Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Evaluation of Growth, Yield and Quality of Head Lettuce in Response to Salicylic Acid Foliar Spraying

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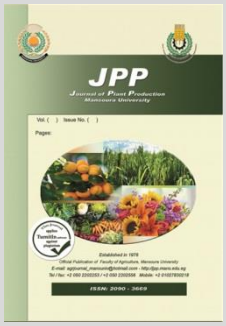

ABSTRACT

In order to evaluate the growth and quality of head lettuce cv. Big bin (Capuchi) in response to salicylic acid at different rates and dates of application as foliar spray, a field experiment was done during seasons of 2022 and 2023. The current study established at the Experimental farm, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt. Four rates of salicylic acid (0.0, 0.1, 0.2 and 0.3 g/l) at different dates of application (30, 40 and 50 days) and their combinations were applied to enhance lettuce growth and productivity. The obtained results pointed out that sprayed lettuce plants with salicylic acid at 0.2 g/l significantly enhanced growth traits such as, plant height, fresh weight of foliage and leaves per plant. As well as, leaves numbers and area per plant, chlorophyll content and NPK percentages in outer leaves, head yield and its physical and chemical quality compared to the other concentrations under study. The highest values in these growth traits, leaves chemical constituents and heads yield and their quality was achieved when lettuce plants sprayed at early date (at 30 days after transplanting) compared to mid and late dates of season growth. In general, sprayed lettuce plants at early date 30 days from planting with salicylic acid 0.2 g/l significantly improved head lettuce cv. Big bin growth, yield and quality compared to the other combination treatments under Dakahlia Governorate conditions.

Keywords: Lettuce, Salicylic acid, Foliar-spraying dates, Nitrate content, Head lettuce quality.

INTRODUCTION

Globally, lettuce (*Lactuca sativa* L.), a member of the *Compositae* family, is becoming more and more popular (Kim *et al*., 2016). According to Labeda *et al*. (2007) and Chiesa *et al.* (2009), it is usually eaten fresh or in salads. This vegetable is reported to provide a multitude of health benefits because of its high phytonutrient content, high vitamin K and A contents, beta-carotene content, fiber content, phenolic compounds, and minerals including calcium, phosphorus, potassium, manganese, and iron (Mulabagal *et al.*, 2010; Xylia *et al*., 2021).

The total Capuchi Head lettuce cultivated area in 2020 in Egypt was 588 feddan (284 feddan in new land and 304 feddan in old land), which produced 4846 tons (2840 tons from new land and 2006 tons from old land) with average 8.241 tons /feddan (10.0 tons /feddan in new land and 6.6 tons/ feddan in old land) according to Statistics of the Ministry of Agriculture (2020).

The Latin word "Salix," which refers to the *Salix safsaf* tree, is where salicylic acid (SA) originated. It is placed within the category of plant hormones and is widely distributed throughout the entire kingdom of plants (Raskin *et al*., 1990). SA plays an active part in the intake and transport of ions in plants. According to Arfan *et al*. (2007), it can also have a significant impact on plant growth, water relations and photosynthesis.

Youssef *et al*. (2017) reported that the application of 1.5 mM salicylic acid spraying resulted in the highest significant values of chlorophyll (a, b and total), leaf relative water content, macro- and micronutrients and growth parameters (plant length, head diameter, fresh and dry weights of head, number of leaves/lettuce head, average leaf area and leaf area index). In addition, lettuce growth parameters (plant height and plant biomass) were significantly enhanced when plants sprayed with 1 mM SA rate (Bankole *et al*., 2018). Also, the efficiency of salicylic acid in improving lettuce whole plant dry weight and total chlorophyll content as SPAD units (Zekiye *et al*., 2023), outer and inner leaves weight per plant as well as head weight per plant and total yield (Al-Khafaji and Al-jubouri, 2023) were reported.

Therefore, this work aimed to evaluated the profitable effects of foliar spraying of salicylic acid (SA) at different rates combined with dates of applications in terms of enhanced growth, heads yield and their physical and chemical quality of Capuchi lettuce (*Lactuca sativa*, L.) cv. Big bin under Dakahlia Governorate conditions, Egypt.

