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Effect of Sodium Nitroprusside (SNP) on Minerals Content of Cabbage *Brassica oleracea* var. *capitata* L. Grown under Salt Stress

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Abstract:. The experiment was conducted during the winter season of 2017-2018 and 2018-2019 at directorates of agriculture in Al-Zubair district, Basrah, Iraq to study the effect of sodium nitroprusside (SNP) at four concentration (0, 50, 100 and 150) µM with number of sprays (once and twice) and three cultivars (Pruktor F1, Luna and Rain ball F1) on mineral content of Nitrogen (N), Phosphorous (P), Potassium (K), Sodium (Na), Potassium/Sodium (K^+/Na^+) ratio, Chloride (Cl^-), Sulfur (S) and Iron (Fe) of leaves. Split-Split Plot design was used with three replicates per treatment. The means of treatments were compared by L.S.D. at 0.05 probability. Results indicated that Pruktor F1 had the highest percentage of N, P, K, K^+/Na^+ ratio for both growing seasons while the highest accumulation of Na and Cl^- in Rain ball F1 cultivar. Plants sprayed twice with SNP had a significant increase in P, K, K^+/Na^+ ratio, S, and Fe comparing with once spray for both growing seasons. PruktorF1 *sprayed* with SNP at 100 µM twice time was superior in P, K, K^+/Na^+ ratio, S and Fe, whereas, the same cultivar at 150 µM concentration was superior in N for both growing seasons, same cultivar at 100 and 150 µM sprayed twice time gave the lowest percentage of Na^+ and Cl^-, respectively. Also Rain ball F1 at control treatment had the highest accumulation of Na and of Cl^-.

Keywords: Sodium nitroprusside, Salt stress, Nitric oxide, Nitrogen, Phosphorus, Potassium.

Introduction

Cabbage belongs to the Cruciferae family and considers of the favourite winter crop in Iraq and other countries due to its using of salad and cooking, and it is planted in most regions of Iraq and the planted areas were reached 3315 Donums at 2018 with a total production of 6130 tons (Agricultural Statistics Directorate, 2018).

The salinity of irrigation water is one of the most important problems facing agriculture in arid and semi-arid region of the world and it is one of the main problems that faced the agricultural production in the desert region in Al-Zubair resulting in decreasing growth and photosynthesis efficiency, respiration and availability of nutrients and oxidation as a result of salt stress due to reactive oxygen species (ROS) (Munns & Tester, 2008). Agriculture in Al-Zubair depends on the well waters because of the Lack of surface water, low rainfall and the random use of salty water leads to negative results on the availability of nutrients through the toxicity of Na^+ and Cl^- ions and the increasing of them with other ions leads to increase the osmotic pressure and imbalance the homeostasis nutrients, therefore methods must be applied in order to increase production and reduce environmental stress (Phocaides, 2001).

Cabbage is moderately sensitive to salinity and the *salinity has* caused *negative effects* on production (Ayers, & Wescot, 1985), and it is necessary to use some techniques to reduce the influence of salt stress by using the SNP (donor NO), an inorganic compound ($Na_2[Fe(CN)_5NO]\ .2H_2O$) which used to cure from heart disease for human by expanding vascular and it is essential drugs (WHO, 2015). It is one of the important technique which used for regulating most of physiological processes, including the responses to biotic and abiotic stress and increase the tolerance to salt stress by stimulating the antioxidant enzymes, which play a vital role in protection system and increase their tolerance to salt stress resulting in homeostasis nutrients and ionic balance (Nabi *et al*., 2019; Santisree *et al*., 2019).

Many studies referred to the spray with SNP compound for plants under salt stress (Molassiotis *et al.*, 2010) and Nitric oxide (NO) increase the activity of plasma membrane H^+-ATPase in plant exposed to salt stress and led to increase in K^+/Na^+ ratio in the tissue of plants to increase adaptation to salt stress (Zhao *et al.*, 2004). NO has a capability to remove *reactive oxygen species*(ROS) and acts as antioxidant by altering the gene expression of antioxidants and thus *protect cells from oxidative damage* caused by salt stress (Arasimowicz & Floryszak-Wieczorek, 2007).

An experiment aimed to study the effect of SNP and the number of sprays on leaf N, P, K, Na, K+/Na+ ratio, Cl-, S and Fe content for three cultivars of cabbage under salt stress in the desert region southern Iraq.

