he clarified that the antioxidative activity of Se, increased proline accumulation, and/or decreased Cl-ion content in the shoot tissues are what cause the growth-promoting impact of low Se concentrations (5 and 10 µM) in saline conditions.

The K/Na ratio values in eggplant leaves were displayed in Table 5 as a crucial indicator on stress from salt. The K/Na ratio normally increased when Se supplements increased, while it reduced as irrigation water salinity increased. The treatment of ECw 13.5 dS m-1 without Se supplements produced the lowest value of K/Na ratio (0.52) in relation to the interaction between irrigation water salinity and Se supplements, while the treatment of Se 30 µM under irrigation with tap water produced the greatest value (1.71). Several eggplant cultivars showed a rise in Na and a drop in the K/Na ratio when the amount of NaCl in the solution was increased, according to Akinci et al. [34].

According to Germ et al. [36], adding selenium (Se) to senescing plants boosts their antioxidative ability by increasing superoxide dismutase (SOD) activity and preventing the content of tocopherol from dropping. Increased glutathione peroxidase (GPx) activity is linked to increased antioxidation, which partially delays senescence processes. Se-induced increase in GPx activity was linked to decreased lipid peroxidation in ryegrass (Lolium perenne) up to a Se injection of 1.0 mg kg-1 [37]. It has been demonstrated that Se can control the water status of plants during drought [38] and that Se's protective effect during drought stress was attained by boosting the root system's capacity to absorb water.

This is a factorial experiment from two factors: salinity levels (A), selenium concentrations (B) in a spilt plot design, letters A B C D among the main factors, letters a b c d … among the interaction between the two factors (A×B), and different letters means significant

4. CONCLUSION

The current study suggests applying selenium as a foliar application at a concentration of 10 to 20 µM to increase eggplants' tolerance against salinity of irrigation water and prevent salt stress impacts on yield as part of a mitigation and adaptation strategy for climate change impacts with the anticipated increase in salinity of irrigation water, particularly in Northern Egypt due to sea level rise. Because of its antioxidative properties, these Se supplementation dosages offer a feasible option for application when irrigation water contains comparatively high amounts of NaCl. In addition to researching how sea level rise affects irrigation water and soil salinities, more research is needed to determine how Se affects various crops, its actual function within the plant during physiological phases, and its content.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nicholls RJ, Leatherman SP. Global sea- level rise. In: Strzepek KM, Smith JB (eds.), When Climate changes: Potential impact and implications. Cambridge Univ. Press, Cambridge; 1995.

2. El-Raey M, Nasr S, Frihi S, Desouki S, Dewidar K. Potential impacts of accelerated sea level rise on Alexandria governorate, Egypt. J. Coastal Res. 1995; 14:190–204.

3. Sengupta S, Majumder AL. Insight into the salt tolerance factors of a wild halophytic rice, Porteresia coarctata: A physiological and proteomic approach. Planta. 2009; 229:911-929.

4. FAO. Crops and drops. Making the best use of water for agriculture. Food and Agriculture Organization of the United Nations. Roma. 2002;26.

5. Gorai M, Neffati M. Germination responses of Reaumuria vermiculata to salinity and temperature. Annals Appl. Biol. 2007;151:53-59.

6. Abd-Elrahman Shaimaa H. Remediation of some degraded soils using new techniques. Scholars' Press, OmniScriptum GmbH & Co. KG, Germany 2013;8.

7. Heuer B, Meiri A, Shalevet J. Salt tolerance of eggplant. Plant Soil 1986;95: 9-13.

8. Bresler E, McNeal BL, Carter DL. Saline and sodic soils. Springer-Verlag, Berlin 1982.

9. Unlukara A, Kurunc A, Kesmez GD, Yurtseven E, Suarez DL. Effects of salinity on eggplant (Solanum melongena L.) growth and evapotranspiration. Irrig. & Drain. 2010;59:203–214.

10. Hare PD, Cress WA. Metabolic implications of stress-induced proline accumulation in plants. Plant Growth Regulation. 1997;21:79–102.

11. Claussen W. Proline as a measure of stress in tomato plants. Plant Sci. 2005;168:241–248.

12. Chen Z, Cuin TA, Zhou M, Twomey A, Naidu BP, Shabala S. Compatible solute accumulation and stress mitigating effects in barley genotypes contrasting in their salt tolerance. J. Exp. Bot. 2007;58:4245-4255.

13. Terry N, Zayed AM, de Souza MP, Tarun AS. Selenium in higher plants. Annual Rev. Plant Physiol. Plant Mol. Biol. 2000;51:401–432.

