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Effect of NaCl salinity stress on potato (*Solanum tuberosum* L.) plantlets grown and development under in vitro conditions

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ABSTRACT

In vitro osmotic stress screening of plant genotypes is a useful tool that can be used instead of field trials and is based on osmotic stress tolerance. The major purpose of this work was to employ *in vitro* screening to reveal the variation in potato cultivars for salt stress tolerance (10, 30, 50, 70, 100 and 120 mM NaCl). Murashige and Skoog (MS) media supplemented with these concentrations of NaCl was used to culture single node stem cuttings of eight potato cultivars (Gizela, Sponta, Cara, Kaspar, Burren, Lady Balfour, Diamant, and Maritienia).. Significant differences among treatments were noticed the highest concentration of NaCl gave the lowest values for most the study characters. Moreover, there were significant differences response among cultivars for NaCl concentrations. Low concentrations of NaCl gave values close to the control treatment. The highest values of the most study characters found with Diamant cultivar treated with 120 mM NaCl compared to another cultivars.

KEYWORDS: Potato, NaCl, Salinity, *In vitro*

1. INTRODUCTION

Vegetable crops are herbaceous plants that are farmed for human consumption and have edible parts such as foliage, stems, roots, flowers, or fruits. Because the financial value of vegetables is usually high, salt tolerance of vegetable species is significant (Shannon and Grieve, 1999). As a vegetable crop, potato (*Solanum tuberosum* L.) is regarded as one of the most significant in the world. It is the world's fourth most important food crop, after rice, wheat, and corn, and is used for human consumption, animal feed, and as a source of starch for the production of alcohol (Gowayed *et al*., 2017). In temperate and tropical locations, it is becoming more important as a source of carbohydrates, vitamins, and minerals, as well as for industrial reasons. Potatoes are vulnerable to a variety of biotic and abiotic stressors (Adolf *et al.*, 2020). A relatively low historical influx of variation has led to a genetic bottleneck within potato cultivars. Thus, the development of potato varieties with novel genetic diversity is expected to improve resistance to biotic and abiotic constraints (Castañeda-Álvarez *et al.*, 2015; Muñoz *et al.*, 2019).

Egypt became the fifth largest exporter of potatoes in 2018, exporting over 759,200 tones to European Union and the Russia. In 2019 Egypt captured 5% of the global potato export market, with exports totaling 259.6 million dollars (FAO, 2019). The high quality of Egyptian potatoes is well known. Customers also choose Egyptian potatoes because of their lengthy shelf life and acceptable level of firmness and sugar content. The exporting season for Egyptian potatoes runs from the middle of January until the end of May (https://www.groproag.com/).

For most crops, including potatoes, abiotic and biotic stress remain key stressors. According to Van Hoorn *et al.* (1993), irrigated conditions containing 5.9 ds m^{-1} of salt resulted in a 37 percent reduction in potato yield; nonetheless, the potato plant is considered to be fairly sensitive to salinity. The leaves are the most salt-sensitive part of the plant, according to Katerji *et al*. (2000). High levels of salt (greater than 50 mM NaCl) are observed to reduce potato output (Rahman *et al*., 2008). Some of the harmful effects of salt stress on the potato plant include: (1) reduced tuber output; (2) leaf chlorosis, tip burn, and leaf burn; (3) restricted water uptake by roots; (4) accelerated plant senescence; (5) tuber browning and cracking; and (6) tuber browning and cracking (Levy and Veilleux, 2007; Khenifi *et al*., 2011; Jaarsma *et al*., 2013; Gowayed *et al*., 2017).

Salt stress, on the other hand, reduces crop yield by altering plant metabolism and causing significant changes in biochemical and molecular processes, Salinity is one of the abiotic stresses that affect potato growth and productivity mostly in semi-arid and growing areas, causing an imbalance in plant physiological processes . The accumulation of Na^+ and Cl^- in cells is extremely toxic and can affect all of the plant mechanisms and enzymatic actions (Allakhverdiev *et al.*, 2000; Ahmed *et al.*, 2020). The identification and screening of commercial cultivars for salt stress production through *in vitro* system is a key factor in potato production as potato cultivars have different responses of salinity stress (El-Sayed *et al*., 2021) .

The aims of this study were to evaluate the effect of NaCl salinity levels on vegetative growth parameters as well as some chemical constituents of potato cultivars under *in Vitro* growing conditions.

2. MATERIAL AND METHODS

The current *in vitro* study was carried out at the Laboratory of Tissue Culture, Vegetable Branch, Horticulture Department, Faculty of Agriculture, Minia University, Minia, Egypt in 2019 to study the effect of seven salinity concentrations on eight potato varieties (Gizela, Sponta, Cara, Kaspar, Burren, Lady Balfour, Diamant, and Maritienia). The experiment was repeated at least two times and the average is presented.

