# Salt tolerance of sweet pepper seedlings

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***Summary:*** Laboratory germination tests have been made with three white fruit pepper varieties and with one spice pepper in filter paper rolls wetted with KCl solutions of different concentration. Parallel tests have been conducted with the other species (lettuce, tomato, kohlrabi) to compare the salt tolerance of paprika with that of other vegetable crops.

In greenhouse, the action of KCl has been investigated with transplants raised in soil mixture, in rockwool and with seedlings transplanted from rockwool into soil mixture. Like the trials in the laboratory, the experiments in soil mixture have been made with other plant species, too.

***Key words:*** salt tolerance, electric conductivity (EC), irrigation water, dynamics of germination, seedling length, dry matter content, pepper, lettuce, tomato, hohlrabi

## Introduction

The high salt content of soils and of irrigation water causes a lot of problems all over the world. According to the results of our investigations carried out in Hungary's major vegetable growing areas over six years, the salt content of the soil is higher than normal on every fifth farm and the water is unsuitable for irrigation on every fourth farm, also due to its high salt content. The high salt content of soils is (84% in 1999) attributed to excessive potassium fertilisation in most cases *(Slezák* et al, 2000a,b).

Growing on soilless media, an alternative widely spreading in Hungary, eliminates the problem of high salt content. However, plants grown with this technology are more susceptible to the (salty) irrigation water of poor quality as well as to the nutrient solution of too high concentration. Rockwool, the most widespread growing medium in cultural practice, is an inert medium like sand or pebbles; consequently it doesn't bind ions (*Szőriné,* 1999). Such media can only support the roots and, unlike soil, have low regulating capacity (*Forró,* 1999).

It can be generally said of vegetable varieties that they are all affected by the salt content of the growing media as well as that of the irrigation water. However, the varieties differ in sensitivity. According to the most widespread classification in Hungary, three categories are used for characterising plants on the basis of their salt tolerance, considering practical aspects too (*Terbe,* 1995b). In this way, the most susceptible species are cucumber, watermelon, lettuce, sweet pepper, carrot, parsley and radish, whereas other cruciferous plants, celery, spinach, beet-root, chard, asparagus and chives are regarded as salt tolerant. In-between, there is the group of plants with medium salt tolerance, to which other vegetable species, including conical sweet pepper, belong.

In the international special literature, several cases are reported where the classification of species according to salt tolerance differs from that used in Hungary (*Akinchi* & *Akinchi*, 1999; *Eleizalde* & *Larsen*, 1983; *Maas* & *Hoffmann*, 1977; *Maas*, 1984). Some species considered as susceptible to salt in Hungary are referred to as salt tolerant in other countries. These contradictions are mostly due to the different salt tolerance of varieties (*van der Beek* & *Ltifi*, 1991; *Cornillon* & *Palloix*, 1997; *Fischer*, 1985; *Terbe*, 1995a).

Besides, the degree of salt tolerance varies by the age of plants. The most susceptible phenological phase is that of the seedlings after germination, when the root system of the plants is relatively small and high concentration of salt applied temporarily could lead to malformation, reduced growth and, in extreme cases, to the death of the plants.

Due to the increase in the price of seeds and in other expenses arising in the nursery, it is our main task to reduce loss in seedlings caused by high salt content.

Different soil mixtures are used while growing seedlings in order to eliminate the possibly high salt content of the soil in the greenhouse. The salt content is adjusted by using the right quality and rate of components of the soil mixture, by selecting the right type of fertiliser mixed with the soil or applied while growing seedlings, as well as by choosing the right irrigation water (e.g. rain water). In case of soil mixtures with high humus content, the buffer-property of humus has to be taken into consideration, as the high content of humus decreases the harmful effect of salt (*Terbe*, 1981).

