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EFFECT OF IRRIGATION INTERVALS AND SALICYLIC ACID ON QUALITY ATTRIBUTES OF CARROT (*DAUCUS CAROTA* L.)

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ABSTRACT

A field experiment was conducted to study the effect of irrigation intervals and salicylic acid on root and seed production of carrot (*Daucus carota* L.) during *Rabi* seasons 2021–22 and 2022–23 at Horticulture Farm, S.K.N. College of Agriculture, Jobner, Rajasthan, India. The experiment consisted of twenty treatment combinations, including four levels of irrigation intervals and five foliar sprays of salicylic acid. The experiment was conducted in a strip plot design (SPD) and replicated thrice. Results revealed that application of irrigation with an interval of 6-day along with a double foliar spray of SA @ 75 ppm at 25 and 50 DAS significantly increased the quality attributes *i.e.*, nitrogen (0.923 and 0.958%), phosphorus(0.289 and 0.290%), potassium (0.354 and 0.356%), TSS (9.00 and 9.20%) and β-carotene (6.70 and 7.14 mg/100 g) content of carrot, respectively, in comparison to the rest of the treatments except irrigation at 4-day and 8 day intervals in pooled analysis, which were statistically at par to each other.

Key words : Salicylic Acid, Irrigation, SPD, β-carotene and TSS.

Introduction

Carrot is a popular cool season vegetable cultivated in tropical region during winter. Carrot (*Daucus carota* L.) with chromosome number 2n=18 belonging to the family Umbelliferae is one of the important root vegetable crops. It produces edible root of good quality in one season and seed in next seasons. Carrot was originated from Afghanistan. It covers an area of 126 thousand ha in India with production 2413 thousand tonnes (Anonymous, 2023-24).

Among all vegetables, carrot is known for its high nutritional value and used in making different palatable dishes. The edible part of carrot is enlarged fleshy taproot consisting of cortex (phloem) and core (xylem). Good quality carrot roots have a maximum of cortex and minimum of core. The primitive purple and yellow carrots were source for evolution of modern-day edible carrots (Bradeen and Simon, 2007; Simon *et al*., 2008), which have diverse colours *i.e.* red (lycopene), orange (β-carotene), black (anthocyanin), white (lutein) and yellow (xanthophylls). Carrot is typically of two types, namely (i) Asiatic/tropical type, which form edible roots and produce seeds profusely in tropical and sub-tropical climate without vernalization requirement and (ii) the temperate or European type which forms good quality roots in cool months in sub-tropical environment, but needs vernalization to initiate bolting (initiation of flower stalk). In India, tropical carrots are preferred for juice, pudding (gajarhalwa), vegetable, fresh salad and pickle purposes (Kushlaf and Kalia, 2012), but remain available in winter season only while European/ temperate type are available throughout the year due to their storability. Kanji an appetizing drink is also prepared from black colour roots of carrot (Chadha *et al.*, 2003).

Arid and semi-arid zones of Rajasthan are known for water scarce conditions because of low and erratic rainfall. In this regions mainly surface irrigation methods are predominantly adopted by the farmers, the heavy

conveyance and water application results in water logging, salinity and nutrient leaching (Bhagyawant *et al*., 2014). Looking to the factof irrigation at different intervals and salicylic acid were applied in the present investigation.

Salicylic acid is helpful to reduce the Na uptake in plants or increases the uptake of N, P, K, Ca, Mg and the other minerals as compared to control under salt stress. The environment is greatly affected by climatic changes resulting in both biotic and abiotic stresses. Stresses occurring at the primary and secondary levels lead to abiotic stresses that consequently affect the growth, quality and yield of crop plants (Prajapati *et al*., 2015)

Materials and Methods

An experiment entitled effect of irrigation intervals and salicylic acid on root and seed production of carrot (*Daucus carota* L.) was carried out at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Rajasthan during winter (*Rabi*) seasons of 2021–22 and 2022–23. This region falls in agro-climatic zone III-a, which is referred as semi-arid eastern plains of Rajasthan (India). The soil of the experimental field was loamy sand with pH 8.20. Astrip plot design (SPD) with 3 replications was used for this experiment. Seeds were sown in the field on second week of October 2021 and 2022 with a plot size of 1.0 m × 9.0 m and spacing of 30 cm × 15 cm. in raised beds. The crop was harvested in January 2022 and January 2023.

