Progress Report

ODAFF Specialty Crop Demonstration

Nitrogen Practices for Teff Following Over-wintered Spinach

Demonstration 1

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Background

Dean Smith frequently plants teff behind spring harvested crops. For Dean, teff is a dual purpose crop, grown primarily for grain, but the forage harvest after the grain harvest also adds to the total profitability. Interest has been increasing in Oklahoma in teff expressly for forage, especially hay. Historically, Dean applies 100 pounds of actual N on the teff crop. Dense and recumbent growth can sometimes make windrowing difficult.

In 2010, Dean had over-wintered spinach for a crop. Because of market changes, he did not plant any teff for commercial purposes, but did furnish us with teff seed, equipment, and fertilizer to plant the demonstration plots, and made crop observations with us throughout the season. Teff behind a crop such as spinach was one of our scenarios for a demonstration plot.

Demonstration Premise

Fertility management of some vegetable crops, such as spinach, require large amounts of fertilization, especially nitrogen (N). This exercise was to demonstrate:

1) A soil test should be taken following such a crop, and the results can be used to plan fertility management for the following crop, especially where N requirements are concerned.
2) In addition to a regular surface analysis, results from a subsurface N test may also allow for additional reduction in the following crop's need for added N application.
3) Teff, for grain and forage, or just for forage, maybe a suitable crop to utilize residual N after a crop such as spinach.
4) In lieu of a surface and subsurface N soil test, an N-Ramp plot might be a sufficient replacement to guide additional nitrogen application rates as top dress later in the season. Although there are no Green-Seeker teff algorithms to allow for a computer generated fertilizer recommendation, it was hoped that visual differences in the increasing N-Ramp fertility levels might plainly indicate an N top dress rate to recommend.

Materials and Methods

After spinach harvest, a plot area was marked off to accommodate eight treatments, 12 feet wide by 150 feet long, with four feet between the treatments. A soil sample representative to this area was taken and sent to the OSU Soil, Forage, and Water Analytical Lab for analysis. In the surface layer (0 to 6 inches) soil

ph, nitrate nitrogen (lbs per acre), phosphate (OSU P Index), and potassium levels (OSU K Index) was measured. In the subsurface layer (6 to 20 inches), nitrate nitrogen (lbs per acre) was obtained.
The field was sprayed with using 41% glyphosate @ 40 oz/acre and Induce surfactant @ 2qts/100gal of carrier rate equivalents. On June 3, the demonstration area was solidly no-till drilled with 15 lbs of cleaned teff seed per acre. On June 30, the demonstration area was fertilized in eight plots with an N-Ramp applicator, flagged, and areas between the plots later killed with a glyphosate application. The plots (Figure 1.) were laid out to maximize visual observation for differences and trends between fertilizer treatments. Treatments were repeated from the exterior area of the field (south) to the interior (north),
The area was irrigated to supplement rainfall, receiving in total about 10 inches of moisture (~5.0 inches of irrigation, ~4.9 inches rainfall) for the approximate 60 day growing period. On July 29, a two person panel individually rated each plot on: percentage of plants recumbent, percentage of plants headed, and gave ratings for visual color (10=very dark green, 1=yellow, obvious nitrogen deficiency). Five random areas of adjacent one foot drill row lengths from each set of the three main N treatments were clipped and air dried for a month and weighed to estimate biomass yield for the treatments. It was hoped that this sampling could also provide an estimate of grain production.

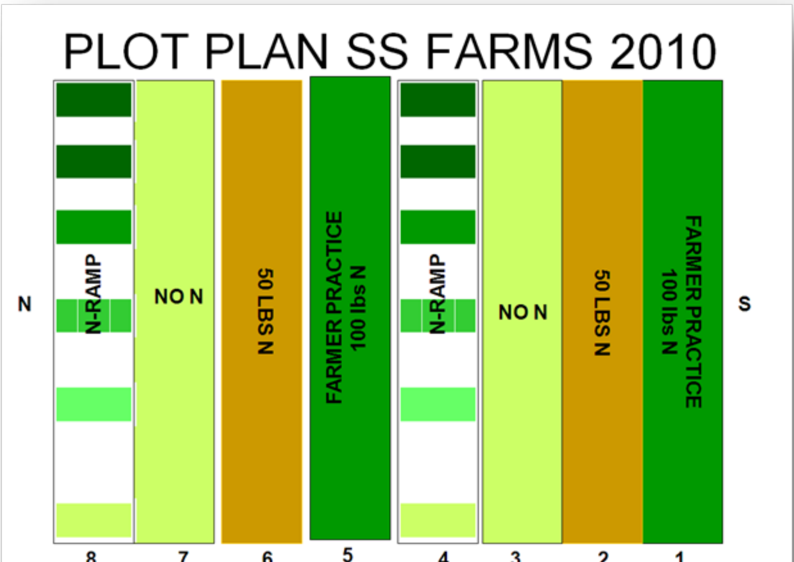
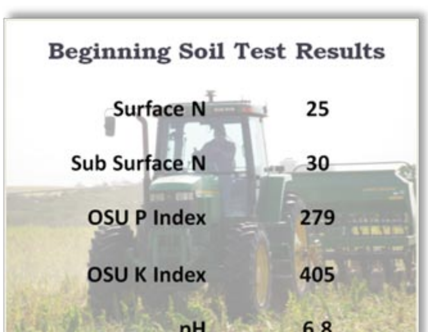


Figure 1. Fertilization layout for teff behind spinach demonstration. Pounds of "N" are the rates at which plots where top dressed



Beginning Soil Test Results

Surface N	25
Sub Surface N	30
OSU P Index	279
OSU K Index	405
pH	6.8

Table 1 Initial Soil Test of Demonstration Area

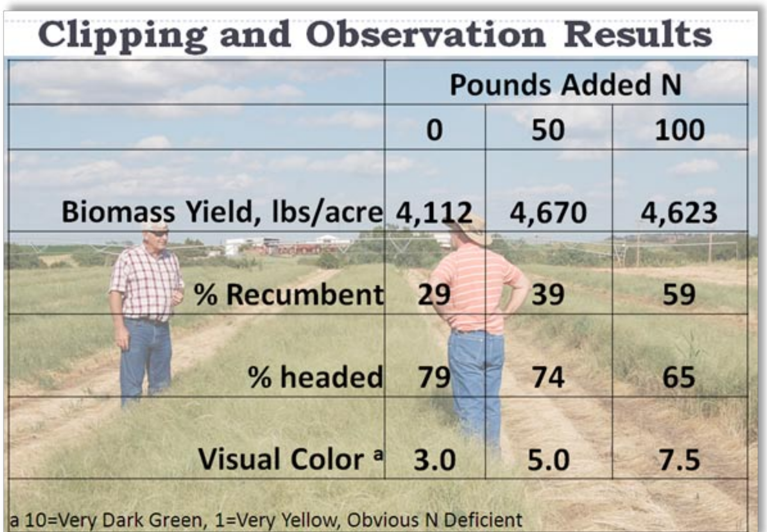
Observations

Initial Nutrient Levels

Table1 shows the results of the pre-plant soil tests. This field area is quite fertile in terms of P and K, as is to be expected for a well cared for property of this soil type (Pond Creek Silt Loam). In fact, