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Effect of irrigation intervals on growth and production of Roselle (*Hibiscus Sabdariffa)*

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Water deficit is a limiting factor in the production of many field crops. The water stress causes different morphological, physiological and biochemical changes including reduction in leaf area, senescence and restricts cell development. This study was carried out to investigate the influence of irrigation intervals on growth and production of roselle (*Hibiscus sabdariffa*) at the Ornamental Horticulture Nursery, Department of Horticulture, The University of Agriculture, and Peshawar during the year 2018. Randomized Complete Block Design was used having single factor i.e., irrigation intervals (T_1:6, T_2:8 and T_3:10 days). The irrigation interval significantly affected various growth and production attributes of roselle. Irrigation of roselle plants at 6 days intervals resulted in maximum plant height, stem diameter, number of branches plant^{-1}, number of leaves plant^{-1} and number of calyces plant^{-1} as well as days to flowering in roselle plants. It was concluded that irrigation of roselle plants at 6 days intervals was more effective as compared to irrigation intervals of 8 and 10 days.

Keywords: Roselle, Calyx, Irrigation interval, Drought stress, Production

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.)., a member of family Malvaceae, is an important annual crop grown successfully in tropical and subtropical climates (Copley, 1975). Roselle is a unique specie grown in tropical regions for its seeds, stem, leaves and calyces (Eslaminejad and Zakaria, 2011).The word Roselle was probably derived from the French word “Oseille” (Wester, 1907). Roselle was originated from Africa and was cultivated in Sudan about 6000 years ago and then introduced to South America and India in 17th century as a vegetable (McClintock,Tahir, 2004). Roselle has smooth, reddish, cylindrical stem. It has simple leaves having petioles and each blade is 3-5 lobes. Roselle has solitary, axial, nearly sessile flowers having diameter of 5-7 cm. The flower has segmented (8-12 segments) epicalyx, having a red cup shaped fleshy calyx at base which contains 5 sepals. Its petals are of yellow color and twice as long as calyx. The stamens exist in large numbers with a filament united into a staminal column. The flower has only one style, 5 branched with capitate stigma. The fruit is 1.25-2.00 cm long velvety capsule, having 5 valves and each valve contains 3-4 seeds. The capsules turn brown from green at maturity and split when dry. The seeds are kidney shaped, 3-5 mm in length and light brown in color (Ross, 2003; Mahadevan et al*.,* 2009).

Roselle plant has multi-uses; it is used in food,animal feed, neutraceuticals, cosmeceuticals and pharmaceuticals (Mohamad et al*.,* 2002). Its outer leaves (calyx) are used frequently in the production of jam, jelly, wine, juice, syrup, gelatin, pudding cake, ice-cream and flavoring. Its bright red color and best flavor makes it a valuable food product (Tsai and Ou, 1996). The juice made from the calyces of roselle contain high amount of Vitamin C, Anthocyanins and other antioxidants. Calyces (sepals) are the main commercial organ in roselle due to their unique color (red) and flavor, are commonly used in food industry for production of beverages, juices, jams, and syrup (Borrás-Linares et al., 2015). Roselle fruit is acidic in nature, with low sugar content. Succinic acid and oxalic acid are the two main organic acids in roselle, whereas glucose is the major sugar present in its fruits (Wong et al., 2002). The plant can grow readily in well-drained soils and can tolerate poor soils, high temperature and drought. It requires 4-8 months with minimum night-time temperature 20° C, 13h of sunlight and monthly rainfall of 130-150 mm. Cultivation of the crop has been revealed throughout India, parts of Asia, America, Australia and throughout Africa (Cobley, 1976). Without any doubt, the scarcity of water resources had led farmers to improve their irrigation strategies, for providing crops with their exact water requirements (Morille et al., 2013). Water deficit is a limiting factor in the production of many field crops, as well as water stress causes different morphological, physiological and biochemical changes including leaf area reduction, leaf senescence and reduction in cell development (Kafi and Damghani, 2001). Water stress adversely affects the plant growth and hence causes a reduction in stem elongation, leaf expansion, growth rate and stomatal conductance (Khalil et al., 2012). Photosynthesis is one of the first physiological processes affected by drought (Babatunde and Mofoke, 2006). The growth, yield, chlorophyll content, relative water content, nitrogen, potassium and phosphorus contents of basil and rosemary plants were decreased under water stress in contrast to proline and total carbohydrate content which were increased (Khalid, 2006). The proper irrigation interval plays a major role in increasing the water use efficiency and the productivity by applying the required amount of water when it is needed. On the other hand, the poor irrigation interval can lead to the development of crop water deficit and results in a redution of yield due to water and nutrient deficiency. Frequent light irrigations result in plants with shallow root systems that suffering from water stress even with short periods of water deficit (Sanders, 1997).