Materials & Methods

A- field experiment

The experiment was carried out during the winter season of 2017-2018 and 2918-2019 in the tomato development project at Al-Zubair, Directorate of Agriculture of Basrah. Random samples of field soil was taken to estimate some of the chemical and physical properties of it (table 1) and table (2) showed some chemical and physical properties of irrigation water (well water). The soil was plowed twice Perpendicular to a depth 30 cm and left for a month, the field arranged in 18 lines 28.8 meters long and 40 cm wide and 40 cm between the lines and every line was divided into four experimental units with a length 7.2 meter. The field soil fertilized with an organic fertilizer at the rate of 13 $tone.Donum^{-1}$ and decomposed fertilizer NPK (15: 15: 15 + TE) at the rate 0.5 kg for every unit and covered with the soil of the field with at 10 cm layer. The field was supplied with a drip irrigation system and the line covered with black plastic mulching.

The seeds were sown in styropor trays with 209 holes and were sterilized with beltanol 50% SL and filled with German peat moss, at 10/9/2017 and 9/9/2018 for both growing seasons. The seedlings were transplanted to the field after 45 days from sowing. First spray with the SNP after two weeks of transplanting and second spray after two

Table (1): Physical and chemical properties of the field soil.

Properties of the soil		2017-2018 Season	2018-2019 Season	Type of analysis
Electrical conductivity ($ds.m^{-1}$)		7.11	7.40	Page *et al*. (1982)
Soil pH		7.31	7.55	
Soluble ions (mM)	Na^{+}	24.0	30.0	Richards (1954)
	Ca^{++}	17.75	20.00	
	Mg^{++}	15.0	10.5	
	SO_4^{-}	19.62	23.14	Page *et al*. (1982)
	Cl^{-}	67.00	65.00	Jackson (1958)
	HCO_3^{-}	2.6	2.8	Richards (1954)
Available Nitrogen	$mg.Kg^{-1}$	154	170	Page *et al*. (1982)
Available phosphorus		69.02	75.40	
Available potassium		201.0	185.4	
Organic matter ($g.Kg^{-1}$)		4.64	5.08	
Soil structure				
Sand		83.0	83.0	Black (1965)
Silt		3.6	3.6	
Clay		13.4	13.4	
Soil texture		Loamy sand texture		

Table (2): Physical and chemical properties of irrigation water (well water).

Properties of the water	Unit	2017-2018 Season	2018-2019 Season
pH	-	7.11	7.35
Electrical conductivity (EC)	$ds.m^{-1}$	11.68	16.55
Ca^{++}	$mg.L^{-1}$	570.0	480.0
Mg^{++}		409.9	-
Na^{+}		870.9	1009.0
K^{+}		40.5	55.2
Cl^{-}		177.2	211.0
NO_3^{-}		8.0	9.0
SO_4^{-}		795.0	850.0

weeks from the first spray for Pruktor F1, Luna and Rain ball F1 with concentration 0, 50, 100 and150 µM.

The treatments were assigned to a completely randomized block design in a split- split plot arrangement with the cultivar in the main plots and spray time in the sub- plots andfoliar sprays of SNP in sub-sub plots with three replicates.

The means of treatments were compared by L.S.D. at 0.05 probability.

B-Determination of leaves content of nutrient elements:

1-Total nitrogen (N %) was determined by micro-kjeldalmethod according to Page *et al*. (1982).

2-Phosphorus (P %) was determined according to the method described by Jakson (1985).

3-Potassium and Sodium (K %, Na %) were determined according to the method described by Page *et al*. (1982).

4-K^+/Na^+ ratio by dividing K^+ % on Na^+ %.

5-Chloride (Cl^- %) was determined according to the method described by Furman (1962).

6-Sulfur (S%) was determined according to a method described by Novozamsky & Eck (1977).

7-Iron (Fe $mg.kg^{-1}$) was determined by using atomic absorption according to a method described by Haynes (1980).

Results & Discussion

Data presented in tables (3-9) explained that Pruktor F1 cultivar had a significant increase in N, P, K, K^+/Na^+ ratio, S and Fe and a significant decrease in Na^+ and Cl^- *compared* to *other cultivars*. Plants sprayed with SNP had a significant increase in the contents_of N, P, K, K^+/Na^+ ratio, S and Fe compared with control treatment and significant decrease in Na^+ and Cl^-. Plants which sprayed twice with SNP at 100 μM had the best result in P, K, K^+/Na^+ ratio and Fe. Plants which sprayed once with SNP at 150 μM had significant increases in N comparing with control treatment.