To execute the present study randomized treatment combinations were taken having irrigation intervals (I_2, 2-day intervals; I_4, 4-day intervals; I_6, 6-day intervals and I_8, 8-day intervals) and salicylic acid (S_0, control (water spray); S_1, SA @ 50 ppm single spray at 25 DAS; S_2, SA @ 50 ppm double spray at 25 and 50 DAS; S_3, SA @ 75 ppm single spray at 25 DAS and S_4, SA @ 75 ppm double spray at 25 and 50 DAS. Irrigation was applied at different intervals as per treatment schedule throughout the growing season of the crop. The first irrigation was given immediately after seed sowing uniformly in all plots. The amount of irrigation water provided at one time to each bed was kept constant for each and every irrigation phase and this was independent of the different irrigation intervals and treatment with foliar application of salicylic acid applied as single spray @ 50 and 75 ppm at 25 days after sowing and double spray @ 50 & 75 ppm at 25 and 50 days after sowing. The recommended NPK dose for carrot as 60:40:120 kg/ha was applied through urea, single superphosphate and MOP. The full dose of phosphorus, potassium and half dose of nitrogen were applied before sowing of seed and the remaining half dose of nitrogen was applied at 30 DAS. Recommended cultivation practices were followed to raise the experimental crop successfully.

The data of various parameters, *viz*. nitrogen, phosphorus, potassium content, TSS % and carotene content of carrotwere noted by following methods:

Nitrogen content (%) : The samples collected at harvest from each plot were dried and thereafter ground to obtain a fine powder for estimating nitrogen content. The nitrogen content was estimated by using Nessler's reagent with colorimetric method (Snell and Snell, 1949).

Phosphorus content (%) : The samples collected at harvest from each plot were dried and thereafter ground to obtain a fine powder for estimating phosphorus content. Phosphorus was estimated by spectrophotometer method using triacid ammonium molybdate ammonium vanadete solution (Jackson, 1967).

Potassium content (%) : The samples collected at harvest from each plot were dried and thereafter ground to obtain a fine powder for estimating potassium content. Potassium content in roots was estimated by flame photometer method using triacid, potassium standard solution (Richards, 1954).

TSS (%) : The roots of the selected plant were crushed to form a homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determining TSS by hand refractometer. A few drops of juice were placed on the surface of the prism. The hinged part was placed back. The reading was noted by revolving the eyepiece at room temperature (A.O.A.C., 1980) and the average TSS content was calculated.

β-carotene content (mg/100g) : β-carotene content (mg/100g fresh weight) was determined by the method suggested by Ranganna (1986). Take 5 g of fresh sample and crush in 10-15 ml acetone, adding in a few crystals of anhydrous sodium sulphate with the help of a pestle and mortar. Decant the supernatant into a beaker. Repeat the process twice and transfer the combined supernatant to a separatory funnel and add 10-15 ml petroleum ether and mix thoroughly. Two layers will be separated out on standing. Discard the lower layer and collect the upper layer in 100 ml volumetric, make up the volume to 100 ml with petroleum ether and record by measuring the absorbance at 452 nm in a spectrophotometer as per the standard procedure. Optical value at 452 nm using petroleum ether as blank. The specific absorbance values tabulated by Davies (1976) will be used for the calculation of carotene using the formula:

$$\beta\text{-carotene (mg/100 g fresh weight)} = \frac{\text{Optical Density} \times 13.9 \times 10^4 \times 100}{\text{Weight of sample} \times 560 \times 1000}$$

Data obtained from two experimental years were statistically analyzed according to the procedure described by Gomez and Gomez (1984).

Results and Discussion

Effect of irrigation intervals on quality attributes

Applications of irrigation intervals have favourable effect on quality attributes. The data presented in Tables 1 and 2 and depicted in Figs. 1 and 2 showed differences in various parameters due to application of different irrigation intervals on root production of carrot. The nitrogen, phosphorus, potassium content, TSS % and β-carotene content of carrot were in general increased gradually with the successive growth and developmental stages of plant. Application of irrigation at 6-day intervals (I_6) significantly increased the nitrogen content (0.923%), phosphorus content (0.289%), potassium content (0.354%), TSS% (9.00%) and β-carotene content (6.70 mg/100 g) of carrot followed by 4-day irrigation intervals (I_4) and 8-day irrigation intervals (I_8), which were statistically at par to itin pooled analysis.

Increased nitrogen, phosphorus, potassium, TSS and β-carotene content in carrot roots with irrigation may be due to the fulfillment of crop water demand and better utilisation of nutrients under optimum moisture availability. The beneficial role of irrigation water in increasing the cation exchange capacity of roots, chlorophyll formation, regulating auxin concentration and its stimulatory effect on most of the physiological and metabolic processes of plants might have helped plants in the absorption of the more significant amount of nutrients from the soil, photosynthates and their translocation of different plant parts, which ultimately increased the concentration of nutrients in the plant.

The results align with the findings of Kumariand Devi (2020) in cauliflower, Bhatti *et al.* (2019) in onion and Zepina *et al.* (2014) in carrot.

