Soil Salinity Measurement and Effects on Corn in Southeast Colorado

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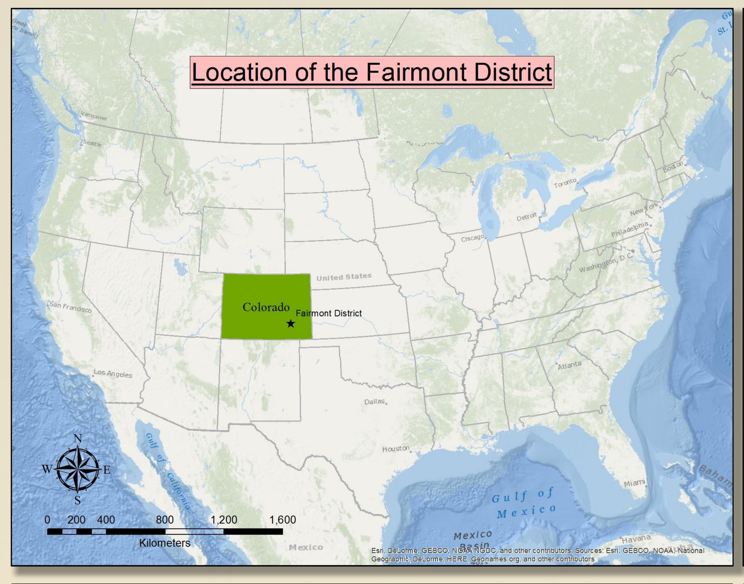
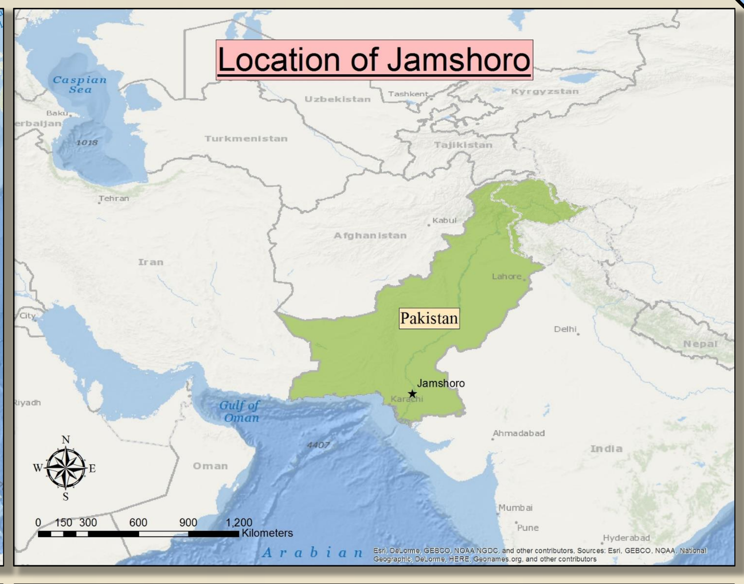
Introduction





Fairmont District, United States	Jamshoro, Pakistan
32cm annual rainfall	20cm annual rainfall
Predominant crops are alfalfa, corn, wheat, and vegetables	Predominant crops are alfalfa, corn, wheat, mangos, and bananas
Mostly surface irrigated (except vegetables)	Mostly surface irrigated (if not all)
Has salinity issues from high intensity irrigation	Has salinity issues from high intensity irrigation
Predominant salt is gypsum	Predominant salt is unknown

- The FAO estimates that 230 million hectares of land is irrigated globally, and of that, nearly 45 million have soils that are considered to be "salt-affected". Through a conjoined effort between Mehran University of Engineering and Technology, Colorado State University, Utah State University, and the USAID, a goal was set to identify and solve common agronomic and hydrological issues relating to reduced crop production and water salinization in Southeast Colorado and Jamshoro, Pakistan. Similar irrigation practices and climates have allowed for the observation of the movement and effect of salts on corn crops in the Fairmont District, as a comparison to Jamshoro in the future.
  - The objective of this observational study is to observe the movement of salts through water via irrigation, canal diversion, and water table monitoring, and to quantify the effects that salt accumulation has on crops in the region.