MATERIALS AND METHODS

At the Experimental Station, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt, a field experiment conducted during the two winter seasons of 2022 and 2023 utilizing a surface irrigation system under clay loamy soil conditions. This to evaluate the response of vegetative growth and productivity of head lettuce (Capuchi) cv Big bin to exogenous foliar application with salicylic acid at four rates (0, 0.1, 0.2, and 0.3 g/l) at different dates of application (30, 40 and 50 days) and their combinations. Physical and chemical analyses of soil were tabulated in (Table 1) according to Chapman and Pratt (1978).

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DOI: 10.21608/jpp.2024.300485.1351

Table 1. Physical and chemical characters during the both seasons of 2022 and 2023

Seasons	Silt %	Clay %	Sand %	Texture soil	PH	E.C (dSm^{-1})	Organic matter %	$CaCO_3$ %	N ppm	P ppm	K ppm
1st season	41.3	37.2	21.5	Clay loamy	8.12	1.73	1.93	3.07	53.9	6.6	289
2nd season	41.4	37.5	21.1	Clay loamy	8.19	1.79	2.01	3.01	52.3	6.7	278

Plant cultivation:

On October 16 and 15, in both seasons, lettuce transplants cv. Big bin, 40 days old were placed at a distance of 35 cm apart on two sides of the ridge (30000 plants per feddan). The plot unit, which measured 11.2 m^2, made up of four ridges that were 3.5 m long and 0.8 m wide.

Salicylic acid application:

Salicylic acid was dissolved in absolute ethanol then added distilled water (ethanol/water: 1/100, v/v) to make stock solution to use in prepare the four rates (0.0, 0.1, 0.2 and 0.3 g/l) of salicylic acid spray solutions. Foliar application of lettuce plants sprayed during early morning using a hand-held sprayer at rate of 200 L/ feddan. Foliar application performed at different dates during both 1st and 2nd growing seasons as following:

- Early date at 30 days from transplanting.
- Mid date at 40 days from transplanting.
- Late date at 50 days from transplanting.

Fertilization rates and times:

Fertilization of lettuce plants was carried out using 40 units of nitrogen as ammonium nitrate (33.5 % N), 40 units of phosphorus as single calcium superphosphate (12.5 % P_2O_5) and 36 units of potassium as potassium sulfate (48% K_2O). During the soil preparation process, all single calcium superphosphate and half dose of the potassium sulfate added. During the first watering, the potassium sulfate dose reminder added. Before the first and second irrigation times, ammonium nitrate was supplied in equal doses. During soil preparation, farmyard manure spread at rate of 20 m^3 / feddan.

Experimental design:

A split-plot in randomized complete block design with three replications used to set up the experiment. The main plots of salicylic acid organized into four rates, and the subplots allocated three dates of applications.

Measurements:

Five lettuce plants randomly chosen from each plot after 65 days from planting date to determine the following parameters for the two seasons.

1- Vegetative growth characters:

Plant height (cm), foliage (outer and inner stem plus outer and inner leaves) weight per plant (g), leaves fresh weight /plant (g), leaves number /plant and leaves area (cm^2) /plant was calculated as relation between area unit and fresh weight of leaves (Koller, 1972) using the following equation: Leaves area = (Disk area x No. of disks x fresh weight of leaves)/ (Fresh weight of disks)

2 – Chemical composition of outer leaves:

Chlorophyll a, chlorophyll b, carotenoids, N, P and K percentage were analyses according to AOAC (1990).