The salt tolerance of sweet pepper seedlings was evaluated with special regard to the white, conical fruited varieties renowned as 'Hungaricum'. Besides, one tomato variety, one lettuce variety and one kohlabi variety were tested in order to compare the salt tolerance of sweet pepper varieties with species, the salt tolerance of which had already been known.

## Material and method

The effect of salinity on different sweet pepper varieties *(Table 1.)* was tested by applying KCL solution of different concentration. The KCL solution was of pharmacopoeia standards. The concentration of the solution was characterised by electric conductivity (EC) accepted in cultural practice (1 mS/cm solution EC is equivalent of 0.58 g/l KCL). Preliminary tests were made with the sweet pepper variety `Fehérözön` to choose the right range of concentration.

*Table 1* Material of tests

| Name of pepper variety | Type of fruit | Type of growth | Tests | | | |
|---|---|---|---|---|---|---|
| | | | Laborat. | Soil mixture | Rockwool | Rockwool/soil mix.. |
| HRF F1 | white, conical | indeterminate | | + | + | + |
| Fehérözön | white, conical | determinate | + | + | + | + |
| Syn. Cecei | white, conical | indeterminate | + | + | + | + |
| Boni | white, blocky | indeterminate | + | + | + | + |
| Titán F1 | hot, pointed | indeterminate | | + | + | + |
| Pritavit F1 | tomato-shaped | indeterminate | | + | + | + |
| Control variety | | | | | | |
| Május királya (lettuce) | | | + | + | | |
| Heinz 1350 (tomato) | | | + | | | |
| Marmande (tomato) | | | | + | | |
| Gigant (kohlrabi) | | | + | + | | |

Germination was studied in filter paper rolls (type: 651/120, made by Macherey-Nagel), wetted with KCL solution of 0–40 mS/cm EC, at the temperature of 20–22 °C, in the laboratory. The tests were continued for a period of time set in the standard MSZ 6354-3. (Germination time is specified to 14 days in pepper and tomato, 10 days in cruciferous plants and 7 days in lettuce by the standard.)

The dynamics of germination, the appearance of the cotyledon, the diseases and the length of the seedlings in the cotyledonous stage were recorded.

During seedling raising, the effect of KCl was studied on plants grown in soil mixture and in rockwool, as well as on those germinated in rockwool and transplanted into soil mixture.

**For the experiments in soil mixture** seeds were sown directly into 176 mesh KITE trays. As starter nutrient, PG-MIX TM was added to the peat and sand (1:1, v/v) mix. The plots were treated with KCl solutions of different EC (0, 3, 6, 9 and 12 mS/cm), respectively. From the 20th day after sowing onwards, the solutions were completed by Volldünger (2.61/5.27/8.16/11.00/13.67 mS/cm). During the 20 days period after sowing, the number of the embryos appeared and that of the healthy ones were recorded. The height, stem diameter and the dry matter content of the plants were measured. Like in laboratory tests, the same trials were performed with other species, too.

**In tests with rockwool**, seeds were sown into Grodan® seedling cubes and were treated with KCL solution of 0, 3, 6, 9 mS/cm EC. The plots were made of seedling cubes covered with plastic film from outside and arranged by 5x2. Until the beginning of germination, the trays were screened in order to reduce drying out. The trials were conducted over 20 days, during which period the substrate was wetted once or twice daily. Plant development was recorded every second day. The healthy embryos as well as the brown ones were counted. The appearance of cotyledons and true leaf were recorded.

**Salt tolerance of seedlings raised on rockwool and planted in soil mixture.**

On the 20th day of the experiment with KCl treated rockwool, the most developed plants of the control (0 mS/cm) and of the 3 mS/cm treatment were pricked out into plastic cups of 20 cm3, filled with peat and sand (1:1, v/v) mixture. Three plants per treatment and per variety were raised and of 5 different concentrations of KCl. Like in the KITE tray experiments, the KCl solutions of 0, 3, 6, 9 and 12 mS/cm EC were completed by 2‰ Volldünger (2.61, 5.27, 8.16, 11.0, 13.67 mS/cm). These solutions were used for irrigation. The dead plants were recorded daily and conclusion on salt tolerance was drawn from data of survival. On the last day, the height of the plants and the number of the leaves longer than 1 cm were noted and the dry matter content was determined while evaluating the results, we have tried to state if the treatments with salt solutions of 3 mS/cm over 20 days had any positive or negative effect on the later treatments.

