

HOW SALT AND SODICITY TOLERANT BARLEY, OATS AND DURUM ARE?

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Barley and oats are one of the most salt and sodicity tolerant annual crops producers can profitably grow in North Dakota. However, at certain salinity and sodicity levels, even barley and oats can result in significant losses. Especially, important are the levels of salinity and sodicity in the top six inches of the soils. It is the first one and half to two inches of soil where seed is planted and at lower salt and sodicity levels, there will be good germination resulting in improved stands and yields. It is important to sample areas where sensitive crops such as soybeans or corn do not grow well and get them analyzed by a soil testing lab for Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and pH by using "Saturated Paste Extract Method". For detailed information on sampling and testing soils for salts and sodicity, please refer to the NDSU Publication: SF-1809; "Soil Testing Unproductive Areas".

Sensing the need to determine the threshold of soil salinity (EC) and sodicity (SAR) for barley and oats, four barley and four oat varieties were planted at the Langdon REC site in 2021 at three different levels of salinity and sodicity. This was a repeat of 2020 trial. In addition, in 2021 four durum varieties were added to the trial to test salt-tolerance of durum alongside barley and oats.

Soil Analysis Results

Two-foot deep composite soil samples separated into 0-6 and 6-24 inch depths were collected on April 23, 2021 from each level of salinity and sodicity (replications 1, 2 and 3) by taking three cores for each sample. Soil EC, SAR and pH were analyzed by using saturated paste extract method, whereas, standard methods were used to analyze NO₃-N, P and K (Table 1). For the purpose of identifying and labeling the three replications based on different salinity and sodicity levels, replication 1 was considered having "low to moderate", replication 2 "moderate to high" and replication 3 "very high" levels of salinity and sodicity.

Table 1. 2021 soil EC, SAR, pH, NO₃-N, P and K results of the three replications for the 0-6 and 6-24 inch depths.

Site	Sample ID	Depth (inches)	EC (dS/m)	SAR	pH	NO ₃ -N (lbs./acre)	P (ppm)	K (ppm)
Rep 1	Low to moderate salinity and sodicity	0-6	4.63	6.20	7.54	37	15	450
		6-24	7.49	14.72	7.97	24	4	115
Rep 2	Moderate to high salinity and sodicity	0-6	13.20	22.88	8.17	53	24	350
		6-24	12.29	21.14	8.21	24	4	200
Rep 3	Very high salinity and sodicity	0-6	14.90	32.74	8.14	46	32	330
		6-24	12.98	32.04	8.16	27	6	180

In 2021, replication 1 had low to moderate levels of salinity and sodicity in the 0-6 inch depth (EC = 4.63 dS/m and SAR = 6.20). These levels would be considered low to moderate for tolerant crops such as barley and oats, whereas, same levels will be considered high for sensitive crops like soybean. In the 6-24 inch depth of replication 1, both salinity and sodicity increased significantly (EC = 7.49 dS/m and SAR = 14.72) even for crops like barley and oats. Replication 2 had high to very high salinity and sodicity levels in both depths. Replication 3 had slightly higher salinity levels in the 0-6 inch depth compared to replication 2, whereas, salinity levels in the 6-24 inch depth were similar to replication 2. However, sodicity levels of replication 3 were higher in both depths compared to replication 2 (Table 1).

For comparison, details of 2020 soil EC, SAR, pH, NO₃-N, P and K results of the three replications for the 0-6 and 6-24 inch depths are in Table 2.

Table 2. 2020 soil EC, SAR, pH, NO₃-N, P and K results of the three replications for the 0-6 and 6-24 inch depths.

Site	Sample ID	Depth (inches)	EC (dS/m)	SAR	pH	NO ₃ -N (lbs./acre)	P (ppm)	K (ppm)
Rep 1	Low to moderate salinity and sodicity	0-6	3.99	7.12	7.18	5.00	20.00	299.00
		6-24	7.32	15.05	7.71	6.00	5.00	137.00
Rep 2	Moderate to high salinity and sodicity	0-6	7.80	18.13	7.61	6.00	29.00	247.00
		6-24	10.39	20.92	7.95	6.00	2.00	148.00
Rep 3	Very high salinity and sodicity	0-6	10.50	27.30	7.59	5.00	51.00	270.00
		6-24	9.86	32.87	7.81	6.00	4.00	169.00

Trial Design, Plot sizes and Planting Data

Trial design was randomized split block and plot sizes were 4.7 X 22 feet in 2021 and 2020. 2021 details are in Table 3, whereas, Table 4 has the 2020 details.

Table 3. 2021 barley, oat and durum varieties, seeding rates and depths and fertilizer rates per acre.

Crop	Variety	Planting Date	Seeding Rates (live seeds/acre)	Seeding Depth (inches)	Fertilizer Application (lbs./acre)
Barley	AAC Synergy (2-row)	May 13, 2021	1.00 million live seeds per acre	1 to 1 & 1/2	Based on the soil NO ₃ -N, P and K analysis 59, 43 and 47 lbs. of N per acre was applied to replications 1, 2 and 3 respectively. P rate for replication 1 was 26 lbs., whereas replications 2 and 3 received 20 lbs. each per acre. No K application was applied to any of the replications.
	ND Genesis (2-row)				
	Pinnacle (2-row)				
	Tradition (6-row)				
Oats	CS Camden		1.00 million live seeds per acre		
	ND Heart				
	Rockford				
	Souris				
Durum	ND Riveland	1.5 million live seeds per acre			
	ND Stanley				
	Divide				
	Joppa				

Table 4. 2020 barley and oat varieties, seeding rates and depths and fertilizer rates per acre.