Head lettuce were harvested at 70 days from planting, and total yield measured depending on plot yield and 5 random plants per plot chosen to determine head quality traits as follow:

3- Heads yield and its physical qualities:

- Average head weight (g) /plant (inner and outer leaves plus inner stem)
- Edible head weight (g) /plant (inner stem plus inner leaves)
- Edible head diameter (cm).
- Edible head compactness rate according to (Riad *et al*., 2009). Where theoretically compactness rating of 1 means the edible head is very compact and it contains no air. The lower rate the more compactness and vice versa.

$$\text{Compactness rate} = \frac{\text{edible head volumes } (0.75 \times 3.14 \times \text{radius}^3)}{\text{edible head weight}}$$

- Total heads yield (ton/ feddan)

4- Heads chemical qualities:

- Outer and inner leaves dry matter percentage.
- Vitamin C (mg/ 100 g as fresh weight), TSS (%) and nitrate (NO_3 mg/ Kg dry weight) contents were determined in inner leaves according to AOAC (1990).

Statistical analysis:

All data were statistically analyzed using the analysis of variance according to Snedecor and Cochran (1980). Least significant difference (LSD) at the probability of 5 % used due to the procedure reported by (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of salicylic acid treatments on head lettuce growth characters:

Results presented in Table 2 reveal that the tallest plants (20.4 and 21.0 cm), heaviest fresh weight of foliage (1101 and 1130 g/plant), more leaves number (36.8 and 37.7 leaves/plant), largest leaves area (6107 and 6271 cm^2 / plant), and heaviest leaves fresh weight (991.0 and 1017.6 g /plant) were achieved when lettuce plants sprayed with SA at 0.2 g/l in 1st and 2nd seasons, respectively. Generally, all salicylic acid rates (0.1, 0.2 and 0.3 g/l) significantly increased all vegetative growth characters of lettuce compared to control (unsprayed plants) in both seasons.

Delaying the date of application of salicylic acid gradually decreased all lettuce vegetative growth characters in the two seasons (Table 2). Furthermore, adding SA early date during growing season gave the highest values of plant height, foliage and leaves fresh weights per plant as well as leaves number and area per plant in the two consecutive seasons.

In general, under each salicylic acid rate, delaying SA application during season led to a gradual decrease in growth characters of lettuce were noticed (Table 2) as descending curve. The best combination treatment was 0.2 g/l rate applied at early growing season. Regard the enhancement of plant height (22.7 and 23.4 cm), foliage fresh weight (1221 and 1258 g/ plant), number of leaves (40.8 and 42.0 leaves/plant), leaves area (6778 and 6981 cm^2/plant) and leaves fresh weight (1099.8 and 1132.7 g/ plant) compared to the other combination treatments under study.

It has been demonstrated that salicylic acid strengthens the immune system within plant cells, hence enhancing the physiological mechanism of the plant at the first stage of growth that support plant to accumulate more nutrients and enhancing vegetative growth rate. The results of Stevens *et al.* (2006), which showed that salicylic acid supports photosynthesis, transpiration rate, conductance of stomatal cells, and membrane integrity, are consistent with the current findings. These results are in line with those reported by Shehata *et al*. (2020) on lettuce and Naz *et al*. (2022) on pea (*Pisum sativum* L.) plants. In the

same way, El-Taher *et al.* (2022) reported that spraying SA 100 ppm at 6 and 8 week from planting, increased the plant height, number of compound leaves, fresh weights of leaves and productivity of the cowpea plants compared with the control.

Table 2. Impact of rates and dates of foliar application with salicylic acid on vegetative growth characters of head lettuce during the two seasons of 2022 and 2023