Keeping in view the available information relating roselle culture, it can be grown successfully in subtropical areas, with adverse agro-climatic conditions of Pakistan. Specifically good choice for marginal lands, makes it more suitable for growing this important crop. Research on medicinal plant like roselle is important, since all parts of the plant have many applications in foods, medicine, and industry. Therefore an experiment was planned to investigate the effect of different irrigation intervals on growth and yield related attributes of roselle (*Hibiscus sabdariffa* L).

MATERIALS AND METHODS

Experiment site description

The experiment on "Effect of irrigation intervals on growth and production of roselle "*Hibiscus sabdariffa* L" was carried out at the Ornamental Horticulture Nursery, Department of Horticulture, The University of Agriculture Peshawar, during the year 2018. The research farm is located at 34.01^o N latitude, 71.35^o E longitude at an altitude of 350 m above sea level in Peshawar valley with sub-tropical climate (Ahmad et al., 2019). Peshawar is located about 1600 km north of the Indian Ocean. The research farm is irrigated by Warsak canal from river Kabul (Alam et al., 2020). Both the summer and winter weather are extreme (Basit et al., 2019), characterized by severe winter and hot prolonged summer where the average minimum temperature during winter is 5^{0}C while during summer the average maximum temperature reaches up to 45 ^{0}C.

Experimental design and field preparation

The experiment was designed by using Randomized Complete Block Design (RCBD) with one factor. The experimental treatment comprised of single factor i.e., irrigation intervals (T_1:6, T_2:8 and T_3:10 days).The whole experimental plot was divided into nine sub plots of equal size (2x2 m^2) and each subplot consisted of 12 plants. The plant to plant and row to row distance was kept 20 cm and 40 cm respectively. Roselle is a deep rooted crop, therefore deep ploughing is recommended in preparing the seedbed. The field was thoroughly ploughed and levelled. The seeds were planted 2.5cm deep. Irrigation was done through pipe from hydrant system. Crop management practices such as weeding, hoeing and pest management etc were done equally to all treatments throughout experiment when needed.

Morphological and yield related attributes

Data were calculated on following growth and production related attributes of roselle: Plant height (cm) was measured from the base of the stem to the tip of the plant with the help of measuring tape. Three plants were randomly selected from each sub plot and average plant height was calculated. Diameter (cm) of the stem was measured with the help of Vernier caliper. The stem diameter was measured at the base, in middle and at the top of the plant stem and then their average were calculated. The total number of branches and leaves plant^{-1} were counted from randomly selected three plants in each treatment and then their average were calculated. Days to flowering were counted from germination till the appearance of flowering in each treatment of every replication. Total number of calyces plant^{-1} were counted from randomly selected three plants in each plot and their means were calculated.

Data analysis

Statistical software Statistix (Statistix 8.1, Inc, Tallahassee FL, USA) as described by Basit et al. (2018) was used for calculating ANOVA and means were compared by using Least Significance Differences (LSD) test at 5% level of significance (Jan et al., 2009).

RESULTS AND DISCUSSION

Plant height (cm)

Plant height of Roselle was significantly ($P<0.05$) influenced by different irrigation intervals (Figure 1).Tallest plants (191.44cm) were observed in plots irrigated at 6 days interval followed by (177.22cm) plant height observed in plots irrigated at 8 days interval, while the minimum plant height (169.11cm) was recorded in plots irrigated at 10 days of interval. Drought stress treatments affected the vegetative growth of plants in most of the cases. Water plays an important role in several physiological processes so sufficient supply of water enhanced these physiological processes which resulted in an increase in plant height. El-Boraie et al. (2009) also found that increasing irrigation water in Roselle increased plant height. Our results are in contrast with the fındıngs of Seghatoleslami et al., (2013) who observed non-significant effects of irrigation intervals on plant height of Roselle. The reduction observed in plants grown under 8 or 10 days irrigation interval might be due to the lower turgor pressure caused by the low-soil water availability, which influence processes such as cell division and elongation (Al-Absi, 2009). In this concern, the plant morphology was influenced due to water stress including the plant height and shoot growth (Ekren et al., 2012; Hassan and Ali, 2014) .The reduction in plant height under water stress condition was perhaps due to the slowdown in cell expansion process and hence resulted in stunted growth as compared to the plants that received optimum water (Shau et al., 2008).