## Results

### *Germination test in the laboratory*

Statistically significant protraction of the germination and diminution of the germ length have been observed under the influence of high salt concentration *(Table 2 and 3)*. The solutions of low salt content, however, haven't impaired germination. On the contrary, they have slightly accelerated it. From the four sweet pepper varieties tested, `Syn. Cecei` seemed to be the most susceptible. It was even more responsive to the salt treatments than lettuce, a crop regarded expressly salt-sensitive by several authors. 'Fehérözön' and 'K.M.622' showed the least sensitivity among paprika varieties.

***Table 2*** Number of days when germination reaches 50% (since the begining of germination)

| Treatment | Fehér-özön | Syn. Cecei | Boni | K.m. 622 | M. királya | Heinz 1350 | Gigant |
|---|---|---|---|---|---|---|---|
| 0 mS/cm | 4 | 7 | 6 | 5 | 1 | 2 | 1 |
| 5 mS/cm | 4 | 6 | 6 | 5 | 2 | 3 | 1 |
| 10 mS/cm | 5 | 8 | 6 | 5 | 4 | 4 | 1 |
| 15 mS/cm | 6 | – | 8 | 6 | – | 6 | 1 |
| 20 mS/cm | 8 | – | 8 | 8 | – | – | 1 |
| 25 mS/cm | 10 | – | – | 9 | – | – | 1 |
| 30 mS/cm | – | – | – | 8 | – | – | 1 |
| 35 mS/cm | – | – | – | – | – | – | 1 |
| 40 mS/cm | – | – | – | – | – | – | 2 |

***Table 3*** The average length of the seedlings (mm) on the last day of the germination test

| Treatment | Fehér-özön | Syn. Cecei | Boni | K.m. 622 | M. királya | Heinz 1350 | Gigant |
|---|---|---|---|---|---|---|---|
| 0 mS/cm | 51.23 | 49.33 | 55.63 | 54.21 | 47.91 | 122.20 | 83.08 |
| 5 mS/cm | 59.72 | 54.31 | 60.42 | 57.88 | 39.25 | 108.60 | 82.45 |
| 10 mS/cm | 53.14 | 53.82 | 49.31 | 52.16 | 34.39 | 103.10 | 63.82 |
| 15 mS/cm | 40.56 | 40.00 | 23.06 | 30.00 | 23.07 | 79.75 | 50.96 |
| 20 mS/cm | – | – | – | – | – | – | 38.00 |
| 25 mS/cm | – | – | – | – | – | – | 56.80 |
| 30 mS/cm | – | – | – | – | – | – | 41.84 |
| 35 mS/cm | – | – | – | – | – | – | 26.81 |
| 40 mS/cm | – | – | – | – | – | – | 5.00 |

*(Mean values of the least 5 seedlings)*

***Table 4*** Sensitivity of tested varieties on the basis of EC-value of 50% germination

| Salt tolerance | Half-time (germinated) | Last day (healthy plants with cotyledonous seedlings) |
|---|---|---|
| Most tolerant ↑ most susceptible | Gigant *(40)*<br>Fehérözön *(15)*<br>K. m. 622 *(15)*<br>Heinz 1350 *(15)*<br>Boni *(10)*<br>M. királya *(10)*<br>Syn. Cecei *(5)* | Gigant *(30)*<br>Heinz 1350 *(15)*<br>Fehérözön *(10)*<br>K. m. 622 *(10)*<br>M. királya *(10)*<br>Syn. Cecei *(5)*<br>* |

