Journal of Engineering and Applied Sciences 14 (Special Issue 3): 6030-6035, 2019
ISSN: 1816-949X

Mathematical Model for Relation of Wheat and Barley Yield and Salinity in Thi-Qar Governorate Soils, Iraq

Raad Jawad Mohammed Kadhim and Thamer Hussien Jaber
Al-Shatrah Technical Institute, Southern Technical University, Basra, Iraq
raadjawadm@gmail.com

Abstract: This study was conducted through the harvesting period (April and May) of 2018 to suggest an equation for wheat and another for barley which explain the relationship of the yield for wheat and barley with the soil salinity in Thi-Qar Governorate soils which be sited in the South of Iraq to utilize these equations for expecting the yield of mentioned crops if the salinity of soil be known. The twenty three fields that had been cultivated by wheat were selected and twenty four fields were selected for barley to get from them the samples of soil for determining the electrical conductivity of soil paste extracts and to identify the amount of the yield for wheat and barley. The four kinds of equations be drown (Exponential, linear, logarithmic and polynomial equations) to select from them the equations with high coefficient of correlation (r) to depend on them for expecting the yield of selected crops when the soil salinity be known.

Key words: Soil salinity, yield of wheat and barley, polynomial equations, logarithmic, coefficient, wheat

INTRODUCTION

Soil salinity is a global problem that affects approximately 20% of irrigated land and reduces crop yields significantly (Negrao *et al*., 2017) when (Machado and Serralheiro, 2017) regarded salinity that it is a major problem affecting crop production all over the world and that 20% of cultivated land in the world and 33% of irrigated land are salt-affected and degraded. Salinization can be accentuated by climate change, excessive use of groundwater, increasing use of low-quality water in irrigation and massive introduction of irrigation associated with intensive farming (Machado and Serralheiro, 2017), so, (Shrivastava and Kumar, 2015) regarded salinity that is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity which be caused by high concentrations of salts in the soil. Zekri and Albisu (1993) explained that salinity is a result of salt accumulation and it is one of the most serious problems facing agriculture in arid and semi-arid regions. This accumulation is the consequence of both crop evapotranspiration and saline irrigation water, so, (Casterad *et al*., 2018) said that salinity occurs in many irrigated systems, particularly in arid regions where the irrigation water is limited and the conflicts for water allocation are intermingled while (Qureshi and Al-Falahi, 2015) pointed out that poor irrigation practices and lack of drainage facilities have contributed to rising ground water tables and leading to soil salinization in the irrigated areas such that happens in the central and Southern of Iraq.

Salinity problems has robbed the production potential of 70% of the total irrigated area of Iraq with up to 30% gone completely out of production. This situation has threatened the sustainability of irrigated agriculture which produces more than 70% of the total cereal production in Iraq (Qureshi and Al-Falahi, 2015), so, (Casterad *et al*., 2018) had the same vision when they said that salinity substantially reduces income in irrigated agricultural systems around the world and it is a widespread limiting of the range of crops and their yields. Shrivastava and Kumar (2015) explained that the area of land which affected by salinity is increasing day by day and for all important crops, average yields are only a fraction-somewhere between 20 and 50% of record yields, these losses are mostly due to drought and high soil salinity.

For optimal grow and development, cultivated plants require balanced presence of water and dissolved minerals (salts) in their rhizosphere. In that respect, quality and availability of two natural resources, water and soils are crucial in cultivation (Ondrasek *et al*., 2011), this required balance can not be achieved in salt affected soils because the salinity affects growth by reducing plant root ability to extract water from the soil and chloride toxicity, so, the

Corresponding Author: Raad Jawad Mohammed Kadhim, Al-Shatrah Technical Institute, Southern Technical University, Basra, Iraq, raadjawadm@gmail.com

salinity damage varies from season to season due to variations in soil salt concentration as waterlogging increases salinity effects (Simons and Bakker, 2015). It has been found that the salt stress caused the significant increment of grain protein content, wet and dry gluten contents and Sodium Dodecyl Sulfate (SDS) sedimentation volume. Thousand-grain weight, grain protein yield and test weight reduced significantly under salinity stress conditions. So, protein content showed positive correlation with wet gluten, dry gluten, SDS sedimentation and volume and strong negative correlation with other traits (Houshmand *et al*., 2014). As well the salinity of irrigation water has the same effects on crops when its salinity up to 8 dS/m, it reduces significantly the germination percentage and length, dry weight of plumule and radical as well as reduce seedling contain of chlorophyll and potassium while increase sodium concentration (Al-Anbari *et al*., 2009).

