'Norland' Tuber Yields Are Not Affected by Salinity Treatment of Parent Plants

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Abstract. Micropropagation and minituber production technology may enable the establishment of potato (*Solanum tuberosum* L.) seed tuber certification programs in arid and semiarid regions of the world and reduce dependency on expensive seed tuber imports. Therefore, we investigated possible carry-over effects of moderate salt stress on the following production cycle. The yields of seed tuber- and microtuber-derived plants of potato, cv. Norland, grown in both nonsaline and saline (NaCl) growing conditions (pretreatment), were evaluated under nonsaline or saline irrigation (0 or 60 mM NaCl) in a greenhouse trial. Pretreatment had no effect on yield; there was no apparent residual carry-over effect of salt stress of parent plants on tuber yield of seed tuber- or microtuber-derived plants. Irrigation with a 60 mM NaCl solution depressed total tuber fresh weight in both seed tuber- (43%) and microtuber-derived plants (75%), but total tuber number was increased (77% and 663%, respectively). This increase in tuber numbers has potential value in the minituber production industry.

High soil salinity depresses the growth and productivity of many crops. Potato is considered moderately salt-sensitive since a soil salinity level of 2.0 dS·m⁻¹ reduced plant growth and tuber yield up to 50% (Maas and Hoffman, 1977). However, recent reports indicate that low salinity levels may stimulate growth of some cultivars. For example, low salinity levels enhanced micropropagated plantlet growth in vitro in two of six cultivars (Potluri and Prasad, 1993), stimulated microtuber yield in two of five cultivars (Zhang and Donnelly, 1997), and increased tuber yield in two of four cultivars in pot trials (Ahmad and Abdullah, 1979) and six of 10 cultivars in field trials (Kang et al., 1995).

Potato production has been steadily increasing in Africa and the Middle East since the 1960s (Food and Agricultural Organization, 1995). Local production of seed tubers is desirable to reduce dependency on high-cost European and North American imports, but is constrained by many factors, including water quality (Leclerc, 1993). Seed production un-

der protected cultivation is usually a flush-through system involving one or two generations of minitubers in the greenhouse (Lommen and Struik, 1995). 'Norland' was selected for this trial for several reasons. It is an important, short-season cultivar ranked as relatively salt-sensitive (Khrais et al., 1998). Of 130 cultivars tested, Norland ranked in the sixth of eight units (1 = most tolerant and 8 = least tolerant). The carry-over effect of salinity on yield potential of tubers is unknown. We thought it appropriate to investigate carry-over effects on a salt-sensitive cultivar.

The objective of this experiment was to evaluate the impact of salinity stress on yield of 'Norland' plants derived from tubers from plants grown under either nonsaline (control) or saline growing conditions in a greenhouse pot trial. In the trial, minituber production practices were followed except that the water applied was either free of NaCl or contained a relatively high level of salt, such as would be found in parts of the world where irrigation water is reused or naturally saline. This would enable us to: 1) quantify the carry-over effect (if any) on the performance of tubers in their second cycle of exposure to salinity; and 2) determine the effect of moderate salinity stress on the yield components of 'Norland' control tubers having no previous history of exposure to salinity.

Materials and Methods

Seed tubers of 'Norland' were obtained from plants grown in field lysimeters under nonsaline or saline irrigation at electrical conductivity (EC) of 1.5 and 3.5 dS·m⁻¹ (≈17 and 40 mM NaCl), respectively (Zhang and Donnelly, 1997), and were stored for 8 months

at 4 °C in the dark. Microtubers of 'Norland' were obtained from plantlets layered on a modified MS (Murashige and Skoog, 1962) basal salt medium without or with NaCl at 80 mM (Leclerc et al., 1994; Zhang and Donnelly, 1997) and were stored for 4 months in sealed petri dishes at 10 °C in the dark.

The experiment was conducted in the Raymond Greenhouse of Macdonald Campus, McGill Univ., Montreal. For both seed tubers and microtubers, there were two pretreatments (parental history of exposure to nonsaline vs. saline growing conditions) and two imposed salinity stress levels (0 and 60 mM NaCl). Seed tubers (50–70 g) and microtubers (0.2–0.5 g) were planted 10 or 5 cm deep, respectively, into 10-L pots filled with 8 L of potting mixture (ProMix-BX; Premier Brand, Riviere-du-Loup, QC, Canada). Slow-release fertilizer (Osmocote; 19N–2.7P–10K at 5 g per pot) was applied at planting time and again 6 weeks later. The 40 seed tubers or microtubers were arranged in a completely randomized block design (CRBD), with five blocks and eight tubers per block. Plants were grown at 26 °C day/20 °C night temperature under natural light conditions.