Treatments		Plant Height (cm).		Foliage FW g / plant		Leaves No / plant		Leaves area (cm^2) / plant		Leaves FW g / plant	
		1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s
Rates of foliar spray with salicylic acid g/l											
zero		17.8	18.3	961	987	32.1	32.9	5333	5476	856.4	888.6
0.1		20.1	20.6	1081	1110	36.1	37.1	5997	6157	973.1	999.1
0.2		20.4	21.0	1101	1130	36.8	37.7	6107	6271	991.0	1017.6
0.3		18.3	18.8	985	1012	32.9	33.8	5467	5613	887.1	910.9
LSD 5%		0.2	0.4	15	19	0.4	0.8	84	90	13.6	14.1
Dates of application of salicylic acid											
Early		19.8	20.4	1066	1098	35.6	36.7	5914	6091	959.6	988.4
Mid		19.3	19.8	1039	1066	34.7	35.5	5767	5917	953.7	960.0
Late		18.4	18.8	991	1015	33.1	33.9	5499	5631	892.2	913.6
LSD 5%		0.2	0.3	11	14	0.4	0.6	65	71	10.7	11.0
Interaction											
	Early	17.8	18.3	959	987	32.1	33.0	5319	5478	863.1	889.0
zero	Mid	17.9	18.4	964	989	32.2	33.0	5350	5490	868.2	890.8
	Late	17.8	18.3	961	984	32.0	32.8	5332	5460	865.1	885.9
	Early	20.3	20.9	1090	1123	36.3	37.6	6051	6233	981.8	1011.3
0.1	Mid	21.4	21.8	1146	1175	38.3	39.3	6357	6522	1031.5	1058.3
	Late	18.7	19.1	1006	1030	33.7	34.3	5584	5718	906.1	927.8
	Early	22.7	23.4	1221	1258	40.8	42.0	6778	6981	1099.8	1132.7
0.2	Mid	19.7	20.2	1059	1087	35.6	36.1	5876	6029	953.5	978.3
	Late	19.0	19.4	1021	1046	34.1	35.0	5668	5804	919.7	941.8
	Early	18.5	19.0	993	1022	33.2	34.1	5508	5673	893.8	920.6
0.3	Mid	18.4	19.9	988	1014	33.0	33.8	5483	5626	889.7	912.8
	Late	18.1	18.5	975	999	32.6	33.5	5412	5541	878.1	899.2
LSD 5%		0.4	0.6	24	30	0.8	1.3	136	147	22.1	22.8

Early: at 30 days after planting (DAP); Mid: at 40 DAP; Late: at 50 DAP; FW: fresh weight

Effect of salicylic acid treatments on pigments and NPK percentages of head lettuce:

Chlorophyll a, b and carotenoids contents (mg/100 g as fresh weight) as well as nitrogen, phosphorus and potassium percentages significantly increased by utilizing salicylic acid at any rate compared to control in 1st and 2nd seasons (Table 3). The medium rate of SA (0.2 g/l) gave the highest values in pigments and NPK % of outer leaves of lettuce plant compared to the other rates under study in the two seasons.

The highest values of chlorophyll a content (63.7 and 65.6 mg/ 100 g fresh weight), chlorophyll b content (31.0 and 31.9 mg/ 100 g fresh weight), and carotenoids content (21.6 and 22.3 mg/ 100 g fresh weight). As well as total nitrogen percentage (4.12 and 4.24 %), total phosphorus percentage (0.488 and 0.502 %) and potassium percentage (4.04 and 4.63 %) were noticed when lettuce plants sprayed at early growing season in the 1st and 2nd seasons, respectively, compared to the other dates of application under study (Table 3).

Table 3. Impact of rates and dates of foliar application with salicylic acid on pigments, N, P and K in outer leaves of head lettuce during the two seasons of 2022 and 2023