2.1. Plant materials and culture conditions

Primary shoots from all cultivars of potato tubers sprout were aseptically removed and sliced into nodal pieces. On semi-solid MS medium, the individual apical shoot segments were grown. Single nodes; (2–5 mm) were dissected form 4-week-old grown shoots and cultivated on MS media The MS medium was supplemented with 30 g/l sucrose as a carbon and sugar source, as well as 9.0 g/l agar as a gelling agent. The medium was adjusted to a pH of 5.7 before being autoclaved at 121°C for 20 minutes at 15 psi pressure. For further growth sub-culturing, the cultures were incubated at 25±2 ^{o}C in an incubation setting with 16/8 h light/dark, the cultures were exposed to 2000 lux fluorescent light for 28 days.

2.2. *In vitro* screening of potato cultivars for salt tolerance

The studied eight potato cultivars were screened for salt tolerance using *in vitro* multiplication at various concentrations of NaCl supplemented in MS media. The stem cuttings (nodal segments) were used as explants. Each experiment consisted of ten replications and repeated two times. The NaCl treatments were applied as salt stress as described in (Table 1).

The potato cultivars namely; Gizela, Sponta, Cara, Kaspar, Burren, Lady Balfour, Diamant, and Maritienia were obtained from the Tissue Culture unit, Faculty of Agriculture, Minia University, Egypt.

Table 1. Various salt treatments applied as salt stress for screening 8 potato cultivars.

Treatments	Composition
T_1	MS Basal Medium without NaCl (control)
T_2	10 mM NaCl in MS medium = 0.58 g/l NaCl
T_3	30 mM NaCl in MS medium = 1.75 g/l NaCl
T_4	50 mM NaCl in MS medium = 2.90 g/l NaCl
T_5	70 mM NaCl in MS medium = 4.06 g/l NaCl
T_6	100 mM NaCl in MS medium = 5.80 g/l NaCl
T_7	120 mM NaCl in MS medium = 7.20 g/l NaCl

2.3. Layout of the experiments:

The experiment was arranged in a factorial randomized complete design (RCD) in two replicates. The first factor (A) included eight potato cultivars, while the seven treatments of salinity levels were the second factor (B). Therefore, the interaction treatments (A x B) were 56 treatments. Each treatment consists of 10 plantlets.

2.4. Data recorded

After 28 days (4 weeks) of culture initiation plantlets were carefully washed with distilled water then dried with filter paper. The following parameters were recorded:

1. Plantlet height (cm).
2. Root length (cm).
3. Number of roots/plantlet.
4. Number of leaves/plantlet.
5. Root fresh and dry weights (mg).
6. Shoot fresh and dry weights (mg).
7. Plantlets fresh and dry weights (mg).
8. Photosynthetic pigments (a, b and carotenoids).

The height of 20 randomized taken plantlets of each treatment was measured from the lower part to the shoot tip and the mean was recorded. These 20 selected plants were taken out from the jars and washed to remove media, and after drying on filter paper the roots of each plant were counted and the mean value was recorded as well. The root length of these 20 plantlets was measured and their mean was recorded. The fresh roots of these 20 plantlet were detached from the shoot using scalpel and their average weights were recorded. The fresh shoots of these 20 randomly taken plantlets were weighed. For plant dry weight, the samples were dried up at 70 ◦C for 24 h. Chlorophyll a, b and carotenoids content were determined in fresh leaves samples (mg/g. F.W.) according to the method described by Moran (1982).

2.5. Statistical Analysis

All obtained data were tabulated and statistically analyzed according to the analysis of variance using the computer software MSTAT–C (1986) and Duncan Multiple Test at P=0.05 level of probability was used to separate means (Duncan, 1955).

3. RESULTS AND DISCUSSION

The obtained results showed that plant growth was not influenced by the low Concentrationof salinity (10 mM NaC1) and generally it was almost similar to the control treatment, while high levels of salinity significantly reduced plantlet development compared with the control one (Tables 2 and figures!!). Regarding *in vitro* shoot length data presented in Table (2) revealed that shoot length of potato plants was significantly decreased due to increasing salinity level from 0.58 to 7.20 g/l (10 to 120 mM NaCl) as compared to control plants. Moreover, the decrease in shoot length was gradual parallel to the increase in the salinity level from zero to 120 mM NaCl. However, the tallest plants (11.07 cm) was obtained from T2 (100 mM NaCl treatment) with Gizela cultivar followed by Gizela from the control treatment. On contrast, the shortest plants (1.166 cm) was recorded with T5 treatment (70 mM NaCl) in the case of Cara cv. It can be noticed that potato cultivars differ in their tolerance to salinity concentration of the plant height in the following order: Burren ≥ Diamant ≥ Gizela ≥ Lady Balfour ≥ Maritienia ≥ Kaspar ≥ Sponta > Cara, so Burren is the most tolerant variety (under the study condition) while Cara is the most sensitive one for this trait. Similarly, the effect of salinity on shoot length, the same trend was observed on number of leaves/plantlet, whereas increasing salinity levels reduced the number of leaves/plantlet.