The Pruktor F1 cultivar plants that sprayed twice with SNP at 100 μM had highest values of P, K , K^+/Na^+ ratio S and Fe and lowest values of Cl^- . the same cultivar which sprayed once with 150 μM SNP had gave highest N and lowest values of Na, while untreated Rain ball F1 cultivar gave less N , P , K , K^+/Na^+ ratio, S and Fe and highest values of Na and Cl^- for both growing seasons, respectively.

The results presented in table Tables (3, 4, 5, 7, 9 & 10) revealed that Pruktor F1 cultivar was superior compared to other cultivars. Genetic factors of cultivars and its ability to prevent sodium ion uptake to plant roots. Results exhibited accumulation of nutrient elements except for Na^+ and Cl^- when the SNP used well water with high salt (11.68, 16.55) $ds.m^{-1}$ for both growing seasons (table, 2). Spraying SNP twice had a significant effect (tables 4-5 & 7) than once spray (tables 3, 6 & 8) because of the high concentration had unaffected role, so it exhibited the growth (Hayat *et al*., 2014) and due to joint interaction with ROS, which causes damage and breakdown of cells in more than one location, including the cellular membrane which causes oxidative stress (Belgini & Lamattina, 1999).

Tables (3-5, 7 & 9) revealed a significant decrease in the content of N, P, K, K^+/Na^+ ratio, S and Fe when irrigated with salty water compared with the an increase of N^+ and Cl^- ions. This lack of nitrogen content (table 3) caused a decrease in protein because of decreasing the activity of Nitrate reductase enzyme which affected of the synthesis of protein and total nitrogen (Lopez-Cantarero *et al*., 1997; Jabeen & Ahmad, 2011), and the lack of water stimulates protease enzyme (Reddy & Vora, 1985) and the competition between chloride and nitrate ion the exhibited nitrate and transporter because of toxic effect of salt ions (Lin *et al*., 1997) that led to accumulation of Cl^- in leaves (Dean-Drummond, 1986) and it may also be due to the change in permeability properties of the plasma membrane, which affected by membrane proteins (Meloni *et al.*, 2004).

The decrease of P in untreated plants (Table 4) were due to the competition between Cl^- and $H_2PO_4^-$ ions that Cl^- ion acts on decrease absorption $H_2PO_4^-$ by the plant (Pessarkli, 1999) and the reducing of phosphorous translocation from root to vegetative growth (Martinez & Luchli, 1994). The salinity leads to reduction of root growth and its movement in soil and because of limiting movement of P lead s to reduce its adsorption (Al-Taey *et al*., 2017). The reduction of K (Table 5) in untreated plants were due to the competition between Na^+ and K^+ ion on the absorption sites in roots and transporter proteins which transport Na^+ lasted of K^+ (Ashley *et al*., 2006).

Data presented in table (6) revealed the reduction in K^+in untreated plants because of well water that lead to reduce K^+ absorption because of its effect on cellular organelles and transporter of Na^+ and K^+ and H^+ pumps which generate the transporter forces ion in the cells (Zhu, 2003) and the reduction in water absorption was due to the high osmotic pressure in zone root that lead to reduced absorption on K^+ ion (Cuartero & Fernande-Munoz, 1999) and that leads to reduction in the K^+/Na^+ ratio (Table 7).

The high percentage of Na^+ and Cl^- in untreated control (Table 6 & 8) because of their high concentration in a growth medium that lead to an increase of their absorption in plants.

Data presented in table (9) explained a significant decrease in S in untreated plants were due to the high salt in soil that lead to alkaline pH and saturated with calcium ion (Dougrameji & Al-Rawi, 1972) and that effect on the availability of nutrients which important for plant growth. There was a significant decrease in the Iron element of untreated plants (Table, 10) because the irrigation water salinity lead to change the pH in soil and Fe sensitive to pH and that lead to reduce its availability for plant and then reduce its level in leaves and there was another reason of the toxic effect of Na^+ and Cl^- on plasma membrane of root cells, which lead to reduce its ability for absorption and finally on absorption of nutrient elements like Fe (Passarakli, 1999).