Crops species and their cultivars differed significantly in tolerance of salinity (Al-Anbari *et al*., 2009) and (Pal *et al*., 1984), therefor, the wheat and barley differ in their tolerance for salinity, so, wheat was classified as moderately tolerant to soil salinity with a threshold EC of 6.0 dS/m (Eynard *et al*., 2005) when barley is more tolerant. Wheat and barley cultivars showed differences with regard to proline, protein and SOD content, Na^+, K^+ and K^+: Na^+ ratio, indicating existence of genetic diversity among the cultivars, these findings indicated that higher K^+, K^+: Na^+ ratio, proline, protein and SOD content could be the key factors which offer advantage to barley over wheat for superior performance under saline conditions (Izadi *et al*., 2014). In this direction (Steppuhn and Raney, 2005) mentioned that the salinity tolerance of a crop relates to its inherent ability to yield economic product as root-zone salinity increases and barley ranks as one of the more salt-tolerant of the annual cereal grain crops. Therefor, its production of dry matter by the vegetative parts and grain heads increased up to an EC of 12 dS/m then decreased at salinity levels above this value (Hassan *et al*., 1970), so, (Pal *et al*., 1984) found that barley could be grown economically with irrigation water EC 16 dS/m but with an average reduction in grain yield 43.5%, so, the results of (Al-Busaidi *et al*., 2007) showed that the saline water significantly impaired barley growth and the results of Lacolla and Cucci (2008) explained that barley was shown to be a salt-tolerant species and did not experience any salt stress when grown in soils with an initial ECe up to 11 dS/m and when it was grown in more saline soils (initial Ece of about 20 dS/m) despite the correction it showed a reduction in shoot biomass and kernel yield by 26 and 36%, respectively as compared to less saline soils whereas (Casterad *et al*., 2018) referred to the barley that it has good vegetative activity and development until a soil salinity threshold and then the vegetative activity decreases as soil salinity increases until a nil activity for high salinities. Beside that barley crop be affected by saline irrigation water it was found that the germination of barley seeds decreased with the increasing of irrigation water salinity, so, plant height and total number of plant tillers, green matter and dry matter and yield decreased significantly with increasing irrigation water salinity. A comparison of cultivars indicated that irrigation waters with EC 13.40 dS/m and above reduced crop germination and green matter production to a significant level (Hussain *et al*., 1997).

As a result of less tolerance of wheat to salinity, the increasing EC values up to 13.4 dS/m caused decreases in wheat yield of 35.4% and the increases in salinity above the threshold for wheat resulted a linear decrease in crop yield (Cullu, 2003), the maximum reduction was noted in case of number of tillers/plant, followed by grain weight/plant (Abbas *et al*., 2013).

Increasing salinity, progressively decreased plant height, spike length, number of spikelets/spike, 1000 grain weight and yield (straw and grain). Adverse effects of salts on plants were associated with the accumulation of less K^+ and more Na^+ and Cl^- in their flag leaf sap, grains and straw, these results indicated that the effects of salts stress were greater at 10 than at 8, 6 and 4 EC dS/m (Kalhoro *et al*., 2016). So, the results that was obtained by (Feizi *et al*., 2007) showed that the effects of increase of soil salinity on grain relative yield are more significant than effects of increase drainage water salinity and wheat has greater threshold value in drainage water salinity than soil salinity and the correlation of relative grain yield (Ry) with ECe and ECd indicated that ECd could estimate Ry as well as ECe.

The results of (Turki *et al*., 2012) showed that salt treatment (100 mM of NaCl solution) depressed growth and yield production and the decrease in grain yield might be caused by the salinity which induced reduction of photosynthetic capacity leading to less starch synthesis and accumulation in the grain while (Abbas *et al*., 2013) saw that in saline soils the concentration of Na^+ and Cl^- is higher accompanied with the decreased K^+: Na^+ ratio, thus, severely affecting the growth and yield of crops and the maximum reduction was noted in case of number of tillers $plant^{-1}$, followed by grain weight/plant, so, high Na^+ and low K^+, P concentration and K^+: Na^+ ratio was observed in the shoot, root and grain. This disturbed ionic composition seems to be apparent cause of yield reduction and deterioration of wheat quality under salinity. So and according to what was presented such continuous increasing of the areas that affected by salinity and the significant decreasing in the yield of crops with no constant of unit area production and because of these cases that due to confuse the agricultural planning there is a need to suggest mathematical model for determination expected production of area unit if soil salinity be known.