Crop	Variety	Planting Date	Seeding Rates (live seeds/acre)	Seeding Depth (inches)	Fertilizer Application (lbs./acre)
Barley	AAC Synergy (2-row)	June 1, 2020	1.25 million live seeds per acre	1 to 1 & 1/2	Based on soil NO ₃ -N, P and K analysis a uniform rate of 120 lbs. of N was applied through Urea to all three replications with no P and K application.
	ND Genesis (2-row)				
	Pinnacle (2-row)				
	Tradition (6-row)				
Oats	CS Camden		1.00 million live seeds per acre		
	ND Heart				
	Rockford				
	Souris				

Results and Discussion

There were significant differences between the three replications starting from seedbed preparation, germination, plant growth and vigor, maturity, yield and quality. In addition, there were annual differences due to changes in weather such as precipitation, evapotranspiration and soil moisture levels.

Differences in Seedbed

In 2021, there were still some differences in the seedbed between the three replications, however, replication 2 and 3 were not as cloddy or rough the way they were in 2020. That could partially be due to the fact that they were tilled in 2020. These annual differences could also be due to changes in weather and soil moisture levels. See pictures 1, 2 and 3 for comparing 2021 differences.



Picture 1. Replication 1 with nice seedbed on May 10, 2021.



Picture 2. Replication 2 with slightly rough seedbed on May 10, 2021.



Picture 3. Replication 3 with cloddy seedbed on May 10, 2021.

In 2020, seedbed was very mellow in replication 1, whereas, it started getting rough and cloddy with the increase in sodicity in replication 2 and 3. See Pictures 4, 5 and 6 for comparing 2020 differences.



Picture 4. Replication 1 with nice seedbed on June 1, 2020.



Picture 5. Replication 2 with slightly rough and cloddy seedbed on June 1, 2020.



Picture 6. Replication 3 with very rough and cloddy seedbed on June 1, 2020.

Differences in Germination

In 2021, barley and oat seed germination started eight to nine days after planting (May 21st to 22nd) in replication 1 and completed around thirteen days (May 26th), which was slightly delayed compared to 2020. Durum varieties started germinating nine to ten days after planting (May 22nd to May 23rd) and germination completed sixteen to seventeen days after planting (May 29th to May 30th) in replication 1. Barley, oat and durum (Joppa and ND Stanley varieties only) germination in replication 2 overall was about ten-days delayed compared to replication 1 and started around seventeen days after planting (May 30th). All four barley and oat varieties completed germination around twenty-two days after planting (June 3rd) in replication 2. Among durum varieties, ND Stanley had 70-80 percent germination, Joppa had about 20 percent germination, whereas, Divide and ND Riveland varieties had zero germination in replication 2 by June 3rd. In replication 3, barley and oat varieties started germinating twenty-two days after planting (June 3rd) and completed germination around twenty-eight days after planting (June 9th). All four durum varieties had zero germination in replication 3. See pictures 7 to 15 for comparing 2021 differences.



Picture 7. Barley varieties in replication 1 on May 26, 2021.



Picture 8. Oat varieties in replication 1 on May 26, 2021.



Picture 9. Durum varieties in replication 1 on May 26, 2021.



Picture 10. Barley varieties in replication 2 on May 26, 2021.



Picture 11. Oat varieties in replication 2 on May 26, 2021.



Picture 12. Durum varieties in replication 2 on May 26, 2021.



Picture 13. Barley varieties in replication 3 on May 26, 2021.



Picture 14. Oat varieties in replication 3 on May 26, 2021.



Picture 15. Durum varieties in replication 3 on May 26, 2021.

In 2020, seed germination started in replication 1 around seven days after planting (June 8th) and completed in about eleven days (June 11th). In replication 2, germination started around June 16th and completed around June 23rd. So, in replication 2, germination was eight to twelve days delayed compared to replication 1. In replication 3 all four barley varieties had zero germination, whereas, some oat seeds started germinating around June 29th. See Pictures 16 to 18 for comparing 2020 differences.



Picture 16a and 16b. Replication 1 on June 8 (left) and June 11, 2020 (right).



Picture 17a and 17b. Replication 2 on June 16 (left) and June 23, 2020 (right).



Picture 18a and 18b. Replication 3 on June 29, 2020.

Differences in Plant Heights, Vigor and Heading

2021 Plant heights and Vigor Data (June 28, 2021)

Average barley plant heights in replication 1 were 17.73 to 19.97 inches. ACC Synergy, ND Genesis and Pinnacle were in boot to early heading stage with very good vigor, whereas, Tradition was at late boot stage with best vigor. Average oat plant heights in replication 1 were 12.30 to 17.60 inches. Growth stage for all four oat varieties was late boot. Rockford had ok vigor, CS Camden fair, ND Heart very good, whereas Souris had the best vigor. Average durum plant heights in replication 1 were 14.31 to 17.49 inches. Growth stage for all durum varieties was jointing. Joppa had fair vigor, divide fair to good, ND Stanley good and ND Riveland had the best vigor. See picture 19 to 21.



Picture 19a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 1 on June 28, 2021.



Picture 20a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 1 on June 28, 2021.



Picture 21a, b, c and d. Divide, Joppa, ND Riveland and ND Stanley from left to right in replication 1 on June 28, 2021.

