The potato variety “927” tested at the Salt Farm Texel,The Netherlands, proved to be highly salt tolerant.

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Abstract

In the Salt Farm Texel, The Netherlands, potatoes were tested on their tolerance of soil salinity. The potato variety “927’ proved to be much more salt tolerant than than the potato mentioned in literature. In this article the experimental data of the Salt Farm are analyzed using the Maas-Hoffman (MH) model, the cubic regression, and the PartReg method. It appears that “927” does not show a yield decline up to a salinity level (expressed in electrical resistance of the soil moisture) of 6 dS/m, more than 3 times higher than the value mentioned in literature.

Contents

1. Introduction

The soil salinity is usually expressed as the electric conductivity (EC) of an extract (ECe) of a saturated soil paste with units dS/m. The classification of salt tolerance of crops uses this measure.
The salt tolerance of crops is extensively described by the FAO [Ref. 1] , using the Maas-Hoffman (MH) model. The salt tolerance of potato is given here as 1.7 dS/m, the threshold level.
The Salt Farm Texel, The Netherlands, has tested many crops on salt tolerance using saline irrigation water to various degrees. [Ref.2]. The potato “927”, using the MH model was given a higher tolerance level: 3.4 dS/m. It is questionable if application of the MH model was justified in this case, as will be explained later.
In this article the salt tolerance of “927” will be tested with the MH model, a cubic regression, and the PartReg method to verify its salt tolerance.

2. The Maas-Hoffman (MH) model

The MH model may use the following two equations for Y=yield and S=soil salinity:

Y = Yav [S<BP]
Y = A.S + C [S<BP]

where:
Y is crop yield, Yav is the average Y for S<BP, BP is the break point or threshold value of S with S being the soil salinity, A is the slope of the line connecting the point (Yav, BP) with the central point of the (Y,S) data when S>BP, C is the intercept of the sloping line to the right of BP with the Y axis at S=0. The slope of the line to the left of BP is zero and the intercept is Yav.

Figure 1, using the SegReg calculator [Ref. 3] for the segmented regression of Y upon S, shows the result of the MH model on the basis of the Salt Farm data for “927” obtained in the year 2015. SegReg program finds BP by optimization, minimizing the sum of squares of deviations of the observed Y values from the calculated ones according to the MH model (in SegReg called Type 3). This method is also called least squares or LS method