However, this reduction in number of leaves/plantlet among the salinity levels failed to reach the level of significance (Table3). The interaction effect of NaCl concentrations on number of leaves/plantlet of the studied potato cultivars was listed in Table (3). Again, Burren cv. was the most tolerant variety (under the study condition) while Sponta one was the most sensitive one in this respect.

Higher number of leaves without significant reduction was given by Burna cultivar under all tested levels of salinity compared to the other tested cultivars. There was a significant difference in the magnitude of the interaction treatments of the number of roots character, the highest value was (10.75) that obtained from Diamant cv. with 0.10 mM NaCl concentration. On the other hand, the lowest one was obtained from Gizela cv. with 120 mM NaCl (2.125) (Table 4). Thigh NaCl levels prevented the growth of new roots. These results are similar with previous studies (Ahmed *et al*., 2020)

The highest value was 0.4403gwith Diamant cv. with 0.580 g/l NaCl concentration for shoot weight character and the lowest value was 0.10007 g with Gizela cv. treated with 120 mM NaCl (Table 5). It is clear that high NaCl caused a remarkable reduction of plantlet fresh weight in the tested potato cultivars. It was also observed that application of 10 mM NaCl in MS medium enhanced the fresh weight of Diamant, Gizela and Kasper plantlets (Table 4). These results indicated that some of the tested potato cultivars differ in their capacity of Na^+/Cl^- absorption. In table (6) the highest value of root weight was 0.41883g with Sponta cv. treated with 10 mM NaCl followed by Diamant cv. treated with 10 mM NaCl (Fig. 3).

The lowest value of shoot dry weight was obtained from Cara cv. with treatment 30 mM NaCl, (2.90 g/l NaCl) and 70 mM NaCl (4.060 g/l NaCl) concentrations compared to other treatments with other cultivars.

Increased salt levels also resulted in a reduction in root length. Above 100 mM NaCl, (Naik and Widholm, 1993) reported poor root growth in potato. The dry matter of the potato cultivars was marginally impacted by salinity. In addition, under salt stress circumstances, (Evers *et al*., 1999) reported low profile roots in potato. Salt reduced microtuberization by reducing water and CO_2 assimilation, also high levels of stress Na^+ in potato plantlets could lead to nutritional deficiencies and oxidative stress in plants (Chinnusamy and Kumar, 2003).

Table 2. Effect of different concentrations of NaCl on plantlet height of 8 potato cultivars

Cultivars	NaCl Concentrations							
	0.0	10M NaCl	30M NaCl	50M NaCl	70M NaCl	100M NaCl	120M NaCl	Mean
Cara	7.20 G-J	6.16 J-L	3.63 Q-U	2.84 U-X	1.17 Y	1.98W-Y	2.03 W-Y	3.57 e
Diamant	10.38 AB	9.51 B-D	9.05 C-E	8.40 D-G	5.78 L-N	4.28 O-S	3.65Q-U	7.29 ab
Gizela	10.62 AB	11.07 A	9.43 B-D	5.97 K-M	4.18 P-T	2.42 U-Y	1.40 Y	6.44 bc
Kasper	8.63 D-F	8.40 D-G	5.93 K-M	3.29 S-V	3.62 Q-U	2.13 V-Y	2.45 U-Y	4.92 d
Maritienia	8.15 E-H	8.05 E-H	7.01 H-K	7.31 G-J	3.39 R-U	3.53 R-U	1.92 WY	5.62 cd
Lady Balfour	9.44 B-D	8.83 DE	7.56 F-I	6.38 I-L	5.67 L-N	2.42 U-Y	1.46 Y	5.95 cd
Burren	10.59 AB	9.57 B-D	10.15 A-C	9.63 B-D	4.80 M-Q	4.89 M-P	4.59 N-R	7.75a
Sponta	7.48 F-I	7.12 H-K	7.51 F-I	5.45 L-O	2.98 T-W	1.87 W-Y	1.60 XY	4.86 d
Mean	9.10 a	8.59 ab	7.53 b	6.16 c	3.95 d	2.95 de	2.39 e	

Note: Duncan's Multiple Range Test shows that the mean of any treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

Table 3. Effect of different concentrations of NaCl on the average of No. leaves/plantlet character for 8 potato cultivars.