* The variety 'Boni' has not reched 50% even in the controll treatment.
(EC-value is shown in brackets after the name of varieties

The susceptibility of the varieties determined at half-time and the last day of the experiment (on the basis of % of germinated and cotyledonous plants) is shown in *Table 4*. The sweet pepper varieties (except `Syn. Cecei`) started to germinate even in solutions of EC higher than 20 mS/cm. Lettuce proved to be unable to germinate above 15 mS/cm and tomato above 20 mS/cm. This experience, however, doesn't prove that tomato is more sensitive than sweet pepper since a much higher percentage of diseased seedlings occurred in sweet pepper than in tomato. The number of healthy cotyledonous seedlings registered on the last day of the experiment proved, too, that tomato tolerates higher salt concentrations than sweet pepper *(Fig. 1)*.

In all the parameters tested, kohlrabi turned out to tolerate salt better than all other species tested.

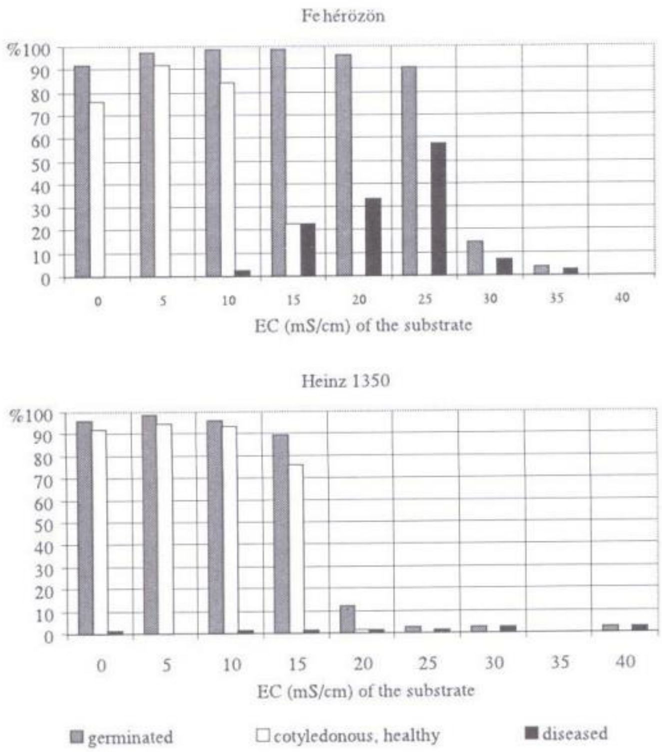


***Figure 1*** Number of germinating, cotyledonous and unhealthy seedlings

### *Experiments of raising seedlings*

- **Raising seedling in soil mixture.**
  Under glasshouse conditions, irrigation with KCl solution of 3 mS/cm EC hasn't impaired significantly the germination in a number of varieties grown in soil mixture. Higher doses have hindered considerably the germination of sweet pepper varieties and of tomato in the second series. The germination was 70% with the solution of 6 mS/cm, 35% with 9 mS/cm and below 20% with 12 mS/cm EC in every variety on the 20th day. In these species, similarly to the findings in the laboratory tests, the

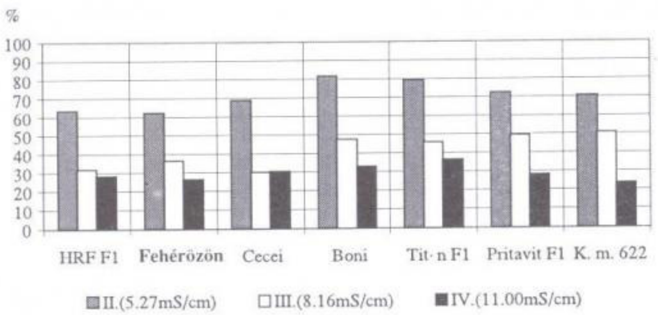


*Figure 2* Seedling length of pepper varieties compared with controll

slowing down of germination has been observed. Among sweet pepper varieties, 'Titán F1' and 'HRF F1' have better tolerated high salt concentration in both series and 'Pritavit F1' has better tolerated high salt concentration in the second trial than the other varieties. However, decline has been found in these varieties, too, and germination was very poor with the highest salt concentration (12 mS/cm) in both series.

