Biosolids-based Fertilizers in California Wheat

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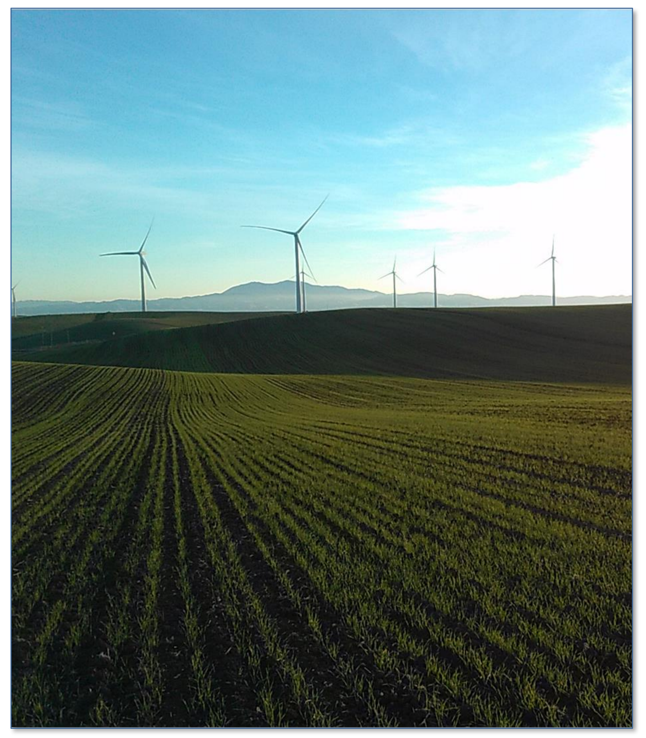
Abstract

Biosolids-based fertilizers can be cost-effective sources of nitrogen (N) for wheat and other agronomic crops. As more California municipalities begin to prioritize the diversion of waste products from landfills into agricultural systems, it is pressing for growers to understand how to utilize new inputs such as liquid-injected biosolids-based fertilizer (LBF) in their operations. The use of biosolids as a fertilizer can also prevent unnecessary disposal of phosphorous, nitrogen, and carbon into landfills. Field trials comparing the performance of LBF to conventional N sources were conducted over the course of three planting seasons in wheat in the southern Sacramento Valley. Laboratory incubations were also carried out to examine the impact on soil chemistry of the LBF relative to a pelletized biosolids-based fertilizer (PBF), and conventional urea. Results indicate that LBF produces equivalent yield and protein results in wheat when compared to conventional forms of fertilizer as an N source. Other findings indicate that there may be some ancillary benefits associated with the use of LBF by providing a source of phosphorous (P), carbon, micronutrients, and water. This suggests that LBF may be a reasonable option for N fertilization for rotational growers in the south Sacramento Valley.



Images: left: Rio Vista, CA where rainfed trials were conducted in 2018 . Right: LBF application rig. Coulters open the soil, material is injected, and the soil is closed again by another set of coulters.

Methods

Field trials were conducted between 2018 and 2021 in the southern Sacramento Valley to evaluate the yield and protein outcomes of fall-planted wheat fertilized with biosolids-based materials across different soil types and moisture regimes. LBF was compared side-by-side with similar rates of conventional mineral N fertilizers. Treatments included 2 or 3 rates of LBF and an application of conventional fertilizer (anhydrous ammonia, UAN32, or urea) at a rate that matched one of the biosolids rates in terms of total N applied per acre. LBF was injected and integrated to a depth of 6 inches on 22.5 inch spacing. Yield and protein data were collected from grain harvest using grower-collaborator combines and weigh wagons. Soil and plant tissue data were collected to document the impact of the material on soil and plant nutrients in-situ. Lab incubations were also carried out (at field capacity, 75F) to document changes in key soil attributes (N mineralization rate, Olsen P, EC, and pH) between LBF, pelletized biosolids-based fertilizer (PBF), and urea.