Cultivars	**NaCl Concentrations** (M)							
	0.0	10M NaCl	30M NaCl	50M NaCl	70M NaCl	100M NaCl	120M NaCl	Mean
Cara	11.54 A-I	7.83 O-R	8.97 K-R	9.35 H-P	10.13 C-N	9.71 G-O	9.54 H-P	9.57 bc
Diamant	12.27 A-C	11.57 A-H	9.71 G-O	10.79 B-K	10.93 B-K	10.97 B-K	9.95E-O	10.89 ab
Gizela	12.05 A-F	12.39 AB	12.21A-D	11.49 A-I	10.29 B-M	9.30 I-Q	8.32 M-R	10.87 ab
Kasper	9.75 G-O	9.49 H-P	11.55 A-I	8.32 M-R	7.825 O-R	7.90 N-R	8.31 M-R	9.02 bc
Maritienia	10.02 D-O	10.70 B-L	10.49 B-M	10.60 B-L	7.02 R	9.16 J-R	7.10 QR	9.30 bc
Lady Balfour	13.47 A	10.86 B-K	9.06 J-R	8.76 K-R	10.30 B-M	9.45 H-P	9.64 G-P	10.22 a-c
Burren	12.17 A-E	11.55 A-I	12.49 AB	12.26 A-D	11.27 A-J	11.88 A-G	12.25 A-D	11.98 a
Sponta	8.82 K-R	9.55 H-P	9.82 F-O	8.00 N-R	8.475 L-R	7.45 P-R	8.32 M-R	8.64 c
Mean	11.25 a	10.49 a	10.54 a	9.95 a	9.53 a	9.48 a	9.18 a	

Table 4. Effect of different concentrations of NaCl on the number of roots/plantlet for 8 potato cultivars.

Cultivars	NaCl Concentrations(M)							
	0.0	10M NaCl	30M NaCl	50M NaCl	70M NaCl	100M NaCl	120M NaCl	Mean
Cara	7.57 B-K	6.91 D-M	8.10 B-H	7.60 B-K	5.31 L-R	1.00 W	1.00 W	5.07 c
Diamant	9.38 AB	10.75 A	8.77 A-D	7.55 B-K	4.82 N-S	4.70 O-T	5.51 L-R	7.36 ab
Gizela	7.10 D-L	6.61 F-N	6.52 F-O	6.27 G-O	6.38 F-O	5.41 L-R	2.12 V	5.78 bc
Kasper	8.00 B-I	9.32 A-C	7.88 B-J	8.10 B-H	6.95 D-L	7.87 B-J	7.46 C-K	7.94 a
Maritienia	9.164 A-C	8.24 B-F	6.66 F-N	6.08 I-P	4.15 Q-U	3.68 R-V	3.03 S-V	5.86 bc
Lady Balfour	7.96 B-I	7.76 B-J	7.63 B-K	7.71 B-J	6.19 H-P	4.05 Q-U	3.85 R-V	6.45 a-c
Burren	6.70 E-N	7.06 D-L	6.70 E-N	6.82 E-M	5.75 K-Q	5.45 L-R	5.05 M-R	6.22 bc
Sponta	8.60 B-E	8.17 B-G	7.47 C-K	6.02 J-P	4.35 P-U	2.88 UV	2.95 T-V	5.78 bc
Mean	8.06 a	8.10 a	7.47 a	7.02 ab	5.49 bc	4.26 cd	3.75 d	

Note: Duncan's Multiple Range Test shows that the mean of any treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

Table 5. Effect of different concentrations of NaCl on shoot weight (mg) for 8 potato cultivars.

Cultivars	NaCl Concentrations (M)							
	0.0	10M NaCl	30M NaCl	50M NaCl	70M NaCl	100M NaCl	120M NaCl	Mean
Cara	178.6 J-S	70.0 RS	92.0 P-S	101.5 O-S	88.0 P-S	77.3 O-S	67.1 S	96.00 b
Diamant	377.5 A-D	440.3 A	342.8 A-H	202.0 I-S	228.7 F-O	208.8 H-Q	202.7 I-R	286.0 a
Gizela	325.0 A-I	349.6 A-G	392.7 A-C	130.1 N-S	144.3 M-S	142.7 M-S	100.7 O-S	226.0 a
Kasper	109.5 O-S	222.0 G-P	206.5 I-Q	198.9 I-S	175.2 J-S	147.8 L-S	154.9 K-S	174.0 ab
Maritienia	302.2 B-J	380.3 B-L	324.0 A-I	321.3 A-I	86.9 P-S	290.7 B-K	107.9 O-S	245.0 a
Lady Balfour	405.3 AB	303.6 B-J	304.4 B-J	259.1 C-N	233.6 E-O	214.5 H-P	180.3 J-S	272.0 a
Burren	351.0 A-G	277.6 B-M	363.4 A-E	362.3 A-F	219.0 G-P	190.8 I-S	276.7 B-M	292.0 a
Sponta	323.9 A-I	250.2 D-N	272.1 B-M	216.5 G-P	199.1 I-S	163.1 K-S	104.4 O-S	218.0 a
Mean	297.0 a	274.0 ab	287.0 ab	224.0 a-c	172.0 bc	179.0 a-c	150.0 c	

Note: Duncan's Multiple Range Test shows that the mean of each treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