In lettuce, only the treatment 12 mS/cm has significantly diminished germination percentage to 45–47%. This seems to be inconsistent with the results of the laboratory trials and with publications on the sensitivity of the species. One has to bear in mind, however, the quick germination of lettuce seed. During the short germination period, much less salt gets into the soil by irrigation than in the course of the germination of sweet pepper and tomato seed. Thus, the results in lettuce mustn't be compared with the results in sweet pepper and in tomato. It is clear, however, that the quick germination of lettuce helps the crop to tolerate salty irrigation water in the early phase of development.

Kohlrabi has shown high salt tolerance of germination, in accordance with publications on the subject and with the results of our laboratory trials.

Plant height and stem diameter diminished with salt treatment in both series, particularly in the second one. Here, the nutrient solution with Volldünger of 11.0 mS/cm EC (KCl EC=9 mS/cm) reduced plant height by 56.7–72% and stem diameter by 31.6–64.8%. In the treatment of EC higher than mentioned, none of the seedlings survived. In the first series, diminution hasn't been observed with the solution containing the lowest dose of KCl. In most cases, superior dry matter content of the top was found with increased salt concentration. This experience agrees with reports on other species.

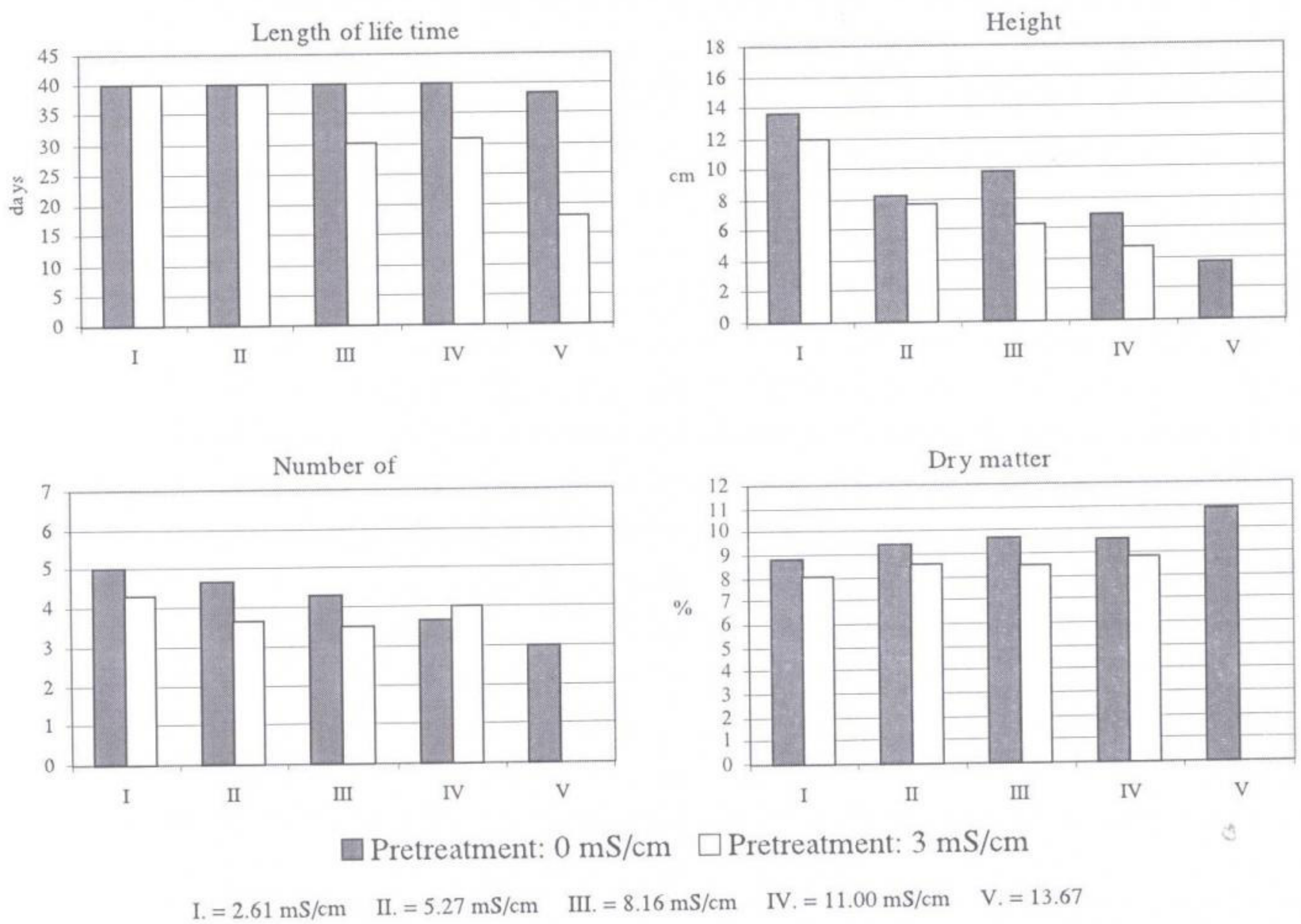


*Figure 3.* The effect of pretreatments and salt treatments on characteristics of seedlings of 'HRF F1' variety

- **Germination in rockwool.** The 3 mS/cm treatment in rockwool, had no negative effect on germination tested on the 8th day after seeding, it was even helpful in several varieties (especially in 'Fehérözön' and in 'Syn. Cecei'). On the 14th day, however, such effect was found in the first experiment only.

  On the 20th day (the most important day in cultivation practice as pricking is usually done at that time) even the lowest salt concentration proved to be harmful in several varieties. The decline in these varieties, was above 20 percent in several cases. In both tests, the varieties with white, conical fruits proved to be more susceptible.