Site Details

Values represent total lbs of N / acre applied

Year	2018	2019	2021
LBF Low	57	66	73
LBF Medium	90	82	146
LBF High	NA	98	219
Conventional Fertilizer	90 'med'	120 'high'	130 'med'
Fertilizer Type	Anhydrous	UAN 32	Anhydrous
Relative Rainfall Pattern	Average-Droughty	Above Average	Extreme Drought
Location	Upland: Bird's Landing	Valley: Dixon Area	Valley: Rio Vista

Results: Yield and Protein

Predominantly insignificant yield and protein differences were seen between treatments; however, there were occasional differences that hint at slightly slower N-mineralization rates which can lead to improved protein uptake (increases in wheat protein are typically associated with N-uptake in the latter stages of the season). In the drought years of 2018 and 2021 the additional moisture associated with the LBF treatments may have facilitated better stand establishment during high drought-stress periods.

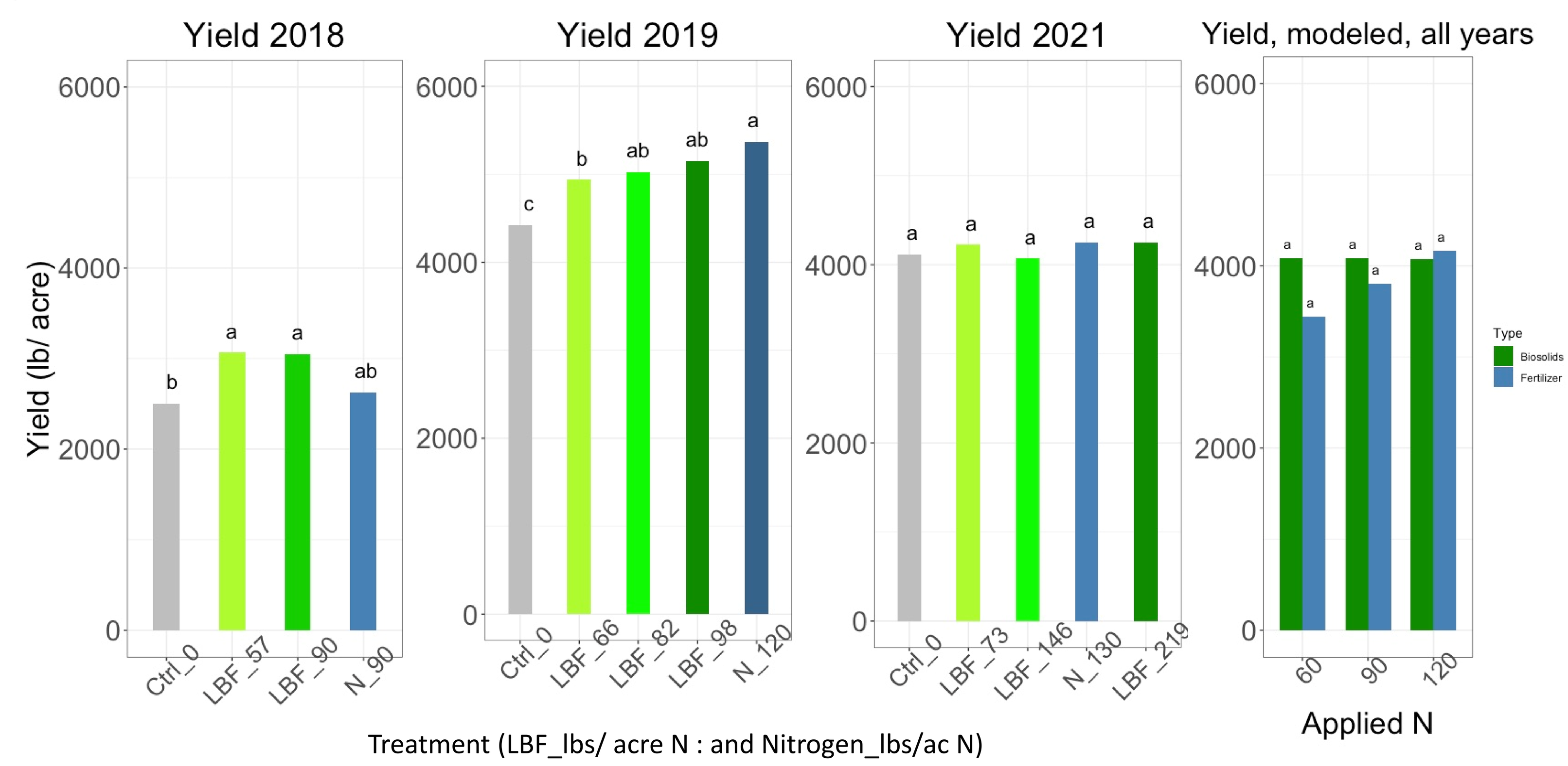
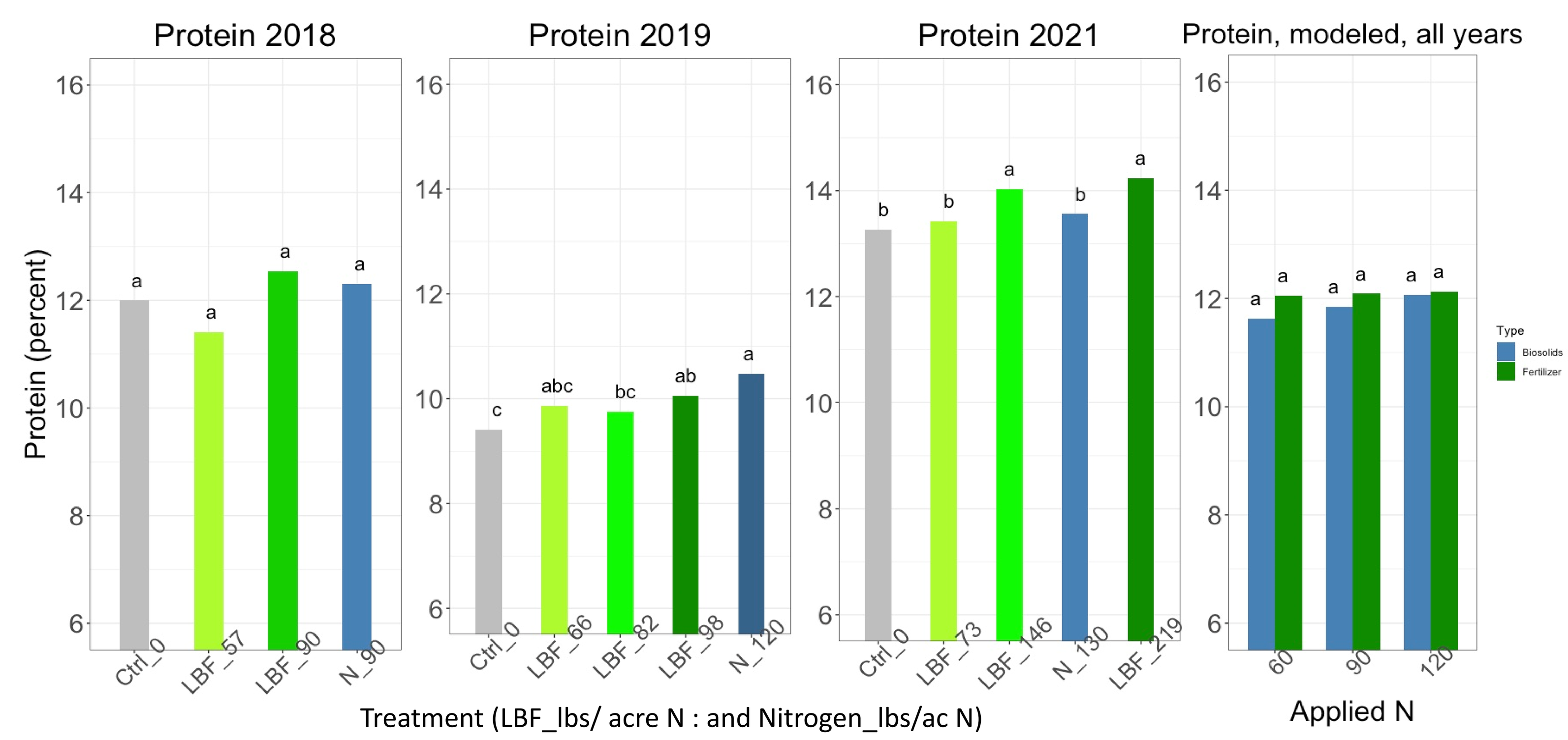