Average barley plant heights in replication 2 were 8.84 to 11.12 inches. ACC Synergy, Pinnacle and Tradition were in tillering to early boot stage, whereas, ND Genesis was in early boot stage. ACC Synergy and Tradition had ok vigor, Pinnacle fair and ND Genesis had fair to good vigor. Average oat plant heights in replication 2 were 5.19 to 10.12 inches. CS Camden was in five-leaf to tillering stage, Rockford and Souris were in tillering stage and ND Heart was in tillering to early boot stage. CS Camden had very poor vigor, Rockford and Souris had fair, whereas, ND Heart had good vigor. Average durum plant heights in replication 2 were 8.00 to 8.62 inches. Joppa was in five-leaf to tillering stage, whereas, ND Stanley was in tillering stage. Joppa had very poor vigor, whereas, ND Stanley had fair to ok vigor. Divide had zero germination, whereas, ND Riveland had very few plants in replication 2 so it was not possible to record any data. See picture 22 to 24.



Picture 22a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 2 on June 28, 2021.



Picture 23a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 2 on June 28, 2021.



Picture 24a, b, c and d. Divide, Joppa, ND Riveland and ND Stanley from left to right in replication 2 on June 28, 2021.

Average barley plant heights in replication 3 were 5.50 to 6.69 inches and all varieties were in four to five-leaf stage. ACC Synergy and Pinnacle had very poor vigor, ND Genesis had poor and Tradition had ok vigor. Average oat plant heights in replication 3 were 6.12 to 8.88 inches. CS Camden was in five-leaf to tillering stage, whereas, ND Heart, Rockford and Souris varieties were in tillering stage. CS Camden had ok vigor, Souris had fair, Rockford had good and ND Heart had very good vigor. All durum varieties had zero germination in replication 3, hence there was no data to collect. See pictures 25 and 26.



Picture 25a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 3 on June 28, 2021.



Picture 26a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 3 on June 28, 2021.

Note: Oats seem to grow slower (less vigor) compared to barley initially, however, pick up pace after heading. Durum is also slower in the beginning compared to barley.

2021 Heading Data (July 7, 2021)

In replication 1, ACC Synergy had completed 70-75 percent heading, ND Genesis and Pinnacle had 80 percent, whereas, Tradition completed 100 percent heading. In replication 2, ND Genesis and Pinnacle just started heading, whereas, ACC Synergy and Tradition had fewer than five plants in the plots so it was not possible to record heading data. All barley varieties in replication 3 had fewer than five plants per plot on July 7, 2021. See pictures 27 to 29.



Picture 27a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 1 on July 7, 2021.



Picture 28a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 2 on July 7, 2021.



Picture 29a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 3 on July 7, 2021.

In Replication 1, Rockford had 60 percent heading completed, whereas, CS Camden had 70 percent and ND Heart and Souris had completed 95 percent heading. In replication 2, ND Heart completed 15-20 percent heading, whereas, there were less than five plants in CS Camden, Rockford and Souris plots. In replication 3, CS Camden, Rockford and Souris varieties had fewer than five plants and no data collection was possible, however, ND Heart had some growth and completed 5 percent heading. See pictures 30 to 32.



Picture 30a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 1 on July 7, 2021.



Picture 31a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 2 on July 7, 2021.



Picture 32a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 3 on July 7, 2021.

Among durum varieties, Divide completed 70 percent, Joppa 75 to 80 percent, ND Stanley 85 to 95 percent and ND Riveland completed 95 percent heading in replication 1. ND Stanley and Joppa had less than five plants per plot in replication 2, whereas, ND Riveland and Divide had zero germination. All four durum varieties in replication 3, had zero germination. See pictures 33 and 34.



Picture 33a, b, c and d. Divide, Joppa, ND Riveland and ND Stanley from left to right in replication 1 on July 7, 2021.



Picture 34a, b, c and d. Divide, Joppa, ND Riveland and ND Stanley from left to right in replication 2 on July 7, 2021.

2020 Plant heights and Heading Data (July 17, 2020)

Average barley plant heights in replication 1 were 21.11 to 27.70 inches with 5 to 100 percent heading completed. Oat plant heights were 22.21 to 25.58 inches with 80 to 90 percent heading completed. In replication 2, barley plant heights ranged between 10.03 to 15.56 inches with no heading initiation. Oat plant heights in replication 2 were 9.12 to 15.27 inches with 5 percent heading completed only in the ND Heart plot. No data was taken from replication 3 due to no-barley and very negligible growth of oats. See pictures 35 to 37 for comparisons.



Picture 35a and b. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 1 on July 17, 2020.



Picture 36a and b. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 2 on July 17, 2020.



Picture 37a and b. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 3 on July 17, 2020.

How Plants Deal with Varying Salinity and Sodicity Levels?

It was also observed that barley and oat plants adopted to different salinity and sodicity levels by keeping bulk of the roots in the top 6 inches instead of growing into the deeper depths with higher salinity and sodicity levels. That was especially true for replication 1 that had low to moderate levels in the 0-6 inch depth and moderately higher levels in the 6-24 inch

depth. However, once surface salinity and sodicity reached high to very high levels in replication 2 and 3 (EC = 7.80 to 10.50 dS/m and SAR = 18.13 to 27.30), both germination and growth were poor to negligible. See picture 38 and 39 to compare the rooting depths of barley and oat plants growing in replication 1 and 2. There were no plants in replication 3 to observe rooting depth at that time.



Picture 38a and b. Barley (left) and oat (right) rooting depths in replication 1 on August 10, 2020.