Methods

Testing for Salt Loading With Flume Data

- Flumes were installed at the applied water and tail water ends of irrigation diversion ditches on three fields. These were used to quantify the amount of water that was infiltrated into each field at different irrigation sets. This was estimated by:

Water Applied – Runoff = Infiltrated Water

- Electrical conductivity readings were taken with an In-Situ smarTroll multiparameter handheld system during irrigation events. Measurements were taken approximately every 2 hours. EC was correlated to total dissolved solids (TDS), which provided salt concentration in the water. EC readings were calibrated to TDS via water samples taken concurrently that were sent off for laboratory analysis. Salt loading could then be calculated by:

Salts Applied – Salts in Runoff = Infiltrated Salts

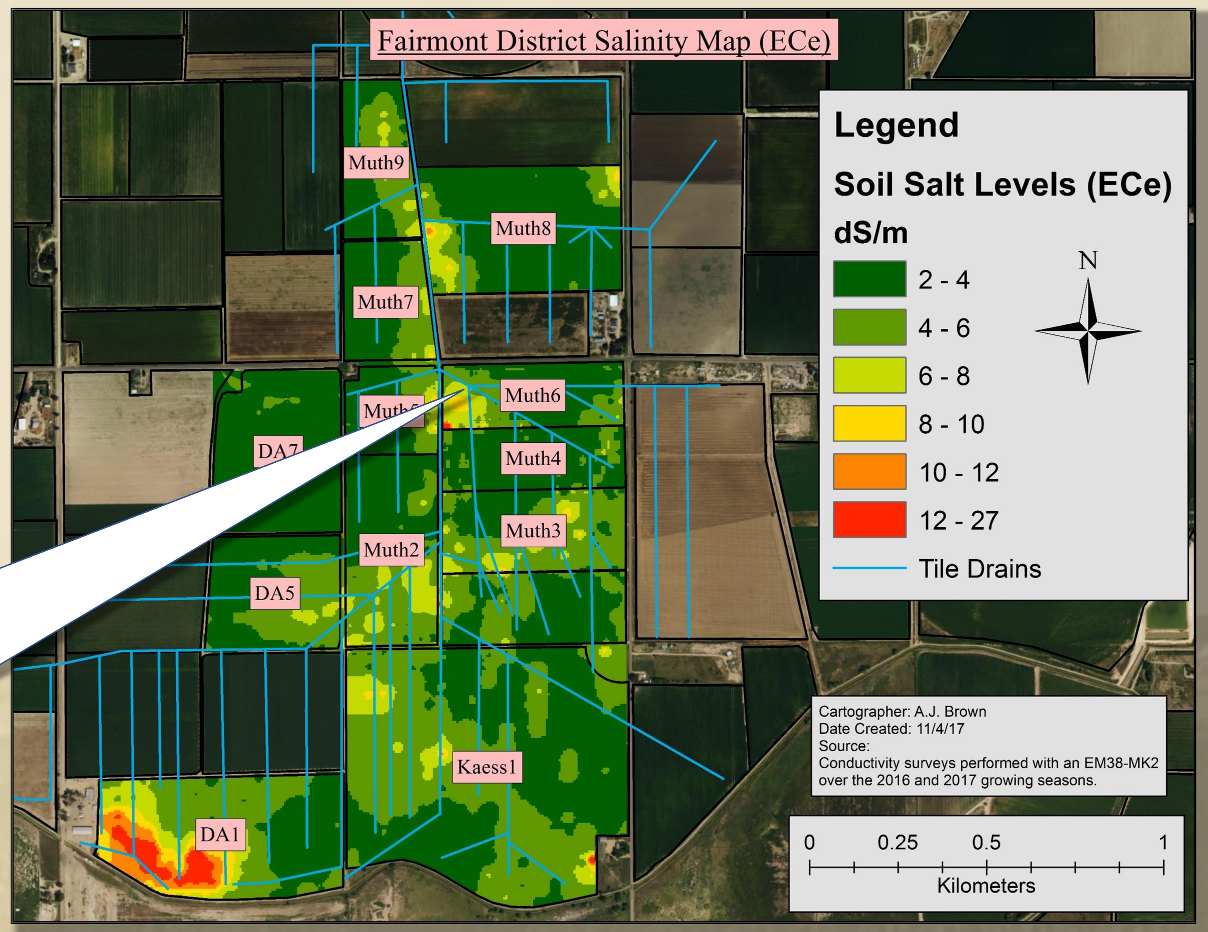
Picture of trapezoidal flume to measure water flow.