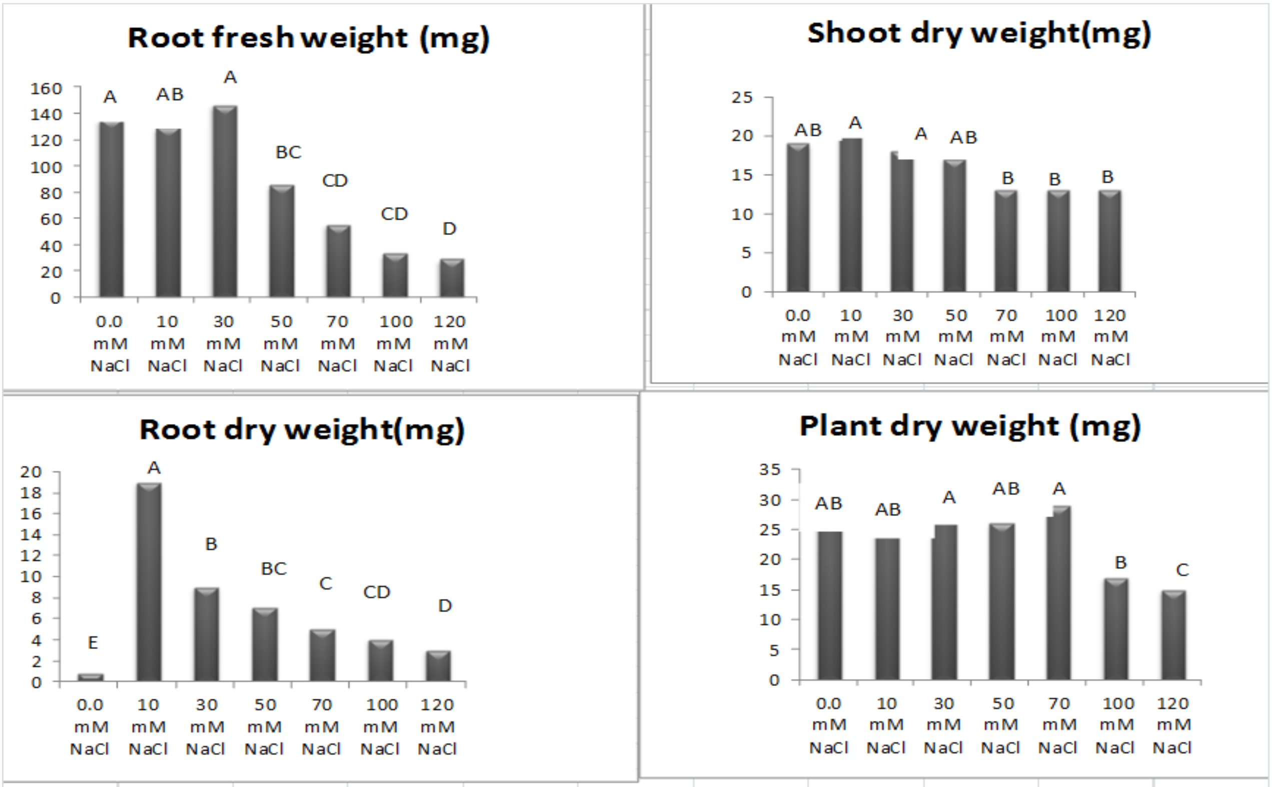

Fig 1. Effect of different concentrations of NaCl on root fresh weight (mg), shoot dry weight (mg), root dry weight (mg) and plant dry weight (mg)