Picture 39a and b. Barley (left) and oat (right) rooting depths in replication 2 on August 10, 2020.

Differences in Maturity

2021

In 2021, in replication 1 barley, oat and durum plots matured around September 3rd. In replication 2, all barley varieties were mature and ready to be harvested, however, oat varieties were still slightly green, whereas, ND Stanley was close to maturity with very poor stand and growth. In replication 3, barley varieties were slightly green, whereas, oats were very close to maturity. See pictures 40 to 47.



Picture 40a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 1 on September 3, 2021.



Picture 41a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 1 on September 3, 2021.



Picture 42a, b, c and d. Divide, Joppa, ND Riveland and ND Stanley from left to right in replication 1 on September 3, 2021.



Picture 43a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 2 on September 3, 2021.



Picture 44a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 2 on September 3, 2021.



Picture 45. ND Stanley in replication 2 on September 3, 2021.



Picture 46a, b, c and d. ACC Synergy, ND Genesis, Pinnacle and Tradition from left to right in replication 3 on September 3, 2021.



Picture 47a, b, c and d. CS Camden, ND Heart, Rockford and Souris from left to right in replication 3 on September 3, 2021.

Overall, trial was harvested on September 8, 2021. See pictures 48 to 50.



Picture 48. Replication 1 on September 8, 2021.



Picture 49. Replication 2 on September 8, 2021.



Picture 50. Replication 2 on September 8, 2021.

2020

In 2020, replication 1 barley and oat plots matured about ten to fourteen days earlier than the plots in replication 2 and were harvested on September 15th. Replication 2 was harvested on September 22nd while it was still slightly green. Though there was not much to harvest in replication 3 except some oats, which were still not fully mature, plots were combined on September 22nd, while harvesting replication 2. See pictures 51 to 53 for comparisons.



Pictures 51a and b. Barley (left) and oat (right) plots ready to be harvested in replication 1 on September 15, 2020.



Pictures 52a and b. Barley (left) and oat (right) plots not quite ready to be harvested in replication 2 on September 15, 2020.



Pictures 53a and b. Barley (left) plots with no-growth and oat (right) plots with sporadic growth not quite ready to be harvested in replication 3 on September 15, 2020.

Differences in Shattering

In 2021, there was a lot of shattering in the oat varieties in replications 1 and 3. However, there was hardly any shattering in replication 2. Whereas, barley (replications 1, 2 and 3) and durum (replications 1 and 2) varieties had negligible shattering in 2021. Excess shattering of oat varieties can be attributed to heavy rains after crop was mature and ready for harvest that also delayed harvest for seven to eight days. In 2020, all barley and oat varieties had negligible shattering. See picture 54 for 2021 shattering.



Pictures 54a and b. Oat shattering in replication 1 (left) and replication 3 (right) on September 8, 2021.