Figure (above and below): Yield and protein data from field trials over three site years in the Southern Sacramento Valley. Conventional N fertilizer rates are indicated in blue. Shades of green represent biosolids treatments, with higher rates becoming progressively darker green. N equivalents are represented numerically in each of the labels (i.e. LBF_57 is 57 pounds of N per acre as Liquid-Injected Biosolids-Based Fertilizer)



Differences in Plant and Soil Measurements

Plant and soil measurements taken from the sites indicate that there were relatively few significant differences between treatments. Soil phosphorous levels did show some indication of a response to relatively high levels of phosphorous associated with biosolids materials.

	2018	2019	2021	All
Yield	1	1	NS	1
Protein	NS	1	2b	NS
Apparent N Recovery	NS	NS	NS	NS
Soil Nitrate at Tillering (lbs/a)	NS	1	2f	1
Soil P at Tillering	NS	1	0	1
Soil K at Tillering	NS	NS	0	NS
Soil Nitrate at Rapid Growth Stage	NS	NS	NS	1
Soil P at Rapid Growth Stage	NS	2b	0	NS
Soil K at Rapid Growth Stage	NS	NS	0	NS
Residual Nitrate	NS	NS	NS	1
Soil P Post Harvest	NS	NS	NS	1
Soil K Post Harvest	NS	NS	NS	1
Soil OM Post Harvest	0	NS	NS	NS
Leaf Nitrate at Tillering	0	1	0	1
Leaf P at Tillering	0	NS	0	NS
Post Harvest Subsoil Nitrate	0	NS	0	NS
Leaf Nitrate at Boot	0	0	1	NS
Leaf P at Boot	0	0	NS	NS

NS = Not Significant
0 = no data
1 = significant differences between control and treatments
2f = significant (fertilizer greater)
2b = significant (biosolids greater)

Table: Summary of results from various soil and plant tissue tests comparing similar rates of total N. Cells are color coded accordingly. (see legend)

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Lab Incubations

Lab incubations reflected some of the patterns witnessed in the field: Increases in phosphorous, slower N mineralization rates, and otherwise similar soil chemistry outcomes relative to that of conventional fertilizer, particularly after 12 weeks.