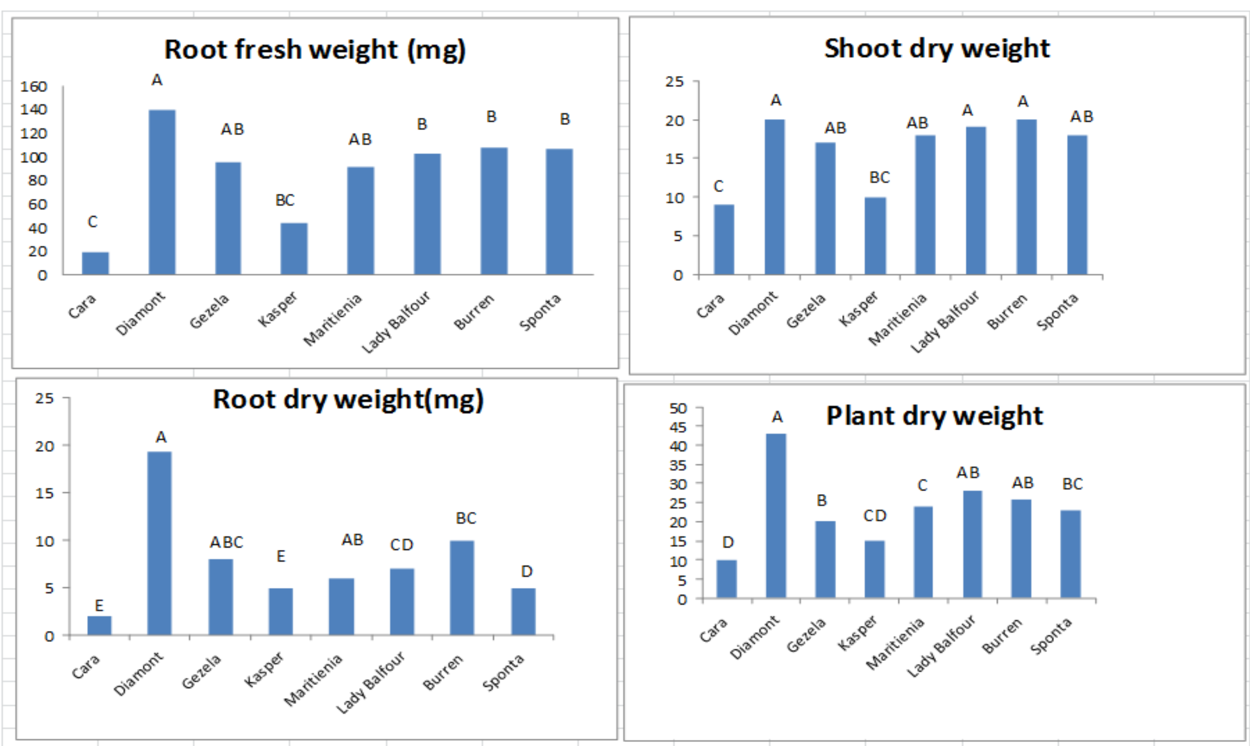

Fig 2. Effect of different concentration of NaCl on eight potato cultivars on root fresh weight (mg), shoot dry weight (mg), root dry weight (mg) and plant dry weight (mg)

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Table 6. Effect of different concentrations of NaCl on chlorophyll a content of some in vitro studied potato cultivars

Cultivars	NaCl Concentrations (M)							
	0.0	**10M NaCl**	**30M NaCl**	**50M NaCl**	**70M NaCl**	**100M NaCl**	**120M NaCl**	**Mean**
Cara	2.215 B	2.204 B	2.219 B	2.218 B	1.408 E-F	1.392 E-F	1.264 F	1.837c
Diamant	2.223 B	2.219 B	2.163 B	2.213 B	2.211 B	2.191 B	2.457 A	2.240a
Gizela	2.158 B	2.181 B	2.177 B	2.176 B	2.176 B	2.161 B	1.502 E	2.080ab
Kasper	2.239 B	2.224 B	2.221 B	2.215 B	2.082 B-C	1.881 D	1.898 D	2.108a
Maritienia	2.207 B	2.206 B	2.204 B	2.201 B	2.190 B	2.239 B	2.178 B	2.204a
Lady Balfour	2.206 B	2.206 B	2.205 B	2.203 B	2.202 B	1.911 C-D	1.853 D	2.112a
Burren	2.208 B	2.204 B	2.201 B	2.201 B	2.197 B	2.195 B	2.192 B	2.200a
Sponta	2.229 B	2.226 B	2.209 B	2.204 B	1.928 C-D	1.472 E	1.253 F	1.932bc
Mean	2.214a	2.209a	2.196a	2.200a	2.049ab	1.930bc	1.825c	

Note: Duncan's Multiple Range Test shows that the mean of each treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

Table 7. Effect of different concentrations of NaCl on Chlorophyll B content character of some in vitro studied potato cultivars

Cultivars	NaCl Concentrations (M)							
	0.0	**10M NaCl**	**30M NaCl**	**50M NaCl**	**70M NaCl**	**100M NaCl**	**120M NaCl**	**Mean**
Cara	1.66 G-G	1.66 B-G	1.66 B-G	1.66 B-G	1.57 L	1.51 N	1.31 O	2.08f
Diamant	1.66 B-G	1.66 C-G	1.66 C-G	1.66 D-G	1.66 D-G	1.66 D-G	1.66 E-G	2.30a
Gizela	1.64 H-G	1.64 H-G	1.64 I-J	1.67 I-J	1.63 J-K	16.23 J-K	1.58 L	2.23d
Kasper	1.67 B-G	1.67 B-G	1.67 B-G	1.68 A-B	1.66 B-G	1.66 F-H	1.68 B-E	2.28bc
Maritienia	1.68 A-B	1.68 A-B	1.70 A	1.68 B-E	1.70 A	1.70 A	1.68 B-E	2.29Abc
Lady Balfour	1.68 B-E	1.68 B-D	1.66 E-G	1.68 B-E	1.68 A-C	1.65 G-I	1.66 F-G	2.28bc
Burren	1.66 B-G	1.66 B-G	1.68 B-D	1.68 B-D	1.66 F-H	1.68 B-F	1.65 G-I	2.29ab
Sponta	1.66 B-G	1.66 B-G	1.67 B-G	1.66 B-G	1.664B-G	1.61 K	1.55 M	2.156e
Mean	2.307a	2.302a	2.298a	2.296a	2.235b	2.18c	2.058d	

Note: Duncan's Multiple Range Test shows that the mean of each treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

Table. (8) Effect of different concentrations of NaCl on Carotenoids content character of some in vitro studied potato cultivars