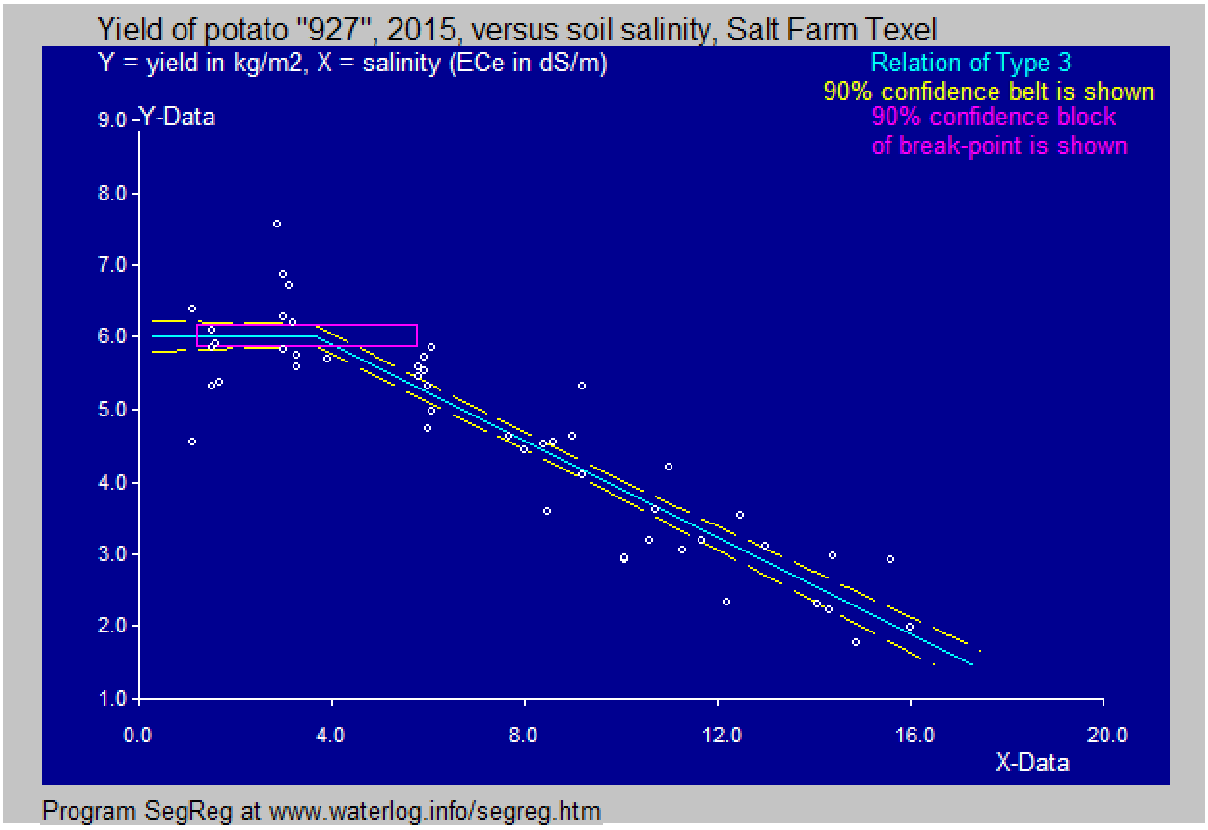

Figure 1. Results of segmented regression for potato "927" The breakpoint or threshold value of S is 3.4 dS/m, double the value given by FAO. The observed data are indicated by "o".

In figure 1, the width of the 90% confidence interval of BP is quite wide. It may be investigated if there are other analysis techniques that can improve the reliability of BP.

3. Cubic regression

The following picture shows the results of a generalized cubic (3rd degree) regression using the amplified SegReg model, called SegRegA [Ref. 3], making use of the LS method.