MATERIALS AND METHODS

The samples of wheat and barley, so, soil samples had collected from 23 fields which be cultivated by wheat and 24 fields which be cultivated by barley from different regions of Thi-Qar Governorate that be sited in the South of Iraq. All samples were collected at the end of April and at the beginning of May (this date represents harvesting period of barley and wheat crops in the studied region) of the year 2018. One sample was collected from each field with considering that this sample had been represented to the field which be taken from it. The volume of sample was 1 m^2 and from this area (1 m^2) the soil sample be taken from depth (0-25 cm) by auger and the whole spikes were found in the referred area (1 m^2) had be taken. Soil samples were air dried then they were crushed and passed through sieve 2 mm to make saturation soil paste that be extracted by vacume to determine the electrical conductivity for extract (ECe) by utilizing apparatus its type was (EC Jenway 4510 conductivity meter). While the spikes were air dried too and the grains manually be separated, then were weighed and calculate the yield on the base of 1 ha. The results were arranged ascending according to an increases of the electrical conductivity values for wheat and barley in singly way (Table 1). Then many equations of relationship between the yield of cereals and the soil salinity were drawn by utilizing Microsoft Excel 2010, to select one of them that characterized by its coefficient of correlation (r) with high value to depend it for expecting the yield of area unit when the electrical conductivity of soil paste extract be known.

Table 1: Soil Ec and yield of wheat and barley

Wheat		Barley	
ECe (dS/m)	Production (kg/h)	ECe (dS/m)	Production (kg/h)
6.75	2145.72	5.83	1787.38
7.94	2029.31	7.6	1791.47
8.83	1687.51	8.32	1609.11
9.37	1728.64	9.82	1483.25
9.94	1501.27	10.41	1123.22
10.23	1397.62	10.98	1272.53
10.81	1374.12	11.41	993.86
11.31	1487.51	11.97	1002.30
11.96	1272.92	12.83	1049.32
12.29	1149.26	13.15	1063.14
12.81	1193.47	13.89	871.05
13.06	1201.15	14.31	981.17
13.42	1107.68	14.93	832.1
13.91	1126.51	15.79	716.43
14.26	1092.16	16.27	735.91
14.94	838.39	16.84	686.29
15.27	683.97	17.02	549.37
15.88	781.69	17.71	491.57
16.71	691.07	18.12	531.61
17.06	618.33	19.26	521.79
17.73	544.21	21.41	573.39
18.41	347.74	22.19	511.01
21.08	439.18	23.27	483.66
		24.13	361.59

RESULTS AND DISCUSSION

It is clear from (Table 1) and (Fig. 1-8) that there is an adverse relationship between the yield of crops and the salinity of soils. This relation means that an increasing in soil salinity causes decreasing in the yield of cultivated crops, so, it illustrates that the yield decreases as a result of high salinity which causes an increasing osmotic pressure that leads to discourage water absorption and of toxicity that caused by chloride ions, so, (Simons and Bakker, 2015) confirmed that salinity affects growth by reducing plant root ability to extract water from the soil and because of chloride toxicity.

So, salinity discourages the nutrients uptake by the plants for that (Hassan *et al*., 1970) referred to a negative relationships between soil salinity and uptake of P, K, Ca, Fe and Cu by the vegetative parts and grain heads. In