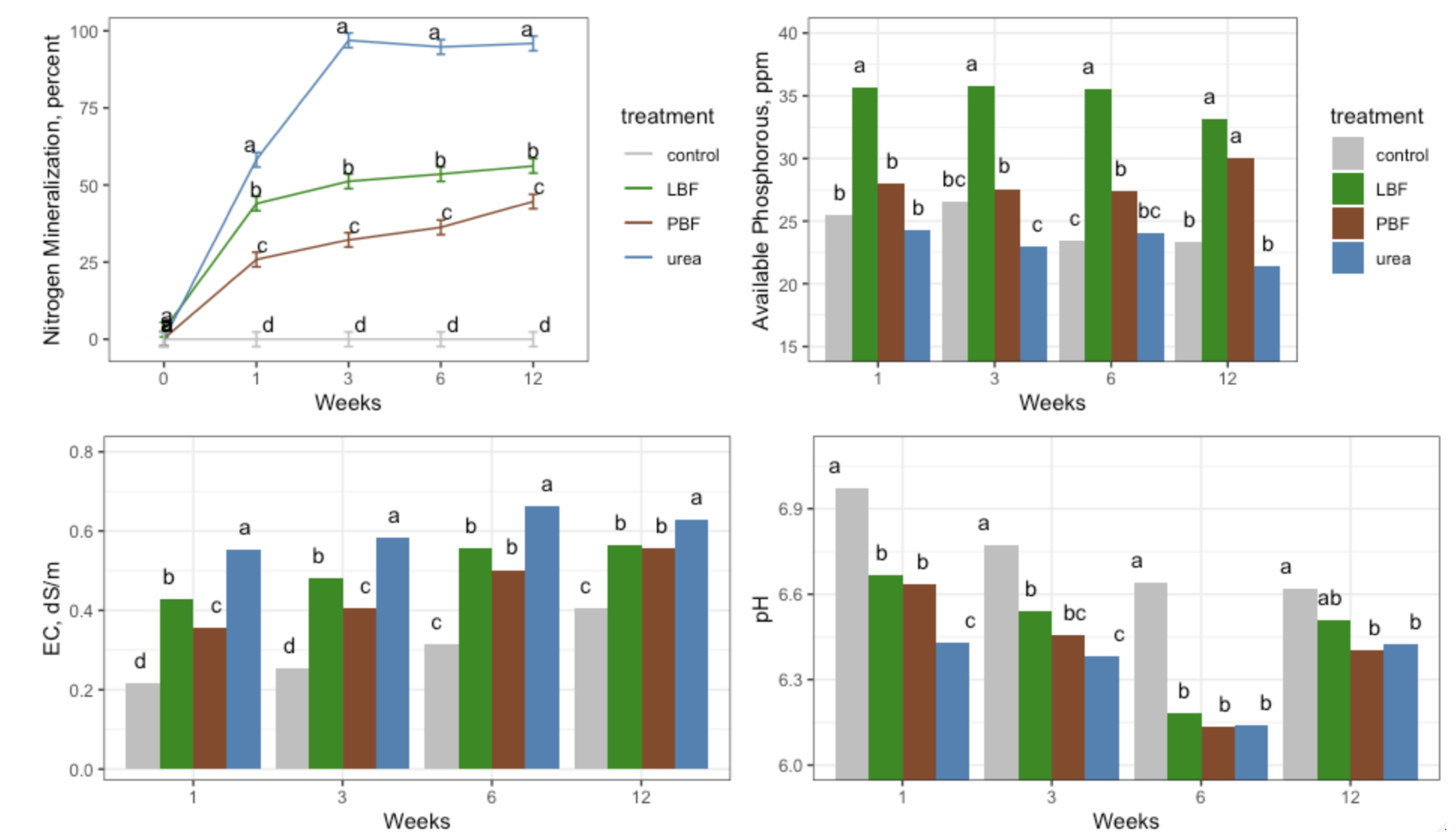


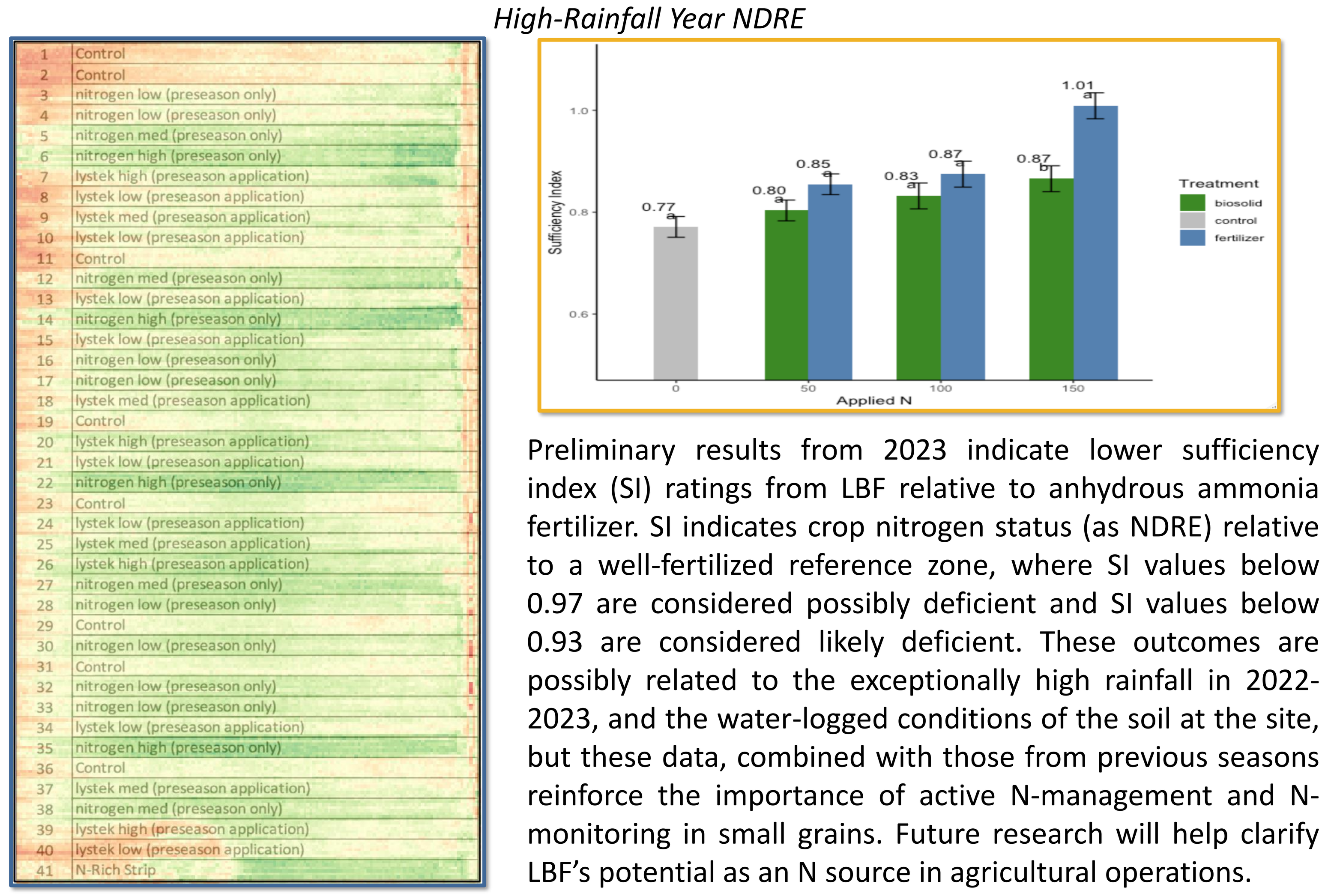
Figure: N mineralization, available phosphorous, salinity (as electrical conductivity, EC), and pH results from 12-week lab incubations comparing LBF, PBF, and pelletized urea mixed into a Yolo loam. Significant difference between treatments is indicated within a given week by different letters.

Key findings:

- Liquid-injected biosolids-based fertilizers (LBF) were insignificantly different to conventional forms of N in terms of yield and protein when used at similar rates of total applied N.
- Nitrogen use efficiency trended slightly higher in LBF treatments relative to convention forms of N: (LBF - 95.6%, Conventional – 91.4%), but was insignificantly different.
- LBF and pelletized biosolids-based (PBF) fertilizers both had a rapid initial release of N, followed by a slow and steady release curve that, relative to urea, released about 40% less N by the end of the 12 week incubations.
- Soil nitrate values at tillering were largely insignificantly different, but trended slightly higher in biosolids treatments at equivalent rates of lb N/ acre in an above average rainfall year (2019).
- Incubations indicated that LBF and PBF treatments increased soil phosphorous, these patterns were visual in some of the soil and plant data as well.
- LBF and PBF caused less of an increase in soil salinity relative to conventional urea
- LBF and PBF caused less of an initial drop in pH relative to conventional urea, but pH became insignificantly different between treatments by week 6 (likely due to soil buffering).

Ongoing Research and Caveats

High-Rainfall Year NDRE



Preliminary results from 2023 indicate lower sufficiency index (SI) ratings from LBF relative to anhydrous ammonia fertilizer. SI indicates crop nitrogen status (as NDRE) relative to a well-fertilized reference zone, where SI values below 0.97 are considered possibly deficient and SI values below 0.93 are considered likely deficient. These outcomes are possibly related to the exceptionally high rainfall in 2022-2023, and the water-logged conditions of the soil at the site, but these data, combined with those from previous seasons reinforce the importance of active N-management and N-monitoring in small grains. Future research will help clarify LBF's potential as an N source in agricultural operations.

Figure: above: NDRE values across multiple treatments in 2023. SI values were low across the board. Above right- Sufficiency index averages based on rates of applied N (lbs/ acre), comparing LBF and anhydrous ammonia