Yield and Quality Data

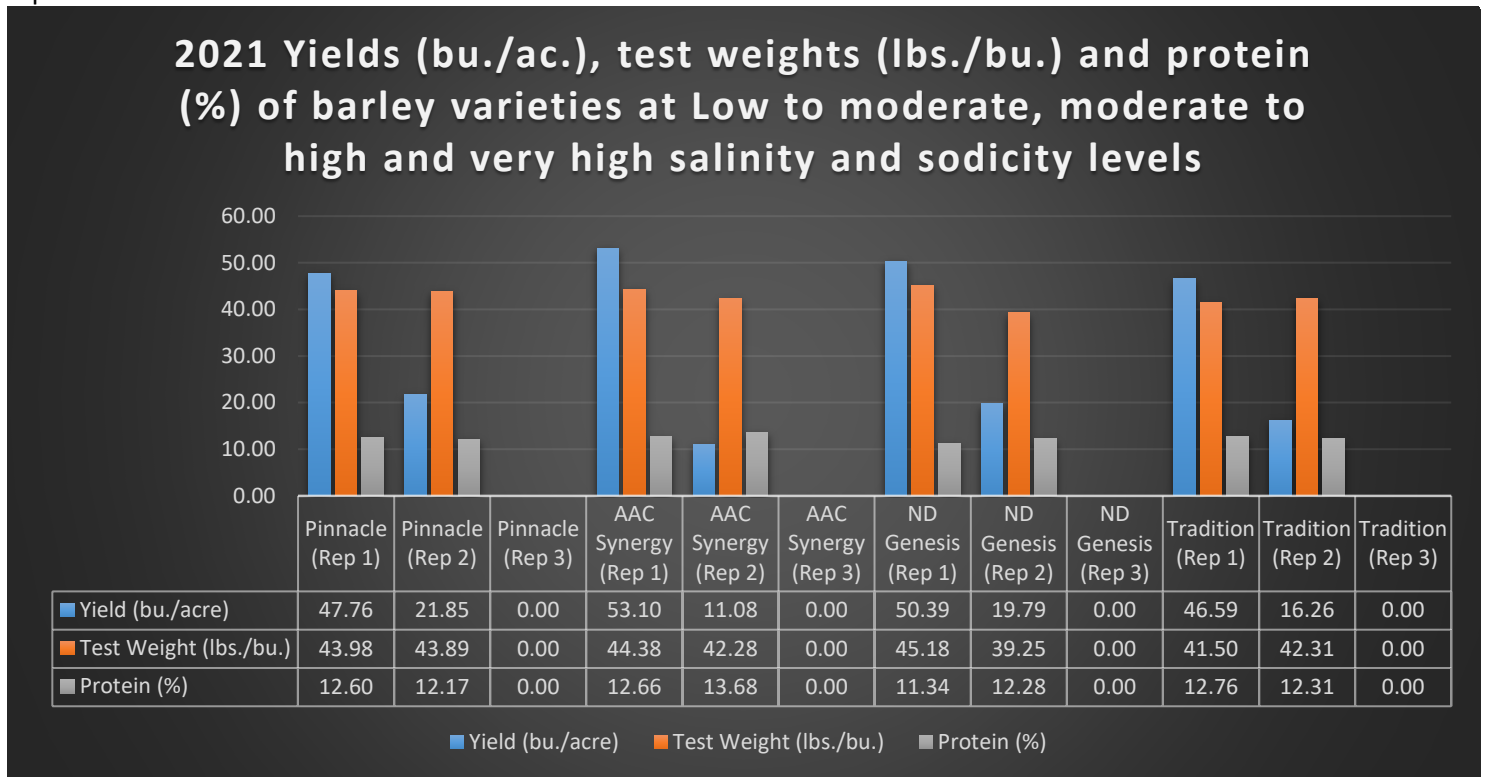
2021

Average barley yield of replication 1 was 49.46 bushels per acre versus 17.24 bushels per acre of replication 2. That was a 65 percent reduction in yield (Figure 1). In replication 3, all barley varieties yielded zero. In replication 1, ACC Synergy had the highest yield (53.10 bushels per acre) followed by ND Genesis (50.39 bushels per acre), Pinnacle (47.76 bushels per acre) and Tradition (46.59 bushels per acre). In replication 2, Pinnacle yielded the highest (21.85 bushels per acre) followed by ND Genesis (19.79 bushels per acre), Tradition (16.26 bushels per acre) and ACC Synergy (11.08 bushels per acre).

Replication 1 had slightly higher test weight (4.18%) than replication 2. ND Genesis had the highest test weight in replication 1 followed by ACC Synergy, Pinnacle and Tradition. In replication 2, Pinnacle had the highest test weight followed by Tradition, ACC Synergy and ND Genesis.

In terms of protein content, replication 1 had slightly lower protein (10.58%) than replication 2. Overall, Tradition had the highest protein in replication 1 followed by ACC Synergy, Pinnacle and ND Genesis. In replication 2, ACC Synergy had the highest protein followed by Tradition, ND Genesis and Pinnacle. See Figure 1 for details.

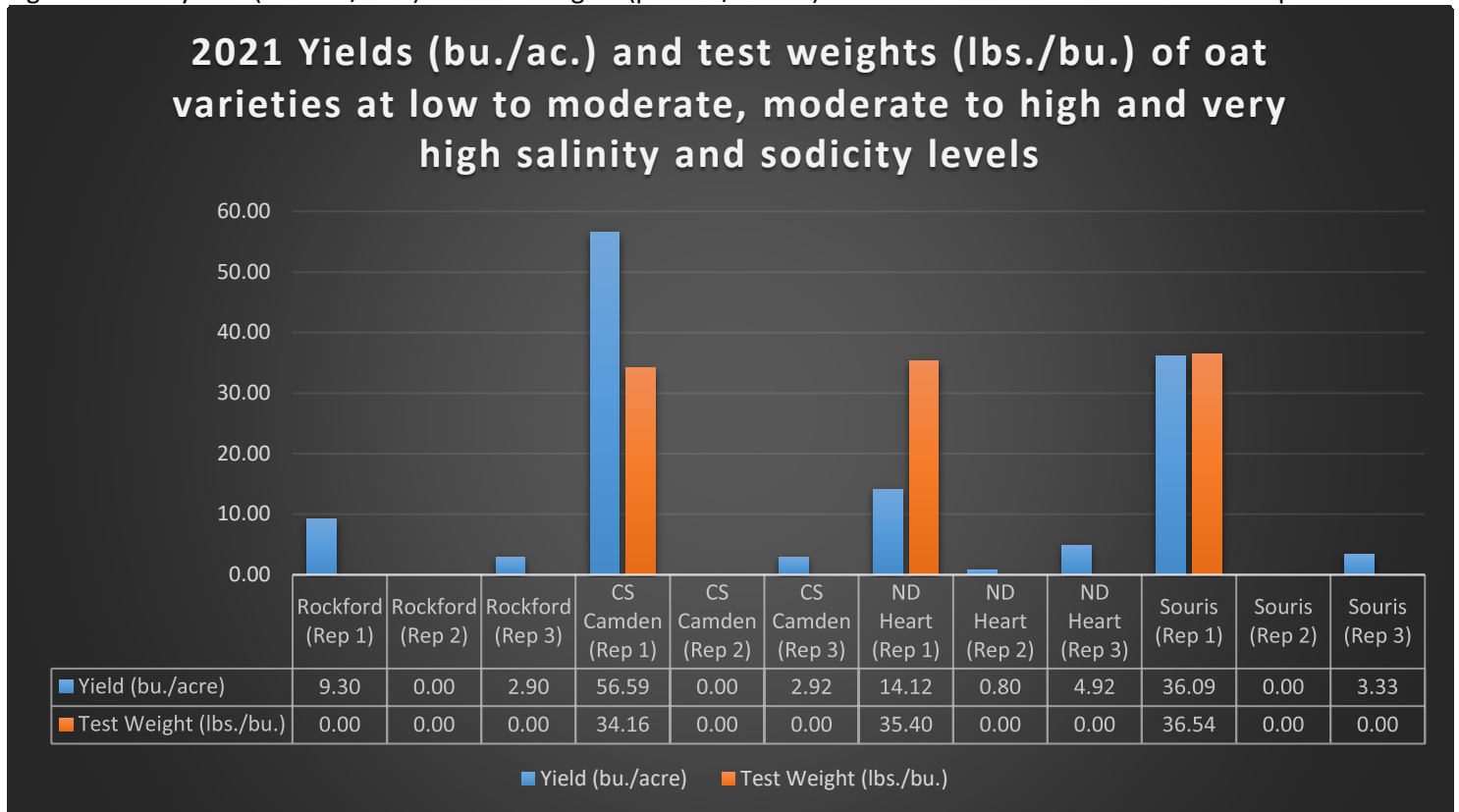
Figure 1. 2021 yields (bushels/acre), test weights (pounds/bushel) and protein (%) of the four barley varieties for all three replications.