Cultivars	NaCl Concentrations (M)							
	0.0	**10M NaCl**	**30M NaCl**	**50M NaCl**	**70M NaCl**	**100M NaCl**	**120M NaCl**	**Mean**
Cara	2.311 A-F	2.298 D-K	2.296 E-L	2.294 E-M	1.887 T	1.841 U	1.634 W	1.580d
Diamant	2.317 A-D	2.309 B-G	2.304 C-H	2.303 C-H	2.303 C-H	2.301 D-I	2.255 O	1.662b
Gizela	2.289 G-M	2.284 H-N	2.280 G-N	2.278 K-N	2.275 MN	2.268 NO	1.955 S	1.627c
Kasper	2.326 A-B	2.313 A-E	2.309 B-G	2.304 C-H	2.281 I-N	2.225 B	2.208 Q	1.670b
Maritienia	2.296 E-L	2.293 E-M	2.293 E-M	2.295 E-M	2.295 E-M	2.295 E-M	2.276 L-N	1.689a
Lady Balfour	2.290 G-M	2.297 E-K	2.297 E-K	2.293 E-M	2.292 F-M	2.289 G-M	2.176 R	1.671b
Burren	2.299 D-J	2.301 D-I	2.301 D-I	2.299 D-J	2.294 E-M	2.291 F-M	2.290 G-M	1.667b
Sponta	2.379 A	2.322 A-C	2.308 B-G	2.302 D-H	2.255 O	1.903 T	1.674 V	1.639c
Mean	1.667a	1.667a	1.667a	1.669a	1.654a	1.637b	1.595c	

Note: Duncan's Multiple Range Test shows that the mean of each treatment followed by the same letter (s) in each column is not significant at the 0.05 level of probability (DMRT)

A

B

C

Fig 3. Effect of different NaCl concentrations on some Potato cultivars A. Burren Cultivar, B. Gizela cultivar, C. Maritienia cultivar