Treatments		Chl. a mg/100 FW		Chl. b mg/100 FW		Carotenoids mg/100g FW		N %		P %		K %	
		1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s
Rates of foliar spray with salicylic acid g/l													
zero		57.4	59.0	27.9	28.7	19.5	20.0	3.72	3.81	0.440	0.457	4.05	4.16
0.1		64.6	66.3	31.4	32.3	21.9	22.5	4.18	4.29	0.495	0.508	4.56	4.68
0.2		65.8	67.5	32.0	32.8	22.3	22.9	4.25	4.37	0.504	0.517	4.64	4.77
0.3		58.9	60.4	28.6	29.4	20.0	20.5	3.81	3.91	0.451	0.463	4.15	4.27
LSD 5%		0.9	1.0	0.4	0.5	0.3	0.4	0.05	0.07	0.005	0.007	0.06	0.07
Dates of application of salicylic acid													
Early		63.7	65.6	31.0	31.9	21.6	22.3	4.12	4.24	0.488	0.502	4.49	4.63
Mid		62.1	63.7	30.2	31.0	21.1	21.6	4.02	4.12	0.476	0.492	4.38	4.50
Late		59.2	60.6	28.8	29.5	20.1	20.6	3.83	3.92	0.454	0.464	4.18	4.28
LSD 5%		0.7	0.7	0.3	0.4	0.2	0.3	0.04	0.05	0.006	0.006	0.04	0.06
Interaction													
	Early	57.3	59.0	27.9	28.7	19.4	20.0	3.71	3.82	0.439	0.452	4.04	4.16
zero	Mid	57.6	59.1	28.0	28.8	19.6	20.1	3.73	3.82	0.442	0.470	4.07	4.18
	Late	57.3	58.8	27.9	28.6	19.5	19.9	3.71	3.80	0.440	0.450	4.05	4.15
	Early	65.2	67.1	31.7	32.6	22.1	22.8	4.22	4.34	0.499	0.514	4.60	4.74
0.1	Mid	68.5	70.2	33.3	34.2	23.2	23.8	4.43	4.55	0.525	0.538	4.83	4.96
	Late	60.1	61.6	29.2	29.9	20.4	20.9	3.89	3.99	0.461	0.472	4.24	4.35
	Early	73.0	75.2	35.6	36.6	24.8	25.5	4.72	4.86	0.559	0.576	5.15	5.31
0.2	Mid	63.3	64.9	30.8	31.6	21.5	22.0	4.09	4.20	0.485	0.498	4.47	4.58
	Late	61.0	62.5	29.7	30.4	20.7	21.2	3.95	4.04	0.468	0.479	4.31	4.41
	Early	59.4	61.1	28.9	29.7	20.1	20.7	3.84	3.95	0.455	0.468	4.19	4.31
0.3	Mid	59.0	60.6	28.7	29.5	20.0	20.5	3.82	3.92	0.452	0.464	4.17	4.28
	Late	58.3	59.7	28.3	29.0	19.8	20.3	3.77	3.86	0.446	0.457	4.11	4.21
LSD 5%		1.4	1.5	0.7	0.8	0.4	0.6	0.09	0.11	0.010	0.012	0.10	0.11

Early: at 30 days after planting (DAP); Mid: at 40 DAP; Late: at 50 DAP; FW: fresh weight

Data tabulated in Table 3 reveal that the combination treatment between salicylic acid rate (0.2 g/l) and early date application during season significantly increased chemical constituents of outer leaves of lettuce compared to control and the other combinations under study in both seasons. In general, earlier SA addition under each SA rate increased Chlorophyll a, b and carotenoids contents as well as nitrogen, phosphorus and potassium percentages in lettuce outer leaves. Readings related to the fact that salicylic acid play a vital role in decreases chlorophyll degradation (Raskin, 1992). As well as, El-Taher *et al.* (2022) clear that spraying cowpea plant with 100 ppm SA at 6 and 8 week from planting, increased photosynthetic pigments content, and concentrations of N, P, and K in leaves compared with the control.

The efficacy of exogenous SA depends on a number of factors, including the developmental stage and SA concentration. SA influences physiological and biological processes in plants and employed as a possible growth regulator to increase plant growth (Borsani *et al*., 2001). Also, spraying SA enhanced N, P, and K accumulation in leaves in both seasons, according to Ibrahim *et al.* (2006). When compared to untreated plants, the lettuce plants sprayed with 100 ppm of SA accumulated the highest amounts of N, P, and K. Moreover, the application of SA was favorably connected with improved uptake of vital minerals in pepper leaves, specifically calcium, magnesium, and potassium. The application of SA had no effect on the levels of carotenoid and chlorophyll (Gülüt and Taze, 2024). Nada and Abd El-Hady (2019) cleared that spraying SA at 0.3 g/l increase leaf content of chlorophyll and carotenoids pigment as well as content of N, P and K compared to other treatment 0.0, 0.15 and 0.45 g/l in cucumber plant under water stress.