14. Pilon-Smits, Elizabeth AH, Quinn, Colin F. Selenium metabolism in plants. In: Hell R, Mendel RR. (eds.), Cell Biology of Metals and Nutrients, Plant Cell Monographs 2010;17:225-241.

15. Kong L, Wang M, Bi D. Selenium modulates the activities of antioxidant enzymes, osmotic homeostasis and promotes the growth of sorrel seedlings under salt stress. Plant Growth Regulation. 2005;45:155-163.

16. Xu J, Yang F, Chen L, Hu Y, Hu Q. Effect of selenium on increasing the antioxidant activity of tea leaves harvested during the early spring tea producing season. J. Agric. Food Chem. 2003;51:1081-1084.

17. Xu J, Hu Q. Effect of foliar application of selenium on the antioxidant activity of aqueous and ethanolic extracts of selenium-enriched rice. J. Agric. Food Chem. 2004;52:1759-1763.

18. Aspila P. History of selenium supplemented fertilization in Finland.Proceedings, 20 Years of Selenium Fertilization; Helsinki, Finland. 2005;8–9:8- 13.

19. Curtin D, Hanson R, Lindley TN, Butler RC. Selenium concentration in wheat grain as influenced by method, rate, and timing of sodium selenate application. New Zealand J. Crop Hort. Sci. 2006;34:329- 339.

20. Lyons GH, Lewis J, Lorimer MF, Holloway RE, Brace DM, Stangoulis JCR. High selenium wheat: agronomic bio-fortification strategies to improve human nutrition. Food Agric. Environ. 2004;2:171-178.

21. El-Behairy UA. The effect of levels of phosphorus and zinc in the nutrient solution on macro and micronutrients uptake and translocation in cucumber (Cucumus sativus L.) grown by nutrient film technique. Ph.D thesis, London University. 1994;299.

22. Nowak HB. Beneficial effects of exogenous selenium in cucumber seedlings subjected to salt stress. Biol. Trace Elem. Res. 2009;132:259-269.

23. Yao X, Chu J, Wang G. Effects of selenium on wheat seedlings under drought stress. Biol. Trace Elem. Res. 2009;130:283-290.

24. Chu J, Yao X, Zhang Z. Responses of wheat seedlings to exogenous selenium supply under cold stress. Biol. Trace Elem. Res. 2010;136:355-363.

25. Yassen AA, Safia M Adam, Sahar M Zaghloul. Impact of nitrogen fertilizer and foliar spray of selenium on growth, yield and chemical constituents of potato plants. Aust. J. Basic & Appl. Sci. 2011;5:1296- 1303.

26. Chapman HD, Pratt PF. Methods of analysis for soils, plants and waters. Division of Agric. Sci. Berkeley, Univ. California, USA. 1961;150-152.

27. Troll W, Lindsley J. A photometric method for the determination of proline. J. Biol. Chem. 1955;215:655-660.

28. Petters W, Piepenbrock M, Lenz B, Schmitt JM. Cytokinine as a negative effector of phosphoenolpyruvate carboxylase induction in Mesembryanthemum crystallinum. J. Plant Physiol. 1997;151:362-367.

29. Watanabe FC, Olsen SR. Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soils. Soil Sci. Soc. Amer. Proc. 1965;29:677-678.

30. Jackson ML. Soil chemical analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ Library of Congress, USA 1958;pp 38-388.

31. SAS Institute. The SAS System for Windows; Release 6.12; Statistical Analysis System Institute Inc., Cary, NC; 1996.

32. Kabata-Pendias A, Pendias H (Eds.). Trace elements in soils and plants. 2nd Ed. CRC Press, Inc. Boca Raton, Florida; 1992.

33. Abd El-Nasser Walaa, Shatlah MA, Hossien M, Srorr HAM. Selenium induces antioxidant defensive enzymes and promotes tolerance against salinity stress in cucumber seedlings (Cucumis sativus). Arab Univ. J. Agric. Sci. 2010;18:65-76.

34. Akinci IE, Akinci S, Yilmaz K, Dikici H. Response of eggplant varieties (Solanum melongena) to salinity in germination and seedling stages. New Zealand J. Crop Hort. Sci. 2004;32:193–200.

35. Khattab HI. Metabolic and oxidative responses associated with exposure of Eruca sativa (Rocket) plants to different levels of selenium. Int. J. Agric. Biol. 2004;6:1101-1106.

36. Germ M, Stibilj V, Kreft I. Metabolic importance of selenium for plants. The Europ. J. Plant Sci. Biotech. 2007;1:91-97.