Average yield of oats in replication 1 was 29.02 bushels per acre versus 0.80 bushels per acre of replication 2 and 3.52 bushels per acre of replication 3. That was 97 and 88 percent reduction in yield in replication 2 and 3 compared to replication 1 (Figure 2). CS Camden had the highest yield in replication 1 (56.59 bushels per acre) followed by Souris (36.09 bushels per acre), ND Heart (14.12 bushels per acre) and Rockford (9.30 bushels per acre). In replication 2, only ND Heart produced a measurable yield of 0.8 bushels per acre, whereas, Rockford, CS Camden and Souris produced zero yields. Surprisingly, all oat varieties yielded slightly better in replication 3 compared to replication 2. In replication 3, ND heart produced 4.92 bushels per acre followed by 3.33 bushels per acre of Souris, 2.92 bushels per acre produced by CS Camden and 2.90 bushels per acre produced by Rockford.

In terms of test weight, Souris had the highest test weight in replication 1 followed by ND Heart and CS Camden. Rockford in replication 1, did not produce enough to send a sample to analyze it for test weight. Similarly, all oat varieties in replication 2 and 3 did not produce enough seed for analyzing them for test weight.

Figure 2. 2021 yields (bushels/acre) and test weights (pounds/bushel) of the four oat varieties for all three replications.