Effect of salicylic acid treatments on heads yield and its physical quality of lettuce:

Data recorded in Table 4 indicate that lettuce plants sprayed with SA at 0.2 significantly increased head fresh weight (1033 and 1061 g/ plant), edible head fresh weight (720 and 739 g/ plant), head diameter (20.8 and 21.3 cm), compactness (3.70 and 3.91) and total heads yield (31.01 and 31.85 tons/feddan) in 1st and 2nd seasons, respectively. Compared to control and the other rates in both seasons. Generally, all SA rates significantly enhanced heads yield and its physical quality compared to control.

Data in Table 4 show that earlier spraying of salicylic acid during season increased heads yield and its physical quality in both seasons more than late date spraying. The highest values of head fresh weight /plant, edible head fresh weight /plant, diameter and its compactness and total heads yield /feddan achieved when lettuce plants sprayed early date.

Spraying SA at 0.2 g/l rate during early date of growing season caused significant increases in head fresh weight /plant, edible head fresh weight /plant, diameter and its compactness and total heads yield /feddan in the two tested seasons. In general, delay SA application dates under any SA rate gradually decreased heads yield and its physical quality.

The stimulatory impact of salicylic acid on endogenous phytohormones, particularly growth promoters like auxins, gibberellins, and cytokinins, may be responsible for the stimulatory effect of salicylic acid on yield and its quality (Shakirova, 2007 and Mady, 2014). In addition, foliar application of salicylic acid significantly increased tubers yield and its physical quality of potato compared to untreated plants (Metwaly and El-Shatoury, 2017).

Effect of salicylic acid treatments on chemical quality of head lettuce:

Vitamin C (mg/ 100 g as fresh weight), TSS (%), edible head NO_3 (mg/kg as dry weight) and dry matter of outer and inner leaves (%) were significantly increased with 0.2 g/l rate of salicylic acid rate compared to the other rates under study in both seasons (Table 5). All SA rates significantly improved chemical quality of lettuce heads in comparison with control.

Table 4. Impact of rates and dates of foliar application with salicylic acid on heads yield and its physical quality of head lettuce during the two seasons of 2022 and 2023

Treatments		Head FW g / plant		Edible head FW(g / plant)		Edible head diameter (cm).		Edible head compactness		Total heads yield(Ton/fed.)	
		1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s
Rates of foliar spray with salicylic acid g/l											
zero		902	927	628	645	18.1	18.6	2.80	2.96	27.08	27.81
0.1		1015	1042	707	726	20.4	20.9	3.56	3.75	30.45	31.27
0.2		1033	1061	720	739	20.8	21.3	3.70	3.91	31.01	31.85
0.3		925	950	644	661	18.6	19.1	2.95	3.11	27.76	28.50
LSD 5%		14	18	9	10	0.2	0.4	0.09	0.19	0.42	0.56
Dates of application of salicylic acid											
Early		1001	1031	697	718	20.1	20.7	3.48	3.69	30.03	30.93
Mid		976	1001	679	697	19.6	20.1	3.30	3.47	29.28	30.04
Late		930	953	648	663	18.7	19.2	2.99	3.13	27.92	28.59
LSD 5%		11	13	7	8	0.2	0.3	0.07	0.09	0.33	0.40
Interaction											
zero	Early	900	927	627	646	18.1	18.6	2.79	2.96	27.01	27.82
	Mid	905	929	630	647	18.2	18.7	2.82	2.97	27.17	27.88
	Late	902	924	628	643	18.2	18.6	2.80	2.94	27.07	27.72
0.1	Early	1024	1055	713	734	20.6	21.2	3.61	3.83	30.73	31.65
	Mid	1076	1104	749	769	21.6	22.3	3.99	4.20	32.28	33.12
	Late	945	968	658	674	19.0	19.4	3.08	3.23	28.35	29.04
0.2	Early	1147	1181	799	823	23.1	23.8	4.53	4.81	34.42	35.45
	Mid	994	1020	692	710	20.0	20.5	3.41	4.59	29.84	30.62
	Late	959	982	668	684	19.3	19.7	3.17	3.33	28.78	29.47
0.3	Early	932	960	649	669	18.8	19.3	2.99	3.18	27.97	28.81
	Mid	928	952	646	663	18.7	19.1	2.97	3.12	27.85	28.57
	Late	916	938	638	653	18.4	18.8	2.90	3.04	27.48	28.14
LSD 5%		23	28	16	16	0.4	0.6	0.15	0.24	0.69	0.86