Initially, pots were watered daily until runoff with 1.5 L tap water per pot. Commencing 10–14 d after first sprout initiation, half of the pots were irrigated with NaCl solutions; these were increased in concentration over a 1-week interval to reach 60 mM (3.51 g·L⁻¹ NaCl). During the course of the trial, the EC of the leachate from the pots irrigated with saline water was 6.0–6.3 dS·m⁻¹, while it remained 0.2–0.4 dS·m⁻¹ in the pots irrigated with tap water. Hilling was done at 20 and 40 d after planting, adding 0.75 L of potting mixture per pot each time, and the plants were harvested 90 d after planting. After harvest, shoot number and yield parameters, including tuber number (N) and fresh weight (FW) for each of two size (diameter) classes; [small (0.5–4.0 cm) and large (4.1–8.0 cm)], were recorded. The two classes of tubers reflected sizes that would probably be recycled under protected cultivation (small) or used for field-increase (large). Data was analyzed with the General Linear Method (GLM) (SAS Institute, 1989).

Results and Discussion

Pretreatment with salinity had no significant effect ($P \leq 0.05$) on the percentage of sprouting, time of emergence (7 to 14 d), mean number of plant stems [4.0–7.4 for seed tuber-derived (std) and 1.0 for microtuber-derived (mtd) plants], or N and FW of small or large tubers in either std or mtd plants. This clearly suggested that there was no carry-over effect on growth or yield of tubers from plants that had been grown under saline conditions, and that tubers produced under moderate salinity stress could be recycled for further minituber increase or used for crop production, without serious adverse effects.

Despite the lack of apparent carry-over effect, saline irrigation (60 mM NaCl clearly had a major impact on yield components of 'Norland'. It significantly reduced std plant

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tuber N (57%) and FW (64%) in the large class size, but increased N (217%) and FW (178%) in the small size category (Table 1). This resulted in a 75% increase in total N, but a 43% decrease in total tuber FW for both std plant tuber size classes combined. Similarly, saline irrigation significantly reduced mtd plant tuber N (75%) and FW (94%) in the large size class, but increased N by 15-fold on average (although FW was not affected) in the small size class. This resulted in a >7-fold increase in the total N, but decreased the total tuber FW by 75% when both tuber size classes were combined.

The observed desirable effect of salt stress on total tuber number in 'Norland' has value in minituber production systems. This type of stress-induced response is achieved with most cultivars through higher planting densities (Lommen and Struik, 1992). For seed production purposes, the number of tubers in the optimum size range (15–40 g) is far more important than is the absolute yield (Nadler and Heuer, 1995). Under protected cultiva-

tion, the smaller tubers, which may not be suitable for field production, can be recycled for further seed production (Ali et al., 1995). In fact, depending on the cultivar, 0.5- to 4.0-g tubers can produce high multiplication factors of six to 10 under controlled environments (Lommen and Struik, 1995).

In conclusion, there was no observed carry-over effect of parental growth under saline growing conditions in the relatively salt sensitive cv. Norland. There is little reason to suspect that a carry-over effect would occur in relatively more salt-tolerant cultivars, as ranked by Khrais et al. (1998). Mild salinity-stress depressed yield of 'Norland' as expected for salt-sensitive cultivars. However, despite significantly reduced total fresh weights, the total tuber numbers were significantly increased. This was particularly true in the microtuber-derived plants. This type of yield response may have potential value to the seed tuber industry and may be an unforeseen benefit of the use of moderately saline irrigation water.

Table 1. 'Norland' potato tuber yield [number (N) and fresh weight (FW) in grams (g) per plant] from pretreated (saline or nonsaline) seed tuber-derived and microtuber-derived plantlets irrigated with 0 or 60 mM NaCl in a greenhouse trial.

Pretreatment	NaCl (mM)	Total tuber yield		Tuber size distribution (cm)			
				0.5–4.0		4.1–8.0	
		N	FW	N	FW	N	FW
<i>Seed tuber-derived plantlets^a</i>							
Saline	0	10	488	5	33	5	455
	60	19	275	17	97	2	178
Nonsaline	0	14	548	6	56	8	492
	60	23	314	20	153	3	161
Total	0	12 b ^y	518 a	6 b	45 b	7 a	474 a
	60	21 a	295 b	19 a	125 a	3 b	170 b
Difference (%)		+75	-43	+217	+178	-57	-64
<i>Microtuber-derived plantlets^a</i>							
Saline	0	7	25	54	35	3	220
	60	50	55	49	40	1	15
Nonsaline	0	9	348	4	72	2	76
	60	72	99	71	83	1	16
Total	0	8 b	302 a	4 b	54 a	4 a	248 a
	60	61 a	77 b	60 a	62 a	1 b	16 b
Difference (%)		+663	-75	+1400	+15	-75	-94

^aSeed tubers were harvested from field lysimeters irrigated with saline (EC 3.5) or nonsaline (EC 1.5) water.

^yMean separation within columns by LSD $P \leq 0.05$.

^aMicrotubers were induced in vitro in saline (80 mM NaCl) or nonsaline (0 mM NaCl) media.

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