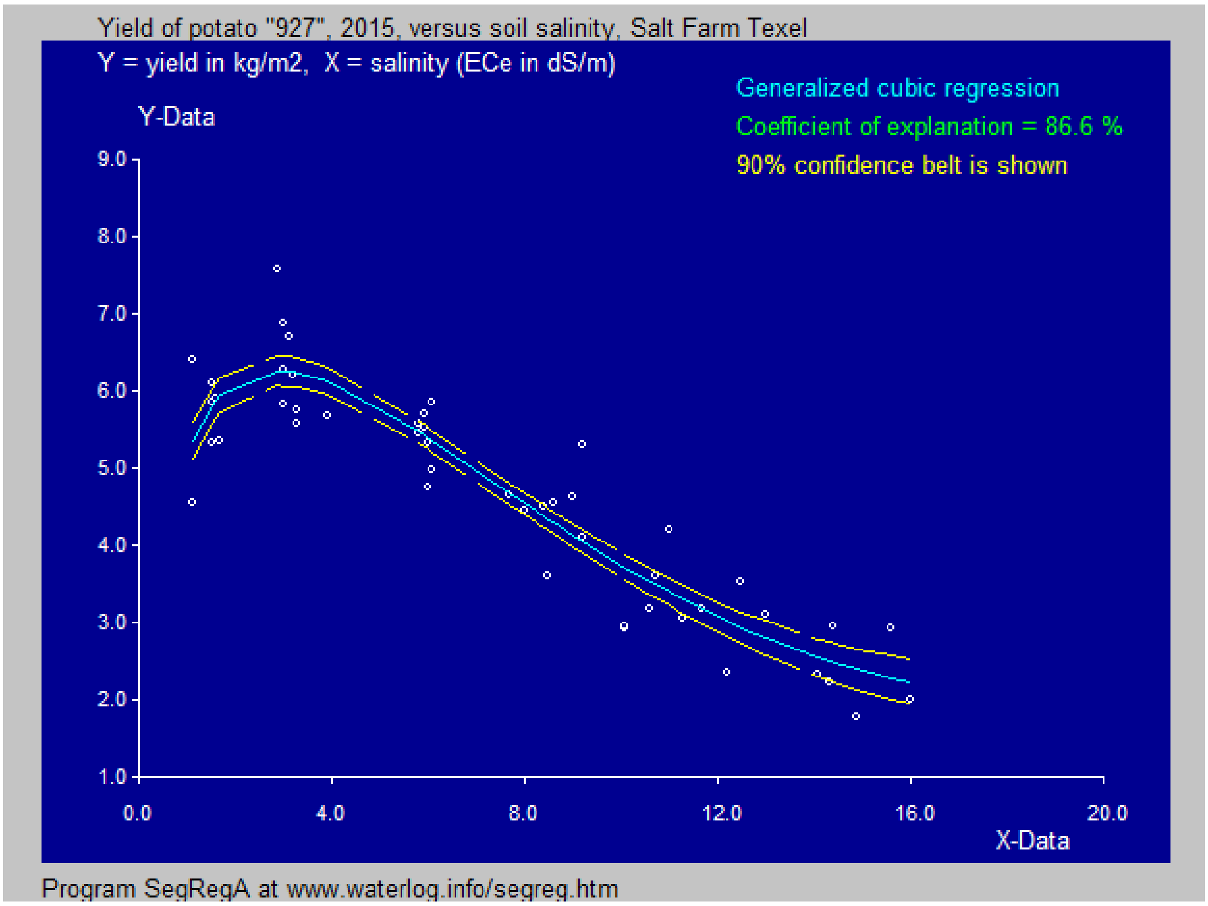

Figure 2. Cubic regression using the "927" data of the Salt Farm.
*The regression equation is Y=0.537*X^(0.49*3)–4.70*X^(0.49*2)+11.2*X^0.49–1.84, where the factor 0.49 effectuates a generalization of the cubic regression (in other words the X values are raised to the power 0.49 before the cubic regression is done, this to increase the goodness of fit).*

Figure 2 shows that initially there is an increase in yield at increasing S values while after the peak the yield tends to decrease. At X=S=6 dS/m the yield is back at its initial value found at at X=1. It can also be seen that the curve flattens out at the higher X=S values.

The coefficient of explanation (also called R^2) is 0.87 and higher than according to the MH model in figure 1, so that the fit of the data to the cubic model is better.

4. The PartReg method

The PartReg method has no parameters and does not use the LS method, but it simply tries to detect ranges of X values over which the slope of the regression line can be taken equal to zero (the horizontal segment). It does partial regressions, from where the name.

The result of the PartReg principle are depicted in figure 3.