Stem diameter (cm)

It is obvious from Figure 1 that irrigation intervals significantly influenced stem diameter of Roselle plants. Maximum stem diameter (18.9 mm) was noted in plots irrigated at 6 days intervals compared to plots irrigated at 8 and 10 days interval (16.2 mm and 14.6mm). Irrigation plays an important role on improving stem diameter as the plants irrigated in short intervals may have more water available for photosynthesis and plant growth, which may resulted in higher stem diameter. Sezen et al. (2006) reported the same findings and observed that irrigation amount and irrigation frequencies had significant effect on the stem diameter of Bell pepper. Similar results were observed by Hayat (2007); Abdel-Kader (2011); Abbas and Ali (2011) on Roselle plants.

Number of branches plant^{-1}

The results pertaining to number of branches plant^{-1} showed significant influence of irrigation intervals on number of branches plant^{-1} (Figure 1). Maximum number of branches plant^{-1} (18) were observed in plots irrigated at 6 days interval followed by (15) branches plant^{-1} observed in plots irrigated at 8 days interval, while the minimum number of branches plant^{-1} (13) were recorded in plots irrigated at 10 days interval. Irrigation has an important role on number of branches as the plants irrigated in proper intervals had more water available for growth and photosynthesis. This may encouraged more number of branches and leaves (Alam, 2013). Water availability is one of the most important factor governing plant growth and development (Manivannan et al., 2007). Among the many studies covering the influence of drought on plant growth, Kalefetoğlu and Ekmekçi (2009) confirmed that drought causes reduction in vegetative growth of chickpea (*Cicer arietinum*). Plant growth and development are commonly influenced by drought. In addition, drought level directly influences the severity of the impact on growth (Baeck et al., 2001).