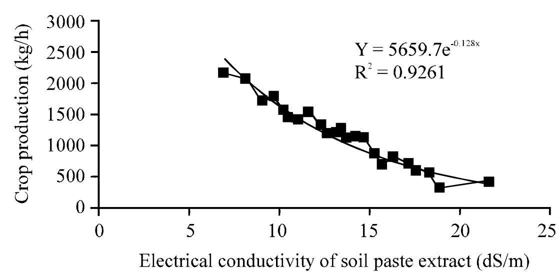

Fig. 1: Exponential equation for crop production and ECe of wheat

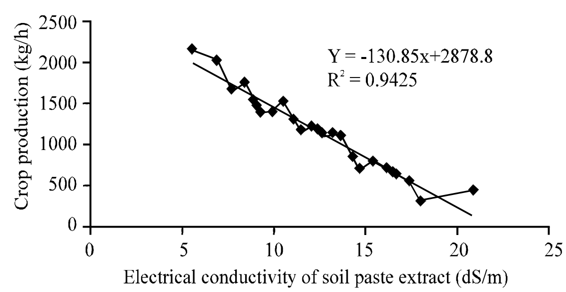

Fig. 2: Linear equation for crop production and ECe of wheat

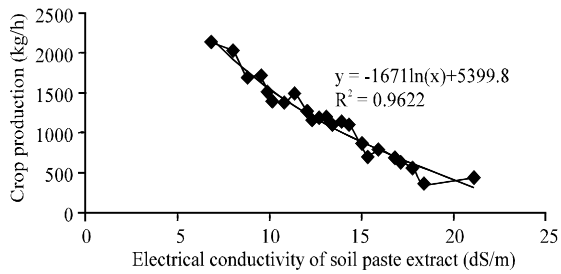

Fig. 3: Logarthmic equation for crop production and ECe of wheat

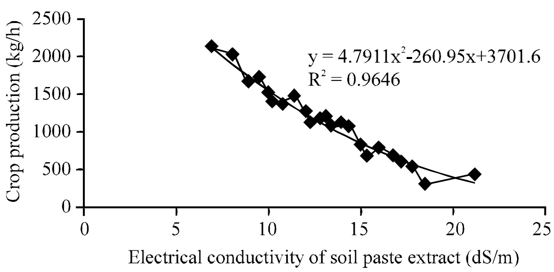

Fig. 4: Polynomial equation for crop production and ECe of wheat

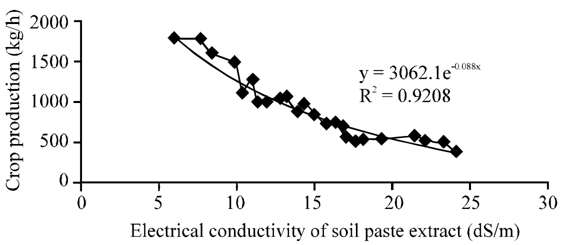

Fig. 5: Exponential equation for crop production and ECe of barley

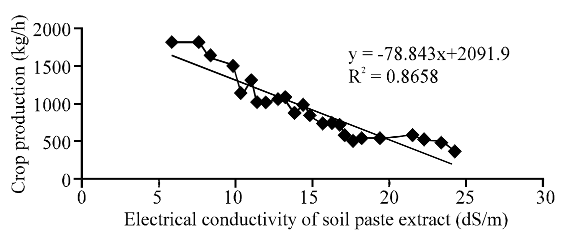

Fig. 6: Linear equation for crop production and ECe of barley

addition to previous effects, salinity creates unbalanced status between the nutrients elements in the soil it was found that in saline soils, the concentration of Na^+ and Cl^- is higher accompanied with the decreased K^+: Na^+ ratio, thus, severely affecting the growth and yield of crops, so, high Na^+ and low K^+, P concentration and K^+: Na^+ ratio

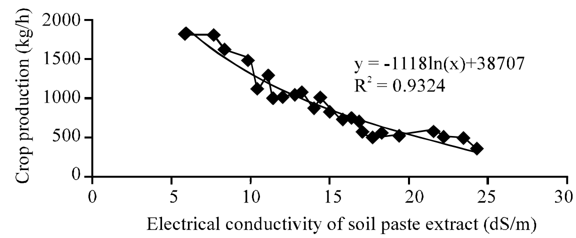

Fig. 7: Logarthmic equation for crop production and ECe of barley

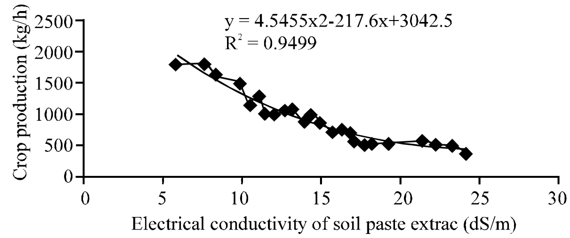

Fig. 8: Exponential equation for crop production and ECe of barley

was observed in the shoot, root and grain, therefor, this disturbed ionic composition seems to be apparent cause of yield reduction and deterioration the quality under salinity (Abbas *et al*., 2013) because of absence the balanced presence of water and dissolved minerals (salts) that cultivated plants require them in their rhizosphere (Ondrasek *et al*., 2011).