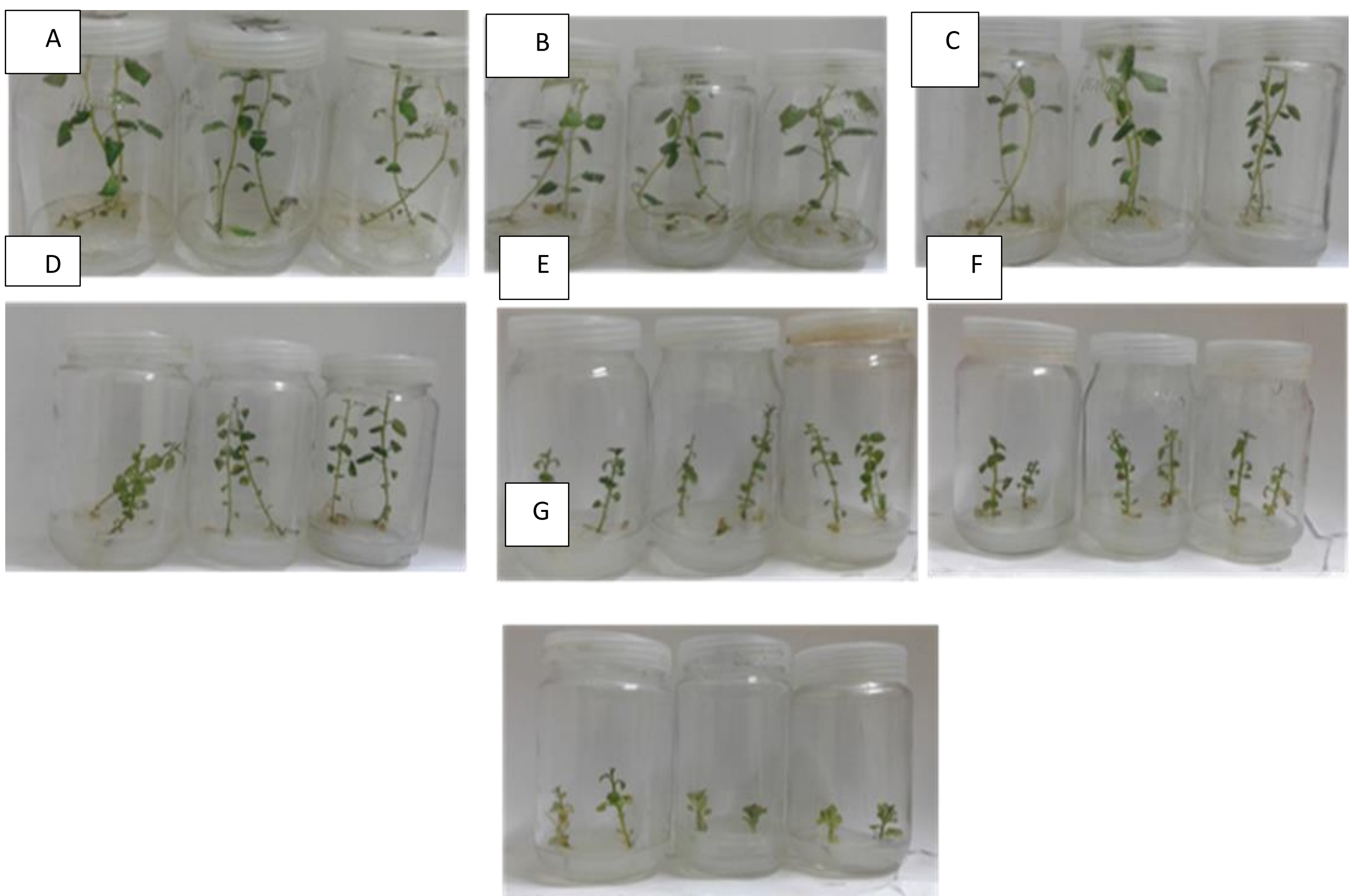

Fig 4. The effect of different NaCl concentrations on Diamant potato cultivar A.) free NaCl; B.) 10 mM NaCl; C30 mM NaCl; D.) 50 mM NaCl ; E.) 7 0mM NaCl; F.) 100 mM NaCl; G.) 120 mM NaCl.

The interaction effect of potato cultivars and salinity stress on photosynthetic pigments chlorophyll a, chlorophyll b and carotenoids were significant. The higher NaCl senility levels significantly decreased chlorophyll a content in five out of the 8 tested cultivars. In levels 10 to 50 mM NaCl, a significant decrease was detected. In addition, an increment was shown in chlorophyll a content by interaction effect of Sponta cultivar and the highest level of NaCl.

Concerning the chlorophyll b results, increasing level of NaCl reduced this parameter in all tested cultivars except Diamant and Burren which were slightly decreased by NaCl application as shown in (Table 7). Thus, potato cultivars respond differently under salinity growing conditions and decreasing trend was observed in chlorophyll a and chlorophyll b at higher NaCl level.

Salinity stress significantly reduced the carotenoids contest in all tested genotypes at the higher levels (Table 7) .The decrease was more pronounced in Cara, Gizela and Sponta than in the other tested cultivars. In the medium with 120 Mm NaCl, plantlets of Diamant and Burren cultivars had higher carotenoids content than those of the other studied cultivars (Fig. 4).

The addition of NaCl to the MS growing medium induced salt-stress that adversely affected shoot, root growth and development of the plantlets of the eighth studied cultivars. This decreasing could be as a result of inducing modifications of balance, water status, mineral nutrition as well as efficiency of photosynthesis as reported by (Abdullah *et al*., 2018). Several investigations has been conducted on salt sensitivity potato genotype under pot and field conditions (Abdullah *et al*., 2018) and in vitro condition (Ahmed *et al*., 2020). However, high NaCl concentration inhibited the development of new roots (Fig.3.). These results are in agreement with a pervious study on potato clones by (Abdullah *et al*., 2018) and commercial cultivars by (Farhatullah and Razin el din, 2020).

Thus, plant tissue cultures the could be considered as is a fast method for different genotypes new clones and commercial against biotic and abiotic stresses and further studies should be done.

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الملخص العربي

تأثير الإجهاد الملحي بكلوريد الصوديوم على نمو وتطور نبيتات البطاطس تحت ظروف المعمل

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تعتبر الملوحة من الضغوط اللاحيائية التي تؤثر على نمو وإنتاجية البطاطس في المناطق النمو شبه القاحلة ، مما يتسبب في حدوث خلل في العمليات الفسيولوجية للنباتات. يعتبر تراكم أيونات الصوديوم والكلوريد في الخلايا من العوامل شديدة السمية ويمكن أن تؤثر على جميع آليات النبات والعمليات الأنزيمية. وتمثل التجارب المعملية للأنماط الجينية النباتية من أجل الإجهاد أداة قيمة كبديل للتجارب الميدانية ويمكن تطبيقه على أساس تحمل إجهاد الملوحة.

كان الهدف من هذه الدراسة هو الكشف عن التباين في تحمل إجهاد الملوحة لأصناف البطاطس باستخدام الفحص في المختبر. تمت زراعة شتلات ساقية تتكون من عقدة واحدة من أصناف مختلفة على وسط من بيئة (MS) مع إضافة تركيزات مختلفة من كلوريد الصوديوم كلوريد الصوديوم (١٠ ، ٣٠ ، ٥٠ ، ٧٠ ، ١٠٠ و ١٢٠ ملي مول من كلوريد الصوديوم) ولوحظت فروق معنوية بين المعاملات حيث أعطى أعلى تركيز لكلوريد الصوديوم أقل القيم لمعظم صفات الدراسة ووجدت فروق معنوية بين الأصناف لاستجابة تراكيز كلوريد الصوديوم وأعطت التركيزات المنخفضة من كلوريد الصوديوم قيم قريبة من معاملة الكنترول.