Image of Irrigation Sets and Flume Locations.

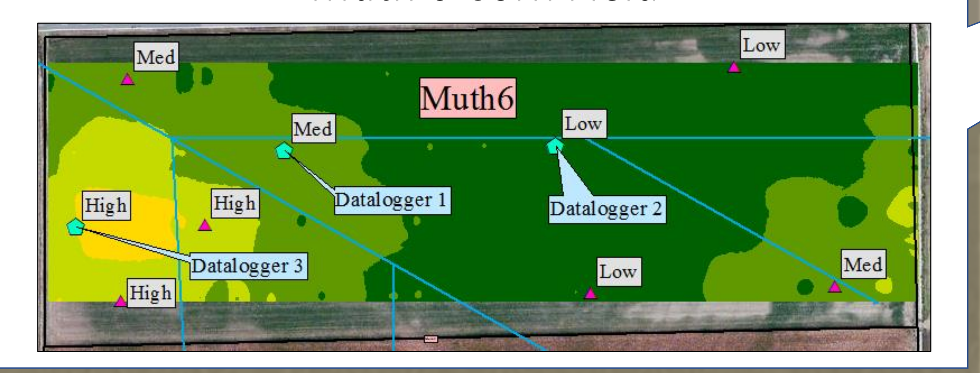
Locating and Identifying the Effects of Salts

- In order to estimate the impact of salts on crops the Fairmont District, a survey of the location concentration of soil salt had to be conducted. The chosen method for this was to use an EM38-MK2 (Geonics, Ltd.) to non-invasively survey the bulk conductivity of the soil. The bulk conductivity readings were then converted into soil saturated paste extract conductivity (EC_e) through a series of soil samples taken at the time of the conductivity survey via a soil salinity survey software called ESAP (Ver. 2.35) developed by the USDA-ARS and a regression developed by (Wittler, Cardon et al. 2006). CS655 (Campbell Scientific, Inc.) water content reflectometers were then installed at "High", "Medium", and "Low" salt zones at three depths in order to capture the impact of salts on soil water and conductivity over the growing season.
- ESAP also identified 9 locations for monitoring the growth of corn plants in Muth6 at the different salt zones. Over the 2017 growing season, crop height, leaf area index (LAI), and growth stage were monitored weekly at each location. Each plot was harvested at the end of the season for yield measurements and total aboveground biomass.