Beside that the salinity affects indirectly through its effect on soil physical properties such soil structure because of sodium dispersing action and on chemical properties such soil reaction (pH) as a result of presence of sodium and carbonate ions , these conditions affect in soil aeration in its water holding capacity and in a nutrients availability. As a result of all salinity effects, the yield of wheat and barley crops clearly decreased. This reduction came from the effects of salinity on some properties that caused the reduction in the yield such salinity reduces the number of tillers/plant and the grains weight $plant^{-1}$ (Abbas *et al*., 2013).

So, Hussain *et al*. (1997) confirmed that the salinity decreased significantly the number of plant tillers when (Houshmand *et al*., 2014) explained that the salinity reduced the thousand-grain weight, so, (Kalhoro *et al*., 2016) found that increasing salinity, progressively decreased spike length, number of spikelets/spike and 1000 grain weight while (Turki *et al*., 2012) referred to that the decrease in grain yield might be caused by the salinity which induced reduction of photosynthetic capacity leading to less starch synthesis and accumulation in the grain.

In spite of the general direction of relationship between soil salinity and crop yield is adverse relation but it appeared from figures that there are fluctuations in wheat and barley yield be occurred out the mentioned adverse relation, the crop yield increased with high salinity in some fields when it decreased with low salinity in the others, this case may be occurred as a result of differences of soil physical, chemical and biological factors which affect on the production of area unit in addition to kind of applied agricultural processes which be achieved in these fields, (Eynard *et al*., 2005) pointed out that the magnitude of yield reduction depends on the crop, soil type and management for example the reduction in yield ranges between 10-90% for wheat while it was between 30-50% for rice, so, crop yield can be enhanced by nutrient management, water management (irrigation with good quality water and appropriate drainage), use of soil amendments (manures and gypsum, etc.) and use of salt-tolerant varieties. These objective things may be the reasons of the differences in that fields.

So, it appeared from the (Fig. 1-8) for wheat and barley which were drawn according to exponential, linear, logarithmic and polynomial equations that the values of determination coefficient (R^2) differ among these relations and the high value of this coefficient was with polynomial equation for wheat and barley, R^2: (0.9646, 0.9499), respectively when the lower value of R^2 for this relation was represented by exponential equation (0.9261) for wheat and by linear equation for barley (0.8658), this case means that polynomial equations for wheat ($Y = 4.7911X^2-260.95X+3701.6$) (Fig. 4) and ($Y = 4.5455X^2-217.6X+3042.5$) for barley (Fig. 8) were with high representation of the relation between the soil salinity and the expected yield of wheat and barley, (Y: crop production kg/h and X: soil salinity of soil paste extract dS/m) because of high correlation coefficient value that had be obtained as a result of square root for determination coefficient, (r) values were (0.9821) and (0.9746) for wheat and barley, respectively when the equations that represent relationship between the yield and soil salinity were polynomial equations. The above equations can be applied to determine the expected yield for wheat and barley after the salinity of soil paste extract be known.

CONCLUSION

The results showed that the relation between the yield and salinity was controlled by polynomial equations for wheat and barley, these equations were selected because they characterized that coefficient of correlation (r) with high values in comparing with its values for another equations. Polynomial equations had been recommended to use them for expecting the yield were: $y = 4.7911x^2-260.95x+3701.6$, $r = 0.9821$ and $y = 4.5455x^2-217.6x+3042.5$, $r = 0.9746$ for wheat and barley, respectively.

RECOMMENDATION

This study recommends to utilize the referred equations for expecting the yield of wheat and barley in studied region, in addition to it is from necessary to implement similar researches that relate another crops which be cultivated in the same region and the others.

REFERENCES

Abbas, G., M. Saqib, Q. Rafique, M.A. Rahman and J. Akhtar *et al*., 2013. Effect of salinity on grain yield and grain quality of wheat (*Triticum aestivum* L.). Pak. J. Agri. Sci., 50: 185-189.

Al-Anbari, M.A.A., K.A.H. Altai and Y.K. Yaser, 2009. Effect of salinity on germination and seedling growth for five varieties of bread wheat (*Triticum aestivum* L.). Euphrates J. Agric. Sci., 1: 178-197.