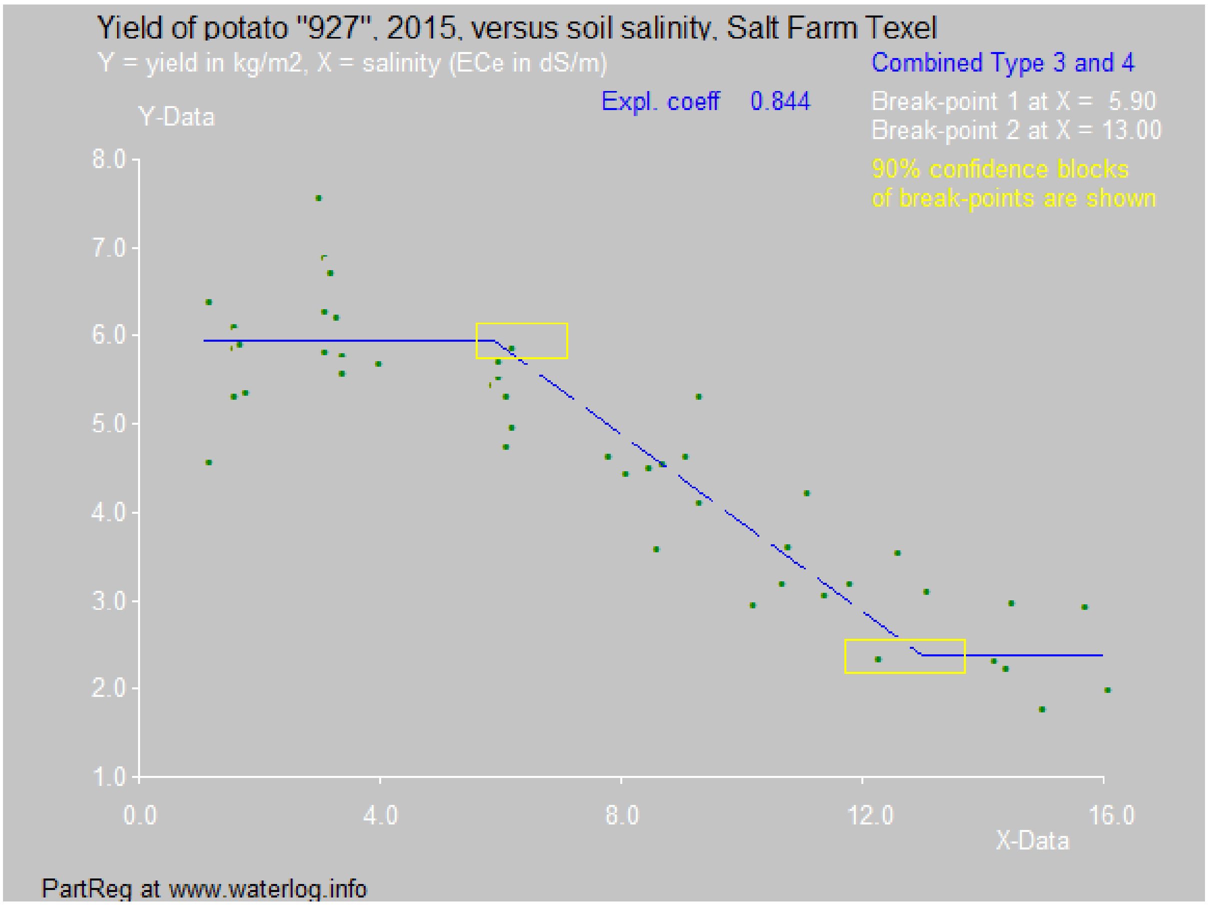

Figure 3. Result of the PartReg. It has detected two horizontal segments and two breakpoints.

In figure 3 the first BP value is 5.9 dS/m, considerably higher than the 3.4 dS/m found with the MH method and almost 4 times the value given by FAO. This BP value corresponds with the value found in the cubic regression where the yield is back to its initial value

The horizontal segment to the right is the reason why the MH model produces a lower BP value, as it makes the regression line to the right of the threshold flatter so that by the LS method the threshold is drawn to the left.

The second horizontal segment corresponds to the flat tail end as seen in figure 2 for cubic regression.

The Z shape seen in figure 3 has been reported before [Ref. 4].

5. Conclusion

The MH model has a weakness when the tail end of the yield-salinity tends to become horizontal.
The cubic regression is useful to detect the general trends of the yield-salinity relations.
The PartReg method detects higher breakpoints than the MH model as it is not influenced by the behavior of the tail end.
The potato “927”, in accordance to the classification used by FAO, can now be denominated as salt tolerant instead of very sensitive as indicated by FAO.

5. References

[Ref.1] K.K.Tanji and N.C. Kielen, 2002. Agricultural drainage water management in arid and semi-arid area. FAO Irrigation and Drainage paper 61. Food and Agricultural Organization of the United Nations. On line: http://www.fao.org/3/a-ap103e.pdf

[Ref. 2] A. de Vos et al. 2016. Crop salt tolerance under controlled field conditions in The Netherlands, based on trials conducted at Salt Farm Texel. On line: https://library.wur.nl/WebQuery/wurpubs/fulltext/409817

[Ref. 3] SegReg, free calculator for segmented regression. Download from: https://www.waterlog.info/segreg.htm

[Ref. 4] Crop tolerance to soil salinity, statistical analysis of data measured in farm lands. https://www.researchgate.net/publication/332466260_CROP_TOLERANCE_TO_SOIL_SALINITY_STATISTICAL_ANALYSIS_OF_DATA_MEASURED_IN_FARM_LANDS

List of publications in which SegReg is used:

https://www.waterlog.info/pdf/segreglist.pdf