- **The salt tolerance of rockwool grown seedlings in soil mixture.**

  It was found that the vitality of the seedlings of the white, conical fruited varieties pretreated with salt solutions was of poorer quality compared to seedlings pretreated with pure water. In the majority of the cases, the plants pretreated with salt solutions were less high than the seedlings pretreated with deionized water. The dry matter content increased in the treatments with salt (by 11.1 to 33.2%) but no close relation to salt concentration was found bythe varieties. In general, the pretreatment with salt resulted lower dry matter content than the pretreatment with pure water (the differences were above 10% in several cases). Relations are shown through the example of the 'HRF F1' variety in *Fig 3.*

## Discussion

To characterise the salt tolerance of sweet pepper plants at the stage of early development, laboratory germination tests are suitable considering the following:

- Rapid germination after applying solution of high salt concentration does not indicate good salt tolerance in every vegetable species. Harmful effects caused by high concentration of salt can occur at a later stage of development (cotyledonous-stage).
- The degree of susceptibility measured in filter paper rolls are suitable for comparing different species, but can not be adapted to germination in growing media.

  The followings should be taken into consideration when using irrigation water of poor quality (high salt content) while growing seedlings.
- Germination is damaged (prevented) by a lower degree in plants characterised by rapid germination, as less irrigation water is applied from sowing until germination.
- Sweet pepper seedlings irrigated with water of poor quality (of high salt content) show increased sensitivity to the quality of water at germination and cotyledonous stage than at later stages of development.
- Sweet pepper plants irrigated with water of high salt content until the cotyledonous stage are more susceptible to the salt content of irrigation water during later phenological phases.

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