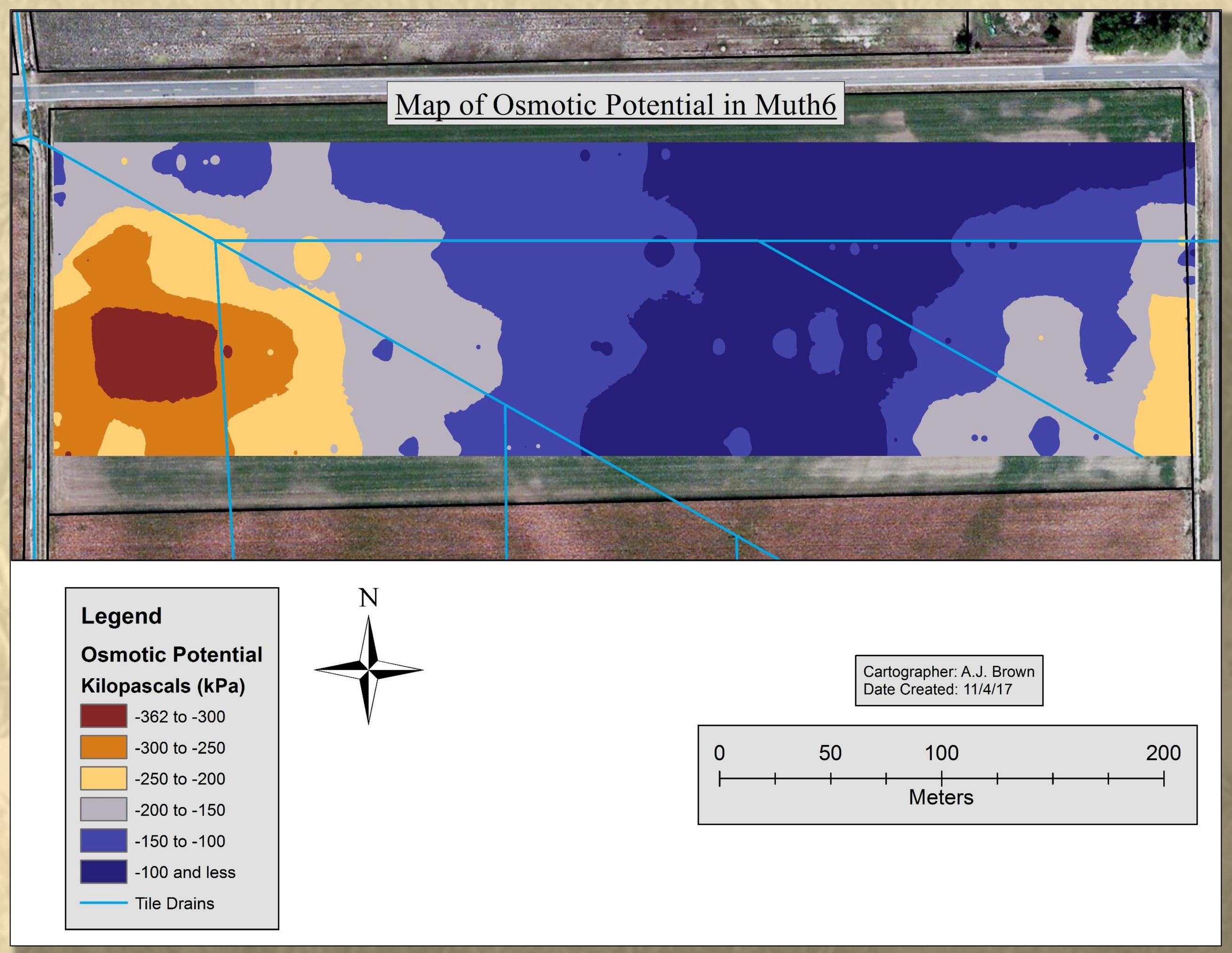
(Right) One of the data logger locations in the Muth6 field. (Far Right) EM38-MK2 conductivity meter at time of soil sampling for EC_e.