Al-Busaidi, A., T. Yamamoto, M. Inoue, Y. Mori, M. Irshad and A. Zahoor, 2007. Monitoring saline irrigation effects on barley and salts distribution in soil at different leaching fractions. Asian J. Plant Sci., 6: 718-722.

Casterad, M., J. Herrero, J. Betran and G. Ritchie, 2018. Sensor-based assessment of soil salinity during the first years of transition from flood to sprinkler irrigation. Sens., 18: 1-18.

Cullu, M.A., 2003. Estimation of the effect of soil salinity on crop yield using remote sensing and geographic information system. Turk. J. Agric. For., 27: 23-28.

Eynard, A., R. Lal and K. Wiebe, 2005. Crop response in salt-affected soils. J. Sustainable Agric., 27: 5-50.

Feizi, M., A. Aghakhani, B. Mostafazadeh-Fard and M. Heidarpour, 2007. Salt tolerance of wheat according to soil and drainage water salinity. Pak. J. Biol. Sci., 10: 2824-2830.

Hassan, N.A.K., J.V. Drew, D. Knudson and R.A. Olsen, 1970. Influence of soil salinity on production of dry matter and distribution of nutrients in barley (*Hordeum vulgare* L.) and corn. Agronomy, 62: 43-45.

Houshmand, S., A. Arzani and S.A.M. Mirmohammadi-Maibody, 2014. Effects of salinity and drought stress on grain quality of durum wheat. Commun. Soil Sci. Plant Anal., 45: 297-308.

Hussain, G., A.A. Al-Jaloud, S.A. Al-Shammafy, S. Karimulla and S.O. Al-Aswad, 1997. Effect of saline irrigation on germination and growth parameters of barley (*Hordeum vulgare* L.) in a pot experiment. Agric. Water Manage., 34: 125-135.

Izadi, M.H., J. Rabbani, Y. Emam, M. Pessarakli and A. Tahmasebi, 2014. Effects of salinity stress on physiological performance of various wheat and barley cultivars. J. Plant Nutr., 37: 520-531.

Kalhoro, N.A., I. Rajpar, S.A. Kalhoro, A. Ali and S. Raza *et al.*, 2016. Effect of salts stress on the growth and yield of wheat (*Triticum aestivum* L.). Am. J. Plant Sci., 7: 2257-2257.

Lacolla, G. and G. Cucci, 2008. Reclamation of sodic-saline soils: Barley crop response. Ital. J. Agron., 3: 279-286.

Machado, R.M.A. and R.P. Serralheiro, 2017. Soil salinity: Effect on vegetable crop growth: Management practices to prevent and mitigate soil salinization. J. Hortic., 3: 1-13.

Negrao, S., S.M. Schmockel and M. Tester, 2017. Evaluating physiological responses of plants to salinity stress. Ann. Bot., 119: 1-11.

Ondrasek, G., Z. Rengel and S. Veres, 2011. Soil Salinisation and Salt Stress in Crop Production. In: Abiotic Stress in Plants-Mechanisms and Adaptations, Shanker, A., (Ed.). Intech, London, UK., ISBN:978-953-307-394-1, pp: 172-190.

Pal, B., S. Singh and H. Singh, 1984. Barley yield under saline water irrigation. Plant Soil, 81: 221-228.

Qureshi, A.S. and A. Al-Falahi, 2015. Extent, characterization and causes of soil salinity in central and southern Iraq and possible reclamation strategies. Intl. J. Engin. Res. Appl., 5: 84-94.

Shrivastava, P. and R. Kumar, 2015. Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi J. Biol. Sci., 22: 123-131.

Simons, J. and D. Bakker, 2015. Diagnosing salinity in canola. Government of Western Australia, Department of Primary Industries and Regional Development, Kensington, Australia. https: //www.agric.wa.gov.au/mycrop/diagnosing-salinity -canola

Steppuhn, H. and J.P. Raney, 2005. Emergence, height and yield of canola and barley grown in saline root zones. Can. J. Plant Sci., 85: 815-827.

Turki, N., M. Harrabi and K. Okuno, 2012. Effect of salinity on grain yield and quality of wheat and genetic relationships among durum and common wheat. J. Arid Land Stud., 22: 311-314.

Zekri, S. and L.M. Albisu, 1993. Economic impact of soil salinity in agriculture: A case study of Bardenas area, Spain. Agric. Syst., 41: 369-386.