Tables (3-5 & 7) showed a significant increase in the percentage of nutrient elements which treated with the SNP because NO plays a vital role in alleviating of high salt in plant tissue and reduce the nutrient absorption. SNP leads to increase gene expression to H^+-ATPase in plasma membrane and that lead to raising K^+/Na^+ in cells cytoplasm (Zhao *et al*., 2004) and showed the addition of SNP on *Zea mays* caused increasing the activity of H^+-ATPase in tonoplast and Na^+/H^+ transporter and enable Na^+ for passing and SNP improve macronutrient elements contents like Fe (Graziano*et al*., 2002).

NO plays a physiological role in improving the transport of Fe from root to vegetative system, also, it made many nutrient elements can be absorbed by Iron-regulated transporter 1(IRT1), which lead to an increase gene expression for them by NO (Connolly *et al*., 2002).

Table (3): Effect of cultivars, sprays and concentration of SNP on N-content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars			SNP × Sprays	Cultivars			SNP × Sprays
		Prukt or F1	Luna	Rain ball F1		Prukt or F1	Luna	Rain ball F1	
0	Once time	2.96	2.77	2.44	2.73	2.91	2.75	2.38	2.61
	Twice time	2.99	2.81	2.49	2.76	2.97	2.79	2.43	2.64
50	Once time	3.27	3.14	2.99	3.13	3.45	3.11	2.91	3.03
	Twice time	3.84	3.38	3.35	3.52	3.43	3.34	3.27	3.44
100	Once time	3.64	3.35	3.24	3.41	3.77	3.30	3.25	3.35
	Twice time	3.51	3.19	3.14	3.28	3.51	3.16	3.11	3.23
150	Once time	4.08	3.69	3.59	3.78	4.03	3.65	3.49	3.67
	Twice time	3.46	3.15	3.14	3.25	3.45	3.16	3.08	3.18
LSD 0.05			0.09		0.05		0.09		0.06
Effect of cultivars		3.47	3.19	3.05	Effect of SNP	3.34	3.10	2.99	Effect of SNP
LSD 0.05			0.02				0.03		
Cultivars × SNP	0	2.98	2.79	2.46	2.74	2.81	2.67	2.38	2.62
	50	3.55	3.26	3.17	3.33	3.44	3.17	3.09	3.23
	100	3.57	3.27	3.19	3.35	3.47	3.22	3.18	3.29
	150	3.77	3.42	3.37	3.52	3.64	3.34	3.30	3.43
LSD 0.05			0.06		0.04		0.05		0.03
					Effect of Sprays				Effect of Sprays
Cultivars × Sprays	Once time	3.47	3.24	3.06	3.26	3.36	3.14	3.00	3.17
	Twice time	3.45	3.13	3.03	3.21	3.33	3.06	2.97	3.12
LSD 0.05			0.03		0.02		*NS		NS

*NS: *not significant*

Table (4): Effect of cultivars, sprays and concentration of SNP on P-content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars			SNP × Sprays	Cultivars			SNP × Sprays
		Pruktor F1	Luna	Rain ball F1		Pruktor F1	Luna	Rain ball F1	
0	Once time	0.330	0.302	0.280	0.304	0.314	0.284	0.269	0.289
	Twice time	0.329	0.306	0.284	0.306	0.310	0.293	0.275	0.293
50	Once time	0.383	0.356	0.333	0.358	0.364	0.341	0.322	0.342
	Twice time	0.466	0.434	0.411	0.437	0.452	0.417	0.400	0.423
100	Once time	0.441	0.413	0.393	0.415	0.423	0.398	0.380	0.401
	Twice time	0.564	0.525	0.496	0.528	0.540	0.507	0.487	0.512
150	Once time	0.504	0.456	0.451	0.470	0.481	0.438	0.438	0.452
	Twice time	0.459	0.479	0.440	0.459	0.444	0.462	0.439	0.448
LSD 0.05			0.012		0.007		0.015		0.008
Effect of cultivars		0.434	0.409	0.386	Effect of SNP	0.416	0.392	0.376	Effect of SNP
LSD 0.05			0.006				0.009		
Cultivars × SNP	0	0.329	0.304	0.282	0.305	0.312	0.288	0.272	0.291
	50	0.425	0.395	0.372	0.397	0.408	0.379	0.361	0.383
	100	0.503	0.469	0.444	0.472	0.482	0.453	0.434	0.456
	150	0.481	0.468	0.445	0.465	0.463	0.450	0.438	0.450
LSD 0.05			0.009		0.005		0.011		0.006
					Effect of Sprays				Effect of Sprays
Cultivars × Sprays	Once time	0.414	0.382	0.364	0.387	0.395	0.365	0.352	0.371
	Twice time	0.455	0.436	0.408	0.433	0.437	0.420	0.400	0.419
LSD 0.05			0.006		0.003		NS		0.004