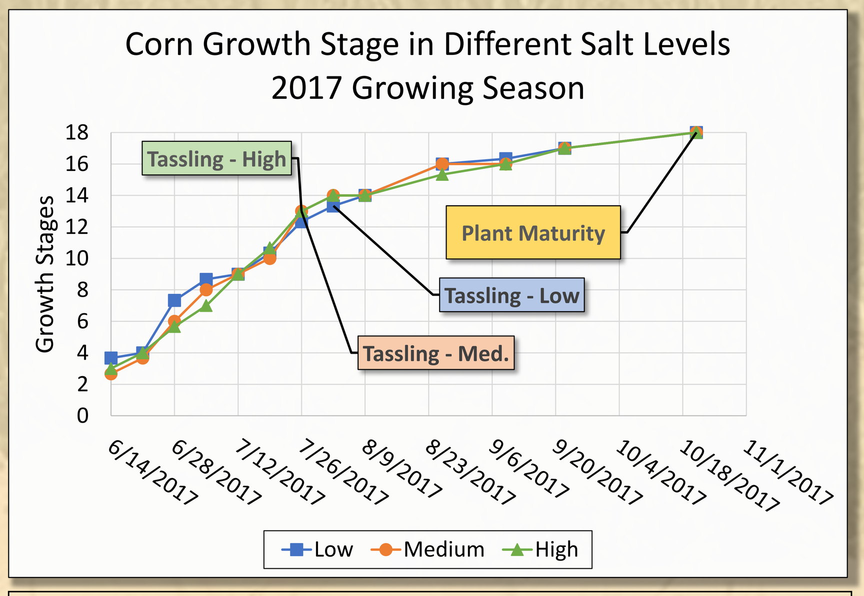
Muth 6 Corn Field



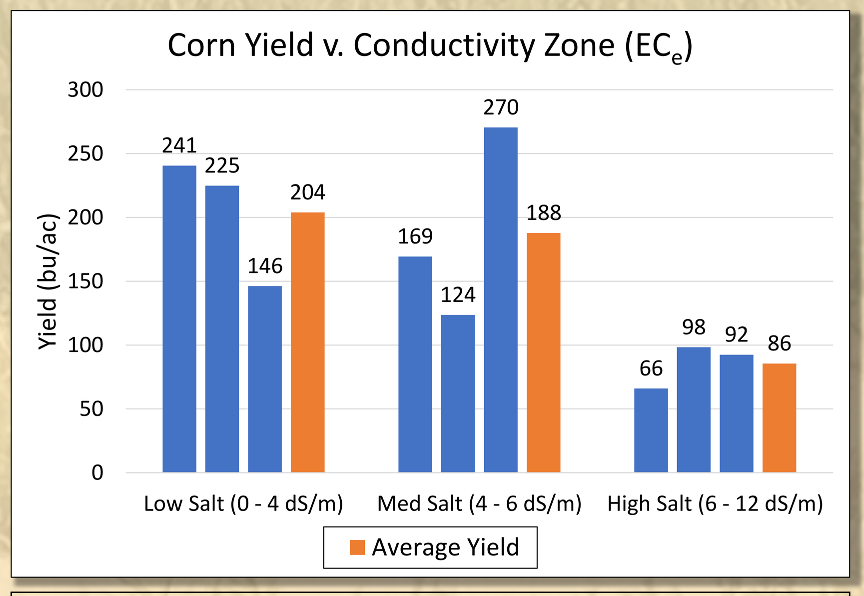
Results



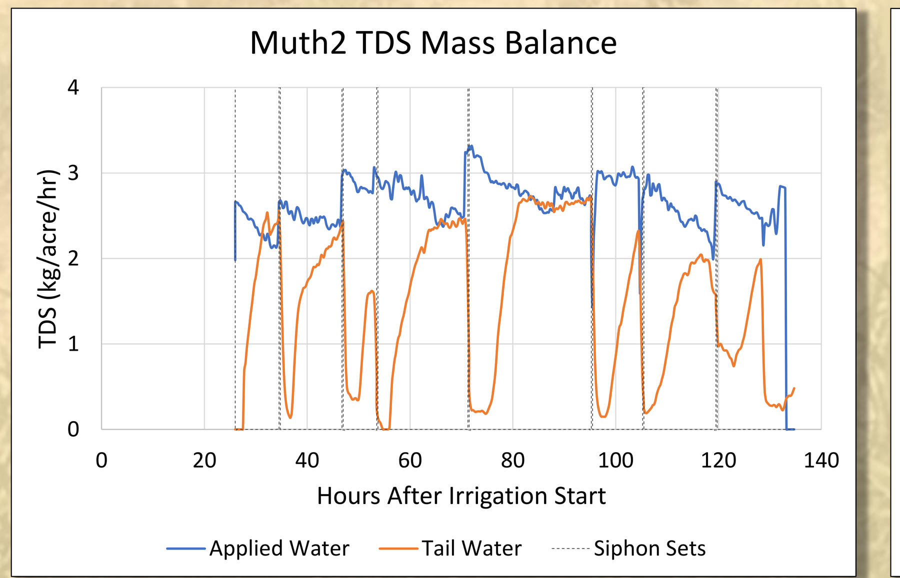
This map shows levels of osmotic potential in the Muth6 field due to salt concentrations. The conversion from EC_e to osmotic potential was made from (Campbell, Bower et al. 1949).