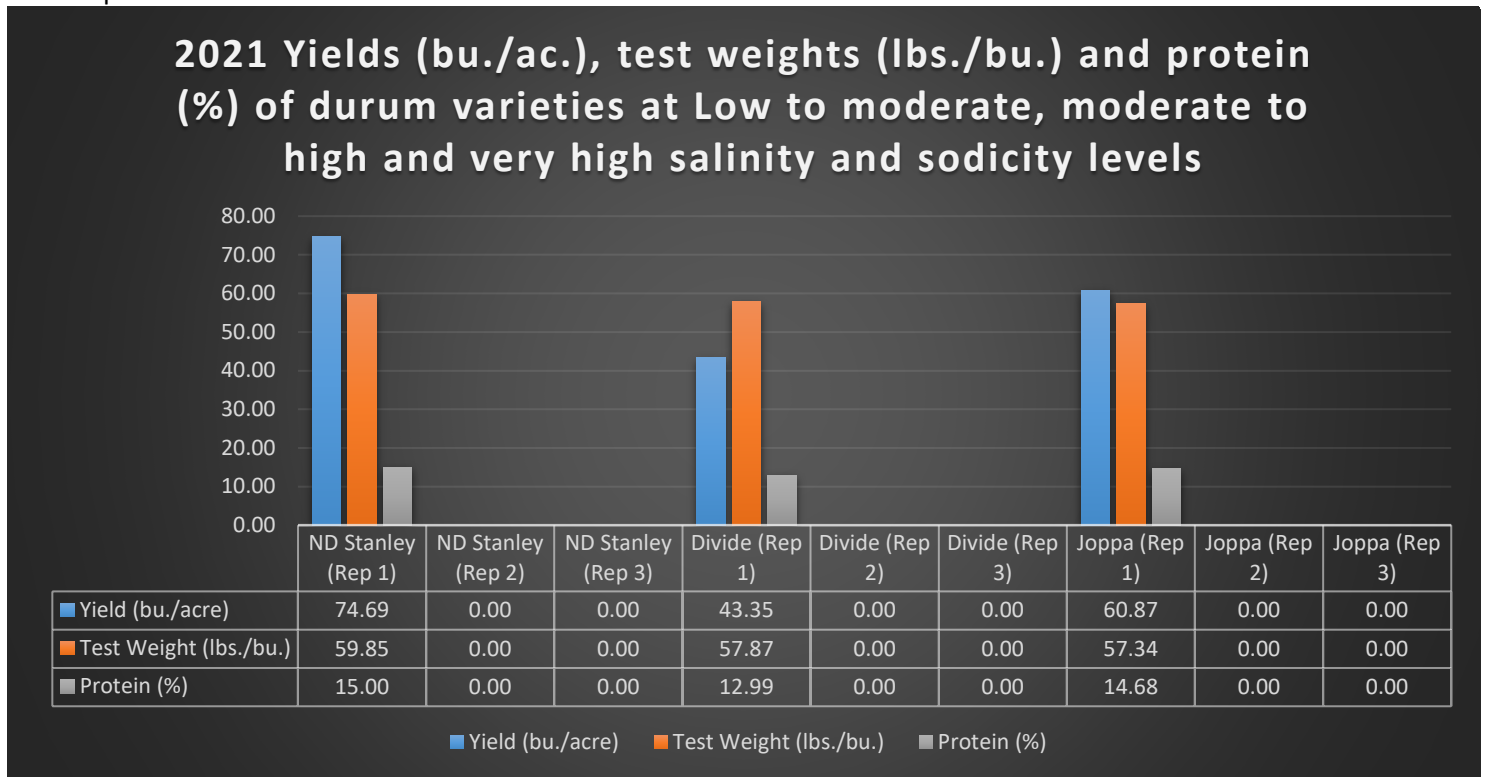


Average durum yield in replication 1 was 74.30 bushels per acre with average test weight of 58.59 pounds per bushel and an average protein of 14.19 percent. In replications 2 and 3, durum produced zero yields. That was a 100 percent decrease in yield in replications 2 and 3 versus replication 1. ND Stanley yielded the most by producing 74.69 bushels per acre followed by Joppa (60.87 bushels per acre) and Divide (43.35 bushels per acre).

ND Stanley had the highest test weight of 59.85 pounds per bushels followed by Divide (57.87 pounds per bushels) and Joppa (57.34 pounds per bushels). In addition, ND Stanley also had the highest protein content of 15.00 percent followed by Joppa (14.68%) and Divide (12.99%).

Note: ND Riveland yield and quality data was excluded from the annual report due to a possible error while calculating the yield per acre, which was 118.30 bushels per acre. As per the Langdon Research Extension Center long-term agronomy trial results, the highest recorded durum yield has been 90 bushels per acre or less.

Figure 3. 2021 yields (bushels/acre), test weights (pounds/bushel) and protein (%) of the three durum varieties for all three replications.



2020

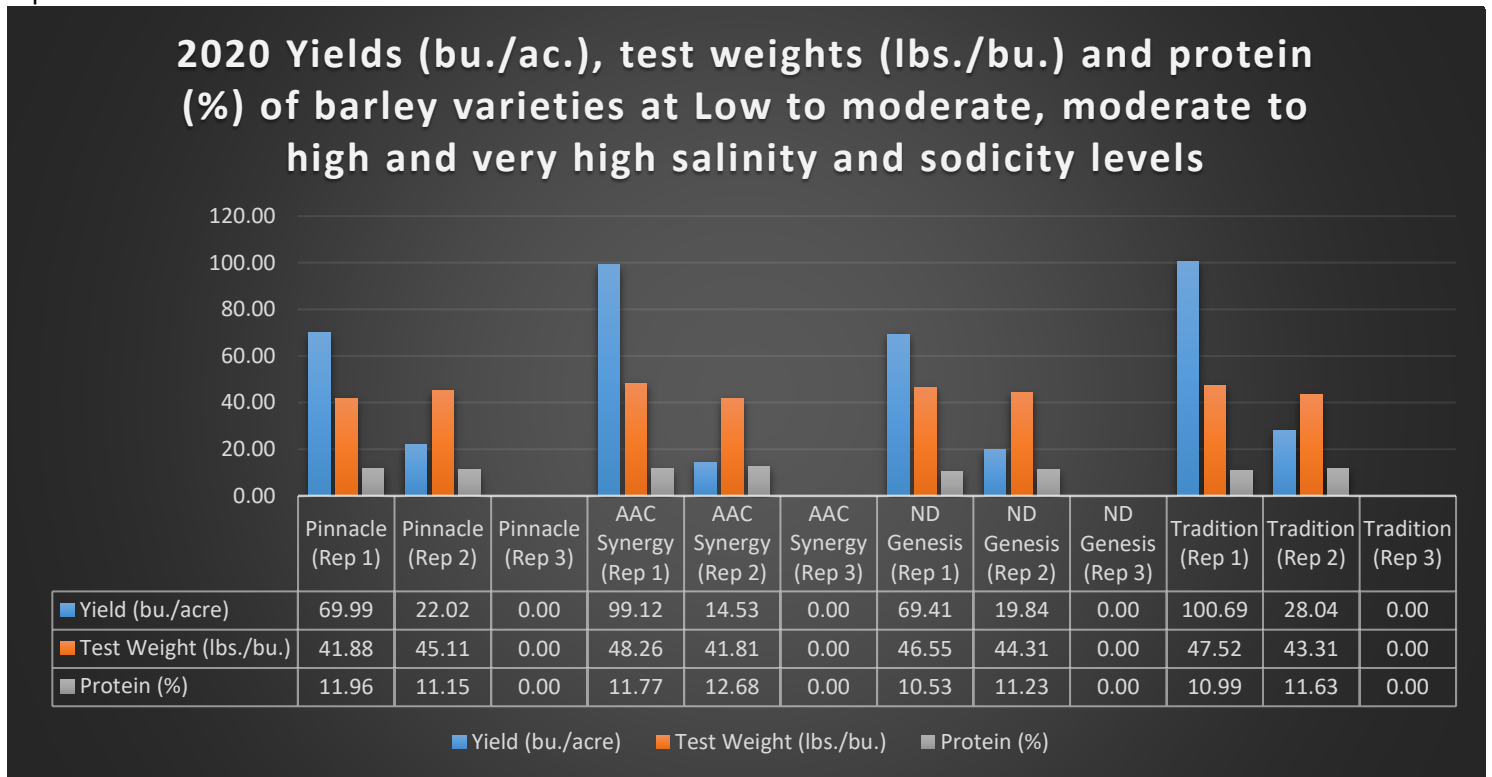
Average barley yield of replication 1 was 84.80 bushels per acre versus 21.10 bushels per acre of replication 2. That was a 75 percent reduction in yield (Figure 4). In replication 1, tradition yielded the highest (100.69 bushels per acre) followed by ACC Synergy (99.12 bushels per acre), Pinnacle (69.99 bushels per acre) and ND Genesis (69.41 bushels per acre). However, at moderate to high salinity and sodicity levels in replication 2, yield trends were different. Tradition still came out as the highest yielding variety at 28.04 bushels per acre followed by Pinnacle (22.02 bushels per acre), ND Genesis (19.84 bushels per acre) and ACC Synergy yielding 14.53 bushels per acre.