Table (5): Effect of cultivars, sprays and concentration of SNP on K content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars			SNP × Sprays	Cultivars			SNP × Sprays
		Prukt or F1	Luna	Rain ball F1		Prukt or F1	Luna	Rain ball F1	
0	Once time	1.92	1.76	1.62	1.77	1.79	1.60	1.53	1.64
	Twice time	1.90	1.73	1.64	1.76	1.78	1.62	1.54	1.65
50	Once time	2.42	2.31	1.99	2.24	2.19	1.87	1.78	1.95
	Twice time	3.03	2.82	2.44	2.76	2.83	2.62	2.28	2.58
100	Once time	2.88	2.61	2.38	2.62	2.68	2.42	2.29	2.46
	Twice time	3.77	3.15	2.82	3.25	3.52	3.05	2.61	3.06
150	Once time	3.61	2.90	2.64	3.05	3.30	2.85	2.46	2.87
	Twice time	2.55	2.56	2.28	2.46	2.38	2.30	2.21	2.29
LSD 0.05			0.09		0.05		0.22		0.12
Effect of cultivars		2.76	2.48	2.23	Effect of SNP	2.56	2.29	2.09	Effect of SNP
LSD 0.05			0.04				0.09		
Cultivars × SNP	0	1.91	1.75	1.63	1.76	1.78	1.61	1.54	1.64
	50	2.72	2.57	2.21	2.50	2.51	2.24	2.03	2.26
	100	3.32	2.88	2.60	2.93	3.10	2.74	2.45	2.76
	150	3.08	2.72	2.47	2.76	2.84	2.57	2.34	2.58
LSD 0.05			0.07		0.04		NS		0.09
					Effect of Sprays		C		Effect of Sprays
Cultivars × Sprays	Once time	2.71	2.40	2.16	2.42	2.49	2.18	2.02	2.23
	Twice time	2.81	2.57	2.30	2.56	2.63	2.40	2.16	2.40
LSD 0.05			NS		0.03		NS		0.06

Table (6): Effect of cultivars, sprays and concentration of SNP on Na content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars				Cultivars			
		Pruktor F1	Luna	Rain ball F1	SNP × Sprays	Prukt or F1	Luna	Rain ball F1	SNP × Sprays
0	Once time	1.693	1.835	2.035	1.854	1.879	1.990	2.113	1.994
	Twice time	1.690	1.852	2.024	1.855	1.873	1.962	2.144	1.993
50	Once time	1.560	1.711	1.898	1.723	1.706	1.865	1.968	1.846
	Twice time	1.207	1.424	1.631	1.421	1.339	1.634	1.816	1.597
100	Once time	1.309	1.572	1.702	1.528	1.572	1.735	1.886	1.731
	Twice time	0.986	1.280	1.439	1.235	1.215	1.396	1.509	1.373
150	Once time	1.117	1.374	1.575	1.355	1.394	1.563	1.725	1.561
	Twice time	0.871	1.079	1.310	1.087	1.088	1.201	1.409	1.233
LSD 0.05			NS		0.039		0.052		0.031
Effect of cultivars		1.304	1.516	1.702	Effect of SNP	1.508	1.668	1.821	Effect of SNP
LSD 0.05			0.023				0.024		
Cultivars × SNP	0	1.691	1.843	2.029	1.855	1.876	1.976	2.128	1.993
	50	1.383	1.568	1.765	1.572	1.523	1.749	1.892	1.721
	100	1.148	1.426	1.570	1.381	1.393	1.566	1.697	1.552
	150	0.994	1.227	1.442	1.221	1.241	1.382	1.567	1.397
LSD 0.05			0.044		0.027		0.036		0.021
					Effect of Sprays				Effect of Sprays
Cultivars × Sprays	Once time	1.420	1.623	1.802	1.615	1.638	1.788	1.923	1.783
	Twice time	1.188	1.409	1.601	1.399	1.379	1.549	1.719	13549
LSD 0.05			NS		0.024		NS		0.020

Table (7): Effect of cultivars, sprays and concentration of SNP on K^+/Na^+ ratio in leaves.