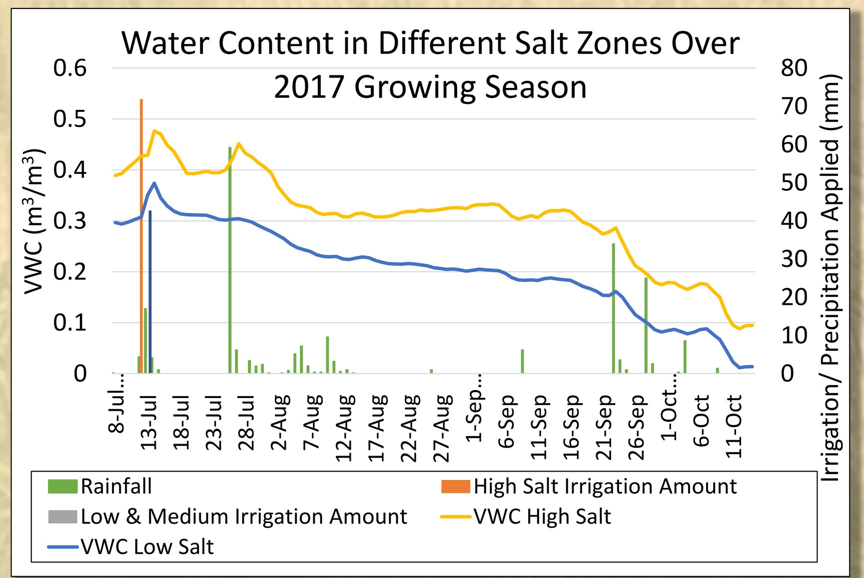
This graph shows corn growth stages in different salt salinity levels. No significant differences were seen in maturation because of salt concentration.



This map shows the difference in yields over different salt salinity levels. Although growth stage did not show a difference, a significant difference was seen in the yields of the corn.



The chart above shows the quantity of TDS found in the applied and tail water flumes during an irrigation. The area between the blue line and orange line indicate TDS that is being "loaded" into the field.



The water content in the low salt zone shows less water than that of the high zone over the whole season, but the yields were much higher. This points us to seeing how much effect osmotic potential has on the plants.

- Flume data and water quality data showed that salts were indeed being loaded onto the Muth2 field. This is predicted to be the case for the Muth6 field as well, because the water is from the same source. This is a contributor to the salt concentrations we see in the conductivity map.
  - Corn growth stage, height, and LAI did not show a much difference between salt salinity levels, but yield showed significant differences. The water content was even higher in the low salt zone over the entire 2017 season. This indicates that the salts are decreasing osmotic potential, causing a drought-like effect on the corn by making it harder for the plants to uptake water.

Discussion

- The application of saline irrigation water contributes to the accumulation of salts in the Fairmont District. This, in conjunction with salt deposits from a fluctuating shallow water table, causes the salt to be trapped in the crop root zone. Further investigation is needed into observing the water table levels and salt concentrations of the Fairmont district. Better irrigation practices could be implemented to not "overload" the flow in the drainage tiles, which prohibits the removal of salts from the fields.
- Many crops exist in the Fairmont District, and are affected by the negative osmotic potential generated by the accumulated salt. If this is also true in Jamshoro, the fruit crops there are even more susceptible to yield loss due to salt, and it would be important to find a method to leach the salts away from the crop.

Conclusion

- Salts are being deposited onto fields in the Fairmont District via irrigation water with high salt concentrations. This is contributing to the long term accumulation of salts on the tail ends of fields where water pools before running off. This trend is illustrated further by the EC_e map generated through the EM38-MK2 surveys
- Even though the high salt zones in Muth6 received more water for leaching, salts accumulated in the root zone in enough quantity to cause a more negative osmotic potential. This leads the corn yield be significantly less than that of the low salt zones.

Pictured right is a comparison of an average corn cob taken from a low salt zone to a cob taken from a high salt zone.

References

Campbell, R., et al. (1949). "Change of electrical conductivity with temperature and the relation of osmotic pressure to electrical conductivity and ion concentration for soil extracts." Soil Science Society of America Journal **13**(C): 66-69.

Wittler, J. M., et al. (2006). "Calibration of electromagnetic induction for regional assessment of soil water salinity in an irrigated valley." Journal of irrigation and drainage engineering **132**(5): 436-444.