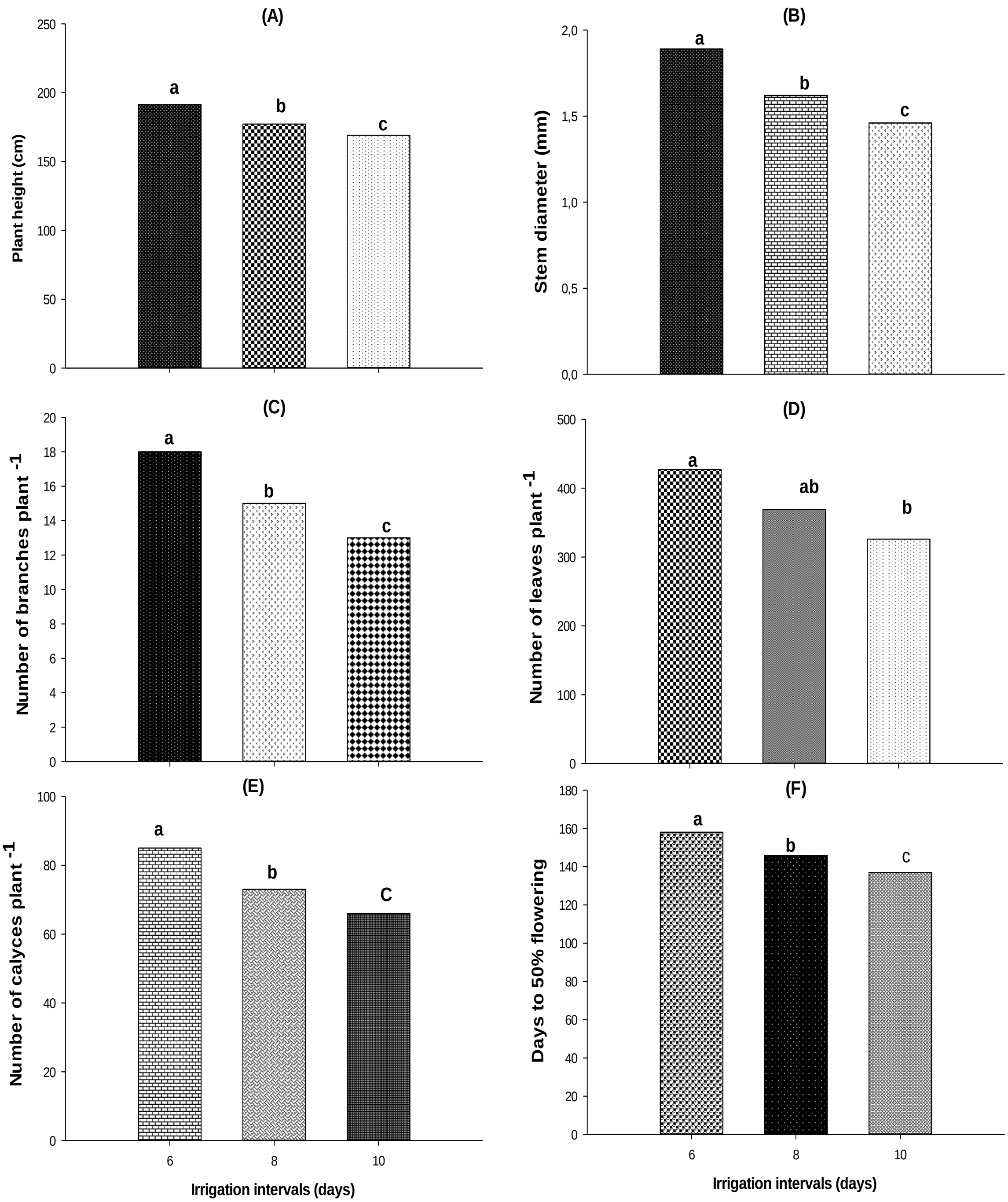

Figure 1: Growth and Yield related attributes of Roselle as influenced by different irrigation intervals

Figure 2: Some pictures of experimental study

The decrease in leaf growth might be attributed to the reduction in cell elongation that led to minimize cell turgor, cell volume and eventually the cell growth. The reduction in cell growth is due to the blockage of xylem and phloem vessels (Boyer, 1982) that was a barrier in translocation of the photo-assimilates to the targeted area, hence affecting the vegetative growth including number of branches plant^{-1} (Choi et al., 2000; Ayodele, 2001).

Number of leaves plant^{-1}

The statistical analysis of data showed that number of leaves plant^{-1} was significantly influenced by irrigation intervals (Figure 1). The highest number of leaves plant^{-1} (427) were recorded in the plots irrigated in plots irrigated at 6 days intervals compared to other irrigation intervals (369,326 respectively).The number of leaves plant^{-1} were increased by irrigation of roselle plants at 6 days intervals because more water applied during irrigation was used by the plant for growth. The decrease in number of leaves due to low water availability may be because of decrease in chlorophyll content through metabolic impairment or stomatal closure (Lawson et al., 2003; Anjum et al., 2003). Drought stress reduces the plant growth by influencing various physiological as well as biochemical functions such as photosynthesis, chlorophyll synthesis, nutrient metabolism, ion uptake and translocation, respiration, as well as carbohydrates metabolism (Farooq et al., 2008; Li et al., 2011). Drought stress have negative effect in reducing growth parameters that might be due to drop in leaf relative water content which inhibit leaf turgidity and osmosis as well as reduce the rate of cell division and cell elongation (Reddy et al., 2003).The increase in drought conditions, accumulation of salts and ions in the upper layers of the soil around the root cause osmotic stress and ion toxicity.

Number of Calyces plant^{-1}

Irrigation intervals significantly influenced number of calyces plant^{-1} of roselle plant (Figure 1). Plots irrigated at 8 and 10 days interval had lowest number of calyces plant^{-1} (73, 66), while the highest number of calyces plant^{-1} (85) were observed in plots irrigated at 6 days interval. The highest number of calyces plant^{-1} attained in plots irrigated with 6 days intervals might be attributed to the availability of soil moisture, nutrients uptake through soil solution and availability of water for efficient photosynthesis that are essential for plant growth and development (Khalil and Yousef, 2014).

Days to flowering

The results pertaining to days to flowering indicated that there was significant influence of irrigation intervals on days to flowering of Roselle. With increasing irrigation interval from 6 to 10 days, a significant decrease in days to flowering (158 to 137days) was recorded. With decrease in irrigation; days to flowering were also reduced due to low water availability. This might be due to stress of drought and injury which causes earlier flowering (Alam, 2013). Water stress leads to stomatal closure, reducing water potential and CO_2 uptake, thus leading to inhibition of photosynthesis (Khan et al., 2010; Prasch and Sonnewald, 2015). In addition to an indirect effect via inhibition of photosynthesis, high temperature and water stress also directly affect reproductive growth (Hedhly, 2011; Snider and Oosterhuis, 2011; Zinn et al., 2010). These abiotic stresses caused floral bud abortion and reduced flower number, leading to poor reproductive performance (Muhl et al., 2013).

CONCLUSION

Conclusively, the current results indicated that irrigation intervals singnificantly ınfluenced growth and yield related attributes of roselle. Growth, phenologıcal and yİeld related attrıbutes of roselle were enhanced when the plants were irrigated with 6 days intervals as compared to irrigation intervals of 8 or 10 days. It was concluded that Roselle plants could be irrigated at six (06) days interval for better growth and production under the agro-climatic conditions of Peshawar.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Conceived and designed the experiments: NA and MA, Performed the experiments: NA and SA. Analyzed the data: NA. Contributed materials/ analysis/ tools: AMK, AR, ZH and AB. Wrote the paper: IU & AB. Reviewed the manuscript: AB. All authors read and approved the final version.

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