SNP µM	Sprays	2017 – 2018 Season Cultivars Prukt or F1	Luna	Rain ball F1	SNP × Sprays	2018 – 2019 Season Cultivars Prukt or F1	Luna	Rain ball F1	SNP × Sprays
0	Once time	1.135	0.961	0.795	0.964	0.951	0.805	0.725	0.827
	Twice time	1.123	0.937	0.808	0.956	0.952	0.826	0.719	0.832
50	Once time	1.549	1.351	1.048	1.316	1.285	1.002	0.906	1.064
	Twice time	2.512	1.983	1.497	1.997	2.112	1.603	1.254	1.656
100	Once time	2.200	1.658	1.399	1.752	1.708	1.394	1.214	1.439
	Twice time	3.832	2.464	1.962	2.753	2.900	2.189	1.728	2.272
150	Once time	3.233	2.111	1.679	2.341	2.369	1.820	1.427	1.872
	Twice time	2.931	2.372	1.744	2.349	2.184	1.912	1.569	1.888
LSD 0.05			0.150		0.090		0.129		0.076
Effect of cultivars		2.314	1.729	1.366	Effect of SNP	1.808	1.444	1.193	Effect of SNP
LSD 0.05			0.071				0.053		
Cultivars × SNP	0	1.129	0.949	0.802	0.960	0.952	0.815	0.722	0.829
	50	2.030	1.667	1.273	1.656	1.698	1.302	1.080	1.360
	100	3.016	2.061	1.681	2.253	2.304	1.791	1.471	1.855
	150	3.082	2.242	1.711	2.345	2.277	1.866	1.498	1.880
LSD 0.05			0.104		0.060		0.091		0.055
					Effect of Sprays				Effect of sprays
Cultivars × Sprays	Once time	2.029	1.520	1.230	1.593	1.578	1.255	1.068	1.300
	Twice time	2.600	1.939	1.503	2.014	2.037	1.632	1.318	1.662
LSD 0.05			0.090		0.062		0.064		0.042

Table (8): Effect of cultivars, sprays and concentration of SNP on Cl content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars				Cultivars			
		Prukt or F1	Luna	Rain ball F1	SNP × Sprays	Prukt or F1	Luna	Rain ball F1	SNP × Sprays
0	Once time	4.53	4.69	4.79	4.67	4.83	4.97	5.08	4.96
	Twice time	4.42	4.56	4.50	4.49	4.69	4.83	4.77	4.76
50	Once time	4.07	4.24	4.27	4.20	4.33	4.49	4.54	4.45
	Twice time	3.53	3.93	3.77	3.75	3.75	4.16	3.99	3.97
100	Once time	3.60	3.78	3.72	3.70	3.83	3.99	3095	3.92
	Twice time	2.83	3.30	3.26	3.13	2.99	3.48	3.45	3.31
150	Once time	3.23	3.43	3.49	3.38	3.43	3.62	3.67	3.57
	Twice time	2.89	3.32	3.21	3.14	3.04	3.52	3.39	3.32
LSD 0.05			0.13		0.08		0.13		0.08
Effect of cultivars		3.64	3.91	3.88	Effect of SNP	3.86	4.13	4.10	Effect of SNP
LSD 0.05			0.06				0.07		
Cultivars × SNP	0	4.47	4.63	4.65	4.58	4.76	4.90	4.93	4.86
	50	3.80	4.09	4.02	3.97	4.04	4.33	4.26	4.21
	100	3.21	3.54	3.49	3.41	3.41	3.73	3.70	3.61
	150	3.06	3.38	3.35	3.26	3.23	3.57	3.53	3.45
LSD 0.05			NS		0.05		0.10		0.05
					Effect of Sprays				Effect of sprays
Cultivars × Sprays	Once time	3.86	4.04	4.07	3.99	4.10	4.27	4.31	4.23
	Twice time	3.42	3.78	3.69	3.63	3.62	4.00	3.90	3.84
LSD 0.05			NS		0.06		NS		0.06