Irrigating too frequently, *i.e.*, 2-day interval creates a very humid region in the root zone, which affects nutrient concentration negatively due to potential leaching. Where root growth and function are affected by

Table 1 : Effect of irrigation intervals and salicylic acid on nitrogen, phosphorus and potassium content of carrot.

Treatments	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Irrigation Intervals									
I_2- 2-day intervals	0.760	0.780	0.770	0.247	0.250	0.249	0.297	0.301	0.299
I_4- 4-day intervals	0.905	0.925	0.915	0.282	0.288	0.285	0.347	0.354	0.351
I_6- 6-day intervals	0.910	0.936	0.923	0.286	0.291	0.289	0.350	0.357	0.354
I_8- 8-day intervals	0.901	0.919	0.910	0.279	0.285	0.282	0.345	0.351	0.348
SEm±	**0.004**	**0.004**	**0.003**	**0.003**	**0.003**	**0.002**	**0.004**	**0.003**	**0.002**
CD (P=0.05)	**0.015**	**0.012**	**0.008**	**0.011**	**0.010**	**0.007**	**0.013**	**0.011**	**0.007**
Salicylic acid									
S_0 Control (Water spray)	0.777	0.799	0.788	0.241	0.247	0.244	0.300	0.310	0.305
S_1- SA @ 50 ppm SS (at 25 DAP)	0.833	0.854	0.844	0.277	0.280	0.278	0.334	0.341	0.337
S_2- SA @ 50 ppm DS (at 25 and 50 DAP)	0.936	0.958	0.947	0.286	0.291	0.288	0.349	0.353	0.351
S_3- SA @ 75 ppm SS (at 25 DAP)	0.853	0.870	0.861	0.278	0.281	0.279	0.337	0.343	0.340
S_4- SA @ 75 ppm DS (at 25 and 50 DAP)	0.946	0.969	0.958	0.287	0.293	0.290	0.355	0.357	0.356
SEm±	**0.007**	**0.005**	**0.004**	**0.003**	**0.003**	**0.002**	**0.004**	**0.003**	**0.002**
CD (P=0.05)	**0.021**	**0.017**	**0.012**	**0.010**	**0.009**	**0.007**	**0.012**	**0.010**	**0.007**

SA= Salicylic acid, SS= Single spray, DS= Double spray and DAS= Days after sowing.

Table 2 : Effect of irrigation intervals and salicylic acid on TSS and β-carotene content of carrot.

Treatments	TSS (%)			β-carotene content (mg/100g)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Irrigation Intervals						
I_2- 2-day intervals	7.55	7.62	7.59	5.63	5.65	5.64
I_4- 4-day intervals	8.84	8.96	8.90	6.60	6.68	6.64
I_6- 6-day intervals	8.95	9.05	9.00	6.68	6.71	6.70
I_8- 8-day intervals	8.75	8.84	8.80	6.59	6.64	6.62
SEm±	**0.12**	**0.12**	**0.08**	**0.05**	**0.05**	**0.04**
CD (P=0.05)	**0.40**	**0.41**	**0.25**	**0.16**	**0.19**	**0.11**
Salicylic acid						
S_0 Control (Water spray)	7.71	7.92	7.82	5.74	5.80	5.77
S_1- SA @ 50 ppm SS (at 25 DAS)	8.28	8.43	8.35	5.93	6.00	5.97
S_2- SA @ 50 ppm DS (at 25 and 50 DAS)	9.04	9.11	9.07	7.02	7.01	7.02
S_3- SA @ 75 ppm SS (at 25 DAS)	8.35	8.47	8.41	6.04	6.14	6.09
S_4- SA @ 75 ppm DS (at 25 and 50 DAS)	9.23	9.16	9.20	7.15	7.14	7.14
SEm±	**0.13**	**0.13**	**0.09**	**0.05**	**0.06**	**0.04**
CD (P=0.05)	**0.42**	**0.42**	**0.27**	**0.17**	**0.18**	**0.12**

SA= Salicylic acid, SS= Single spray, DS= Double spray and DAS= Days after sowing.

inadequate oxygen diffusion into the root zone. In addition, when the soil is too wet, the parenchyma cells in the xylem of the root expand quickly, but the cells in the phloem and periderm cannot expand accordingly, causing root cracking and rotting, ultimately reducing root quality. The results are supported by the findings of Wan and Kang (2005) in radish.

Effect of salicylic acid on quality attributes

The application of salicylic acid had favourable effect on quality parameters in carrot. The data presented in Tables 1 and 2 and depicted in Figs. 1 and 2 showed that double spray of SA @ 75 ppm at 25 and 50 DAS significantly increased the content of nitrogen (0.958%), phosphorus (0.290%), potassium (0.357%), TSS (9.20%) and β-carotene (7.14 mg/100 g) of carrotover rest of the treatments. However, treatment S_2 (double spray of SA @ 50 ppm at 25 and 50 DAS) was found statistically at par to it in pooled analysis.