Early: at 30 days after planting (DAP); Mid: at 40 DAP; Late: at 50 DAP; FW: fresh weight

Spraying lettuce plants at early date significantly recorded the highest values of Vitamin C (20.62 and 21.34 mg/ 100 g as fresh weight), TSS (3.28 and 3.38 %) and dry matter of outer and inner leaves (5.079 and 5.231 as well 2.811 and 2.896%). As well as the lowest values of edible head NO_3 (114.2 and 117.5 mg/kg as dry weight) compared to the other dates of applications under study (Table 5).

The combination between the two studied factors, SA rates and dates of application during season had significant effect on chemical quality of lettuce heads except that of edible head NO_3 content in the two seasons compared to control (Table 5). Under any dates of SA application, increasing SA rate gradually increased vitamin C (mg/ 100 g as fresh weight), TSS (%), and dry matter of outer and inner leaves (%) up to 0.2 g/l, except, edible head NO_3 (mg/kg as dry weight) were decreased in both seasons.

Table 5. Impact of rates and dates of foliar application with salicylic acid on chemical quality of lettuce heads during the two seasons of 2022 and 2023

Treatments		Vit. C mg/100g F.W		TSS %		Edible head NO_3 mg/ kg D.W.		Outer leaves DM%		Inner leaves DM%	
		1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s	1st s	2nd s
Rates of foliar spray with salicylic acid g/l											
zero		18.59	19.09	2.95	3.03	126.8	130.2	4.580	4.703	2.536	2.603
0.1		20.91	21.47	3.32	3.41	110.0	113.1	5.151	5.288	2.851	2.927
0.2		21.29	21.86	3.38	3.47	109.7	112.5	5.245	5.386	2.903	2.981
0.3		19.06	19.57	3.03	3.11	116.1	119.2	4.695	4.821	2.599	2.669
LSD 5%		0.29	0.39	0.04	0.07	1.9	2.1	0.072	0.088	0.040	0.042
Dates of application of salicylic acid											
Early		20.62	21.23	3.28	3.38	114.2	117.5	5.079	5.231	2.811	2.896
Mid		20.10	20.63	3.19	3.28	115.5	118.5	4.952	5.081	2.741	2.813
Late		19.17	19.63	3.05	3.12	117.3	120.3	4.722	4.836	2.614	2.677
LSD 5%		0.22	0.27	0.03	0.04	1.2	1.4	0.056	0.066	0.031	0.033
Interaction											
zero	Early	18.54	19.10	2.95	3.04	123.1	126.8	4.568	4.705	2.529	2.605
	Mid	18.65	19.14	2.96	3.05	127.9	131.2	4.595	4.714	2.544	2.610
	Late	18.59	19.03	2.95	3.02	129.3	132.5	4.579	4.688	2.877	2.595
0.1	Early	21.09	21.73	3.35	3.45	110.1	113.4	5.197	5.353	3.022	2.963
	Mid	22.16	22.74	3.52	3.61	111.5	114.5	5.459	5.601	2.655	3.101
	Late	19.47	19.93	3.09	3.17	108.5	111.4	4.795	4.911	3.222	2.718
0.2	Early	23.63	24.34	3.76	3.87	108.2	111.1	5.820	5.995	2.794	3.319
	Mid	20.49	21.02	3.26	3.34	108.9	111.7	5.047	5.178	2.695	2.866
	Late	19.76	20.23	3.14	3.22	112.0	114.8	4.868	4.985	2.619	2.759
0.3	Early	19.20	19.78	3.06	3.15	115.3	118.8	4.730	4.872	2.619	2.697
	Mid	19.12	19.61	3.04	3.12	113.6	116.5	4.709	4.831	2.607	2.674
	Late	18.86	19.32	3.00	3.07	119.5	122.4	4.647	4.759	2.573	2.634
LSD 5%		0.47	0.59	0.07	0.10	2.8	3.0	0.117	0.139	0.064	0.068