Table (9): Effect of cultivars, sprays and concentration of SNP on S content (%) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars				Cultivars			
		Prukt or F1	Luna	Rain ball F1	SNP × Sprays	Prukt or F1	Luna	Rain ball F1	SNP × Sprays
0	Once time	0.417	0.390	0.375	0.394	0.404	0.377	0.367	0.383
	Twice time	0.397	0.391	0.370	0.386	0.387	0.382	0.360	0.376
50	Once time	0.497	0.460	0.450	0.469	0.486	0.448	0.429	0.454
	Twice time	0.561	0.551	0.541	0.551	0.542	0.540	0.529	0.537
100	Once time	0.551	0.542	0.525	0.539	0.533	0.530	0.511	0.525
	Twice time	0.731	0.681	0.620	0.677	0.717	0.670	0.604	0.664
150	Once time	0.626	0.639	0.582	0.617	0.611	0.632	0.566	0.600
	Twice time	0.675	0.648	0.601	0.641	0.659	0.639	0.586	0.628
LSD 0.05			0.028		0.016		0.020		0.012
Effect of cultivars		0.557	0.538	0.508	Effect of SNP	0.542	0.526	0.494	Effect of SNP
LSD 0.05			0.013				0.008		
Cultivars × SNP	0	0.407	0.390	0.373	0.390	0.396	0.379	0.364	0.380
	50	0.529	0.506	0.495	0.510	0.514	0.494	0.479	0.496
	100	0.641	0.612	0.573	0.608	0.625	0.600	0.558	0.594
	150	0.651	0.643	0.592	0.629	0.635	0.631	0.576	0.614
LSD 0.05			0.020		0.012		0.014		0.009
					Effect of Sprays				Effect of Sprays
Cultivars × Sprays	Once time	0.523	0.508	0.482	0.504	0.509	0.495	0.468	0.491
	Twice time	0.591	0.568	0.533	0.564	0.576	0.558	0.520	0.551
LSD 0.05			NS		0.008		NS		0.007

Table (10): Effect of cultivars, sprays and concentration of SNP on Fe content (mg.Kg^{-1} D W) in leaves.

SNP µM	Sprays	2017 – 2018 Season				2018 – 2019 Season			
		Cultivars				Cultivars			
		Pruktor F1	Luna	Rain ball F1	SNP × Sprays	Pruktor F1	Luna	Rain ball F1	SNP × Sprays
0	Once time	45.32	40.78	45.32	40.93	42.77	38.00	34.71	38.49
	Twice time	44.46	40.71	44.46	40.81	41.37	38.90	35.00	38.42
50	Once time	51.36	45.58	51.36	46.57	47.97	42.77	40.21	43.65
	Twice time	66.18	59.59	66.18	60.61	62.07	51.23	51.97	55.09
100	Once time	60.15	57.44	60.15	57.26	55.60	48.02	47.77	50.47
	Twice time	77.03	69.60	77.03	69.95	74.36	61.06	59.45	64.96
150	Once time	69.32	64.72	69.32	64.59	65.11	53.04	53.93	57.36
	Twice time	67.31	60.36	67.31	61.53	62.87	54.00	54.49	57.12
LSD 0.05			1.91		1.14		1.44		0.97
Effect of cultivars		60.14	54.85	50.86	Effect of SNP	56.52	48.38	47.19	Effect of SNP
LSD 0.05			0.64				0.58		
Cultivars × SNP	0	44.89	40.74	36.99	40.87	42.07	38.45	34.85	38.46
	50	58.77	52.58	49.43	53.59	55.02	47.00	46.09	49.37
	100	68.59	63.52	58.69	63.60	64.98	54.54	53.61	57.71
	150	68.31	62.54	58.34	63.06	63.99	53.52	54.21	57.24
LSD 0.05			NS		0.82		0.86		0.50
					Effect of Sprays				Effect of Sprays
Cultivars × Sprays	Once time	56.53	52.13	48.36	52.34	52.86	45.46	44.16	47.49
	Twice time	63.74	57.56	53.37	58.23	60.17	51.30	50.23	53.90
LSD 0.05			0.89		0.65		NS		0.84

Conclusions

The results showed that sodium nitroprusside (SNP) at 100 µM Sprays twice-time enhanced the tolerance of cabbage cv. Pruktor F1 to salt stress by improving accumulation of P, K, Fe and S and increase K+/Na+ ratio in leaves.

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