The increase in NPK content in the plants might be due to the application of salicylic acid. This may be attributed to the role of salicylic acid in stimulating plant growth, the absorption and transport of nutrients, membrane permeability, growth rate and photosynthesis (Basra *et al.*, 2007; Al-Rubaye and AbdAtia, 2016). Additionally, salicylic acid is an internal growth bio-regulator involved in regulating physiological processes in plants, contributing to modify the activity of antioxidant enzymes and improve the process of photosynthesis, nutrient uptake, the activity of phenolic antioxidants and many vital metabolic compounds (Khandaker *et al.*, 2011). Where, it works as an antidote, oxidative contributes to scavenging free roots and thus protects cell membranes and thus gets the absorption and transport of nutrients better (Mady, 2009); it also leads function in protecting the nucleic acids and protein to prevent crashes (Amanullah *et al.*, 2010). The results of increased phosphorus content in the plants due to the foliar spray of salicylic acid coincide with those reported by Karlidag *et al.* (2009) on strawberries.

There was an increase in TSS content in carrot might be due to the foliar application of salicylic acid. This enhancement of TSS content can be attributed to the role of salicylic acid in improving membrane permeability, absorption and utilisation of mineral nutrients. Some research indicated that salicylic acid increased membrane permeability, which could facilitate the absorption and utilisation of mineral nutrients and the transport of assimilates (Barkosky and Einhellig, 1993 and Gunes *et al.*, 2005). Data obtained from the present study agree with other studies, which indicated that salicylic acid maintained higher concentrations of total soluble solids in cowpea (Chandra *et al.*, 2007) and tomato (Javaheri *et*

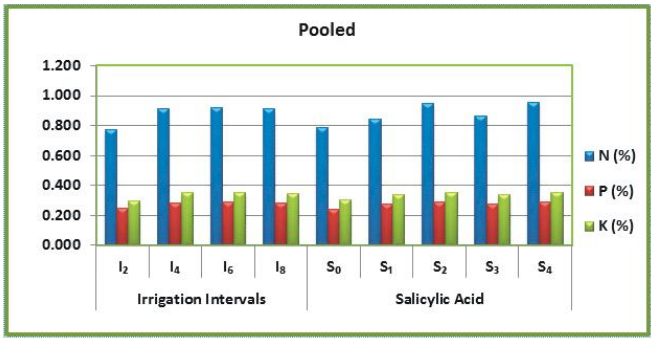

Fig. 1 : Effect of irrigation intervals and salicylic acid on nitrogen, phosphorus and potassium content (%) of carrot in pooled mean analysis.

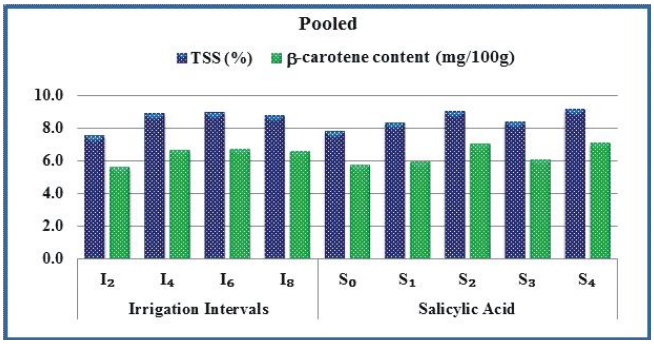

Fig. 2 : Effect of irrigation intervals and salicylic acid on TSS % and b-carotene content (mg/100 g) of carrot in pooled mean analysis.

al., 2012). Salicylic acids increase carotene content, accelerate the photosynthesis process and increase the activity of some essential enzymes. In addition, treatment with salicylic acid increases plant hormone levels like auxins and cytokinins, which leads to increased vegetative growth (Abdul-wahid *et al.*, 2012).

Conclusion

Based on the results of two years experimentation for carrot root production, it may be concluded that application of irrigation at 6-day intervals as well as double spray of SA @ 75 ppm at 25 and 50 DAS were significantly increased the nitrogen, phosphorus, potassium, TSS% and β-carotene content in root of carrot in comparison to the rest of the treatments except 4-day irrigation intervals (I_4) and 8-day irrigation intervals (I_8) along with a double spray of SA @ 50 ppm at 25 and 50 DAS, which were statistically at par to it during both the years as well as in pooled analysis. Thus, the findings of the experiment led to the conclusion that the application of irrigation either at 6-dayor 8-day intervals along with double spray of SA @ 75 and 50 ppm at 25 and 50 DAS recommended for semi-arid condition of Rajasthan.

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