ACC Synergy had the highest test weight in replication 1 followed by Tradition, ND Genesis and Pinnacle. Like yields, with the increase in salinity and sodicity in replication 2, test weight trends changed as well. Pinnacle had the highest test weight in replication 2 followed by ND Genesis, Tradition and ACC Synergy. Overall, replication 1 had five percent higher average test weight compared to replication 2.

Unlike yield and test weight, average protein content of replication 2 was 3.18 percent higher than replication 1. In terms of varietal differences, Pinnacle had the highest protein in replication 1 followed by ACC Synergy, Tradition and ND Genesis. In replication 2, ACC Synergy had the highest protein followed by Tradition, ND Genesis and Pinnacle. Replication 3 resulted in 100 percent loss.

Overall, Tradition (six-row) barley had the highest yields in replication 1 and 2 versus the other three two-row varieties.

Figure 4. 2020 yields (bushels/acre), test weights (pounds/bushel) and protein (%) of the four barley varieties for all three replications.



Average yield of oats in replication 1 was 102.85 bushels per acre versus 35.33 bushels per acre of replication 2 and 2.12 bushels per acre of replication 3. That was 65 and 98 percent reduction in yield in replication 2 and 3 compared to replication 1 (Figure 5). CS Camden had the highest yield (121.35 bushels per acre) in replication 1 followed by ND Heart (114.27 bushels per acre), Souris (87.91 bushels per acre) and Rockford (87.88 bushels per acre). Like barley, oat yield trends also changed with the increase in soil salinity and sodicity. In replication 2, Rockford had the highest yield (39.33 bushels per acre) followed by ND Heart (37.81 bushels per acre), Souris (35.90 bushels per acre) and CS Camden (28.26 bushels per acre). All varieties yielded negligibly in replication 3 with ND Heart yielding the most with 5.75 bushels per acre.

Replication 1 had 6.31 and 83.53 percent higher average test weight than replication 2 and 3. Rockford had the highest test weight in replication 1 followed by ND Heart, Souris and CS Camden. Souris had the highest test weight in replication 2 followed by ND Heart, Rockford and CS Camden. ND Heart was the only oat variety that produced a big enough sample in replication 3 to measure the test weight, which was 23.22 (pounds per bushel).

One key observation was that all four oat varieties had some growth in replication 3, whereas, barley had zero growth pointing to a slightly higher salt and sodicity tolerance of oats compared to barley.

The 2021 and 2020 average oat yields in replications 1, 2 and 3 were 65.94, 17.76 and 2.82 bushels per acre respectively. Therefore, oat yields in replication 2 and 3 reduced by 73.06 and 95.72 percent respectively versus replication 1. In addition, oats produced very low, however, measurable yields in replication 3 compared to barley, which resulted in 100 percent loss in 2021 and 2020. Details are in Figure 6.

Summary

- Soil surface salinity and sodicity levels (0-6 inch depths) had more impact on the seedbed preparation, germination, plant growth and vigor, maturity, yield and quality than the levels in the 6-24 inch depths in 2021 and 2020. Increased EC and SAR levels in the topsoil may result in significant economic losses.
- At moderate to high and very high salinity and sodicity levels, average barley and oat yields decreased significantly versus low to moderate levels in 2021 and 2020. In 2021, average barley yield was 65 and 100 percent less in replications 2 and 3 respectively versus replication 1. Whereas, in 2020, average barley yield was 75 and 100 percent less in replications 2 and 3 respectively versus replication 1. Average oat yields in 2021 were 97 and 88 percent less in replications 2 and 3 respectively versus replication 1. Reduction in average oat yield in 2020 was 65 and 98 percent respectively in replication 2 and 3 versus replication 1.
- Annual growing-season weather and precipitation also made significant impacts on barley and oat yields even when surface soil salinity and sodicity levels were low to moderate. Average 2021 barley yield in replication 1 was 41.67 percent less compared to 2020 average barley yield. In replication 2, average 2021 barley yield was 18.29 percent less than 2020 barley yield. In replication 3, barley produced zero yield in 2021 and 2020. Oats in 2021 had a 71.78 percent average yield reduction versus 2020 in replication 1, whereas, in replication 2, 2021 average yield was 97.73 percent less than 2020. Opposite trend was observed in replication 3 for oats. Average 2021 oat yield in replication 3 increased by 166 percent versus 2020.
- Both barley and oat varieties produced variable yields and quality at different salinity and sodicity levels. Varieties that produced higher yields at low to moderate salinity and sodicity levels, yielded lower at moderate to high salinity and sodicity levels.
- Tradition barley (six-row) produced highest yields in replication 1 and 2 versus the other three two-row varieties in 2020.
- Oats turned out to be equally or slightly more tolerant to salinity and sodicity compared to barley.