Early: at 30 days after planting (DAP); Mid: at 40 DAP; Late: at 50 DAP; FW: fresh weight; DW: dry weight; DM: dry matter

There was a positive link found between the SA application and the intake of key macronutrients, specifically calcium, magnesium, and potassium. This implies that SA has a specific impact on these important nutrients, which reflected in chemical quality (Shi and Zhu, 2008). The combination treatment (250 ppm of SA applied at plant emergence stage) recorded a maximum values of vitamin C content, TSS and French bean (*Phaseolus vulgaris* L.) pod dry matter content (Sharma *et al*., 2023). Treatment of SA as foliar spray on cucumber plant enhances fruit yield, VC, TSS and fruit dry matter at 0.3 g/l (Nada and Abd El-Hady 2019)

CONCLUSION

It can be concluded that sprayed lettuce plants by salicylic acid at 0.2 g/l during early date of growing season at 30 days from planting enhancing growth characters, chemical constituents in outer leaves and heads yield and its physical and chemical quality of head lettuce (Capuchi) under Dakahlia Governorate conditions.

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تقييم نمو، محصول وجودة نباتات خس الرؤوس كاستجابة للرش الورقي بحمض الساليسيليك

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الملخص

أجريت تجربة حقلية خلال موسمي ٢٠٢٢ و٢٠٢٣ بهدف تقييم نمو ومحصول وجودة خس الرؤوس صنف بيج بن (الكابوتشا) استجابة لحمض الساليسيليك بتركيزات ومواعيد الرش الورقي. تم تنفيذ الدراسة الحالية بمزرعة التجارب بكلية الزراعة جامعة المنصورة، محافظة الدقهلية، مصر. تم تطبيق أربع معدلات من حمض الساليسيليك (صفر، ٠,١، ٠,٢ و٠,٣ جم/ لتر) في ثلاث مواعيد رش مختلفة (مبكر ٣٠ يوم، متوسط ٤٠ يوم، ومتأخر ٥٠ يوم من زراعة الشتلات) والتداخل بينهما لتحسين نمو وإنتاجية نباتات الخس. أشارت النتائج المتحصل عليها إلى أن رش نباتات الخس بحمض الساليسيليك بتركيز ٠,٢ جم/لتر أدى إلى تحسين معنوي في صفات النمو (ارتفاع النبات، الوزن الطازج للأوراق والنباتات، وعدد الأوراق ومساحتها لكل نبات)، ومحتوى الكلوروفيل والنسب المئوية من العناصر الغذائية الأساسية (النيتروجين والفسفور والبوتاسيوم) في الأوراق الخارجية، ومحصول الرؤوس وجودته الطبيعية والكيميائية مقارنة بالتركيزات الأخرى قيد الدراسة. وقد تحققت أعلى القيم في هذه الصفات عند رش نباتات الخس في الميعاد المبكر اثناء موسم النمو (عند ٣٠ يومًا من الزراعة) مقارنة بالرش الورقي في المواعيد المتأخرة عن ذلك خلال موسم النمو. وبشكل عام أدى الرش المبكر لنباتات الخس بحمض الساليسيليك بتركيز ٠,٢ جم/ لتر أثناء موسم النمو (٣٠ يوم من الزراعة) إلى تحسين معنوي في نمو وإنتاجية وجودة خس الرؤوس (الكابوتشا) صنف بيج بن مقارنة بمعاملات التداخل الأخرى تحت ظروف محافظة الدقهلية.