37. Hartikainen H, Xue T, Piironen V. Selenium as an antioxidant and prooxidant in ryegrass. Plant Soil. 2000;225:193-200.

38. Kuznetsov VV, Kholodova VP, Kuznetsov VIV, Yagodin BA. Selenium regulates the water status of plants exposed to drought. Doklady Biological Sciences. 2003;390: 266-268.

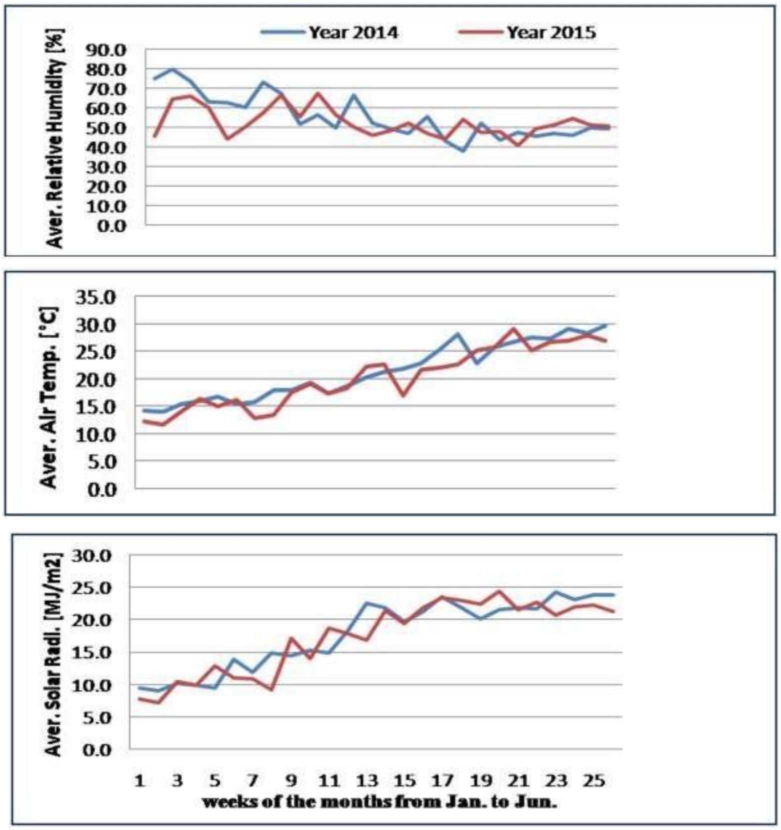

Fig. 1. Climatic data at Dokki site during the studied seasons of 2014 and 2015

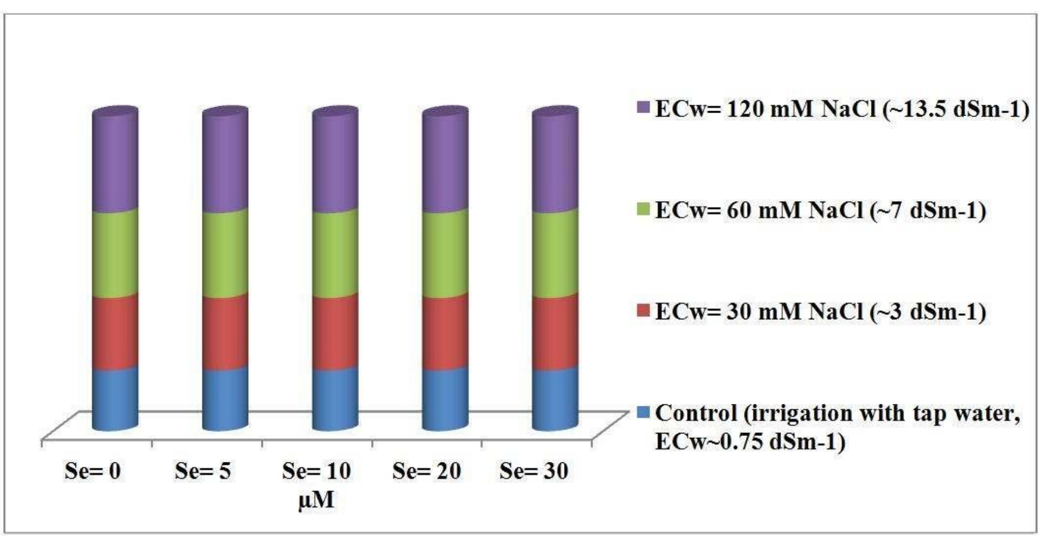

Fig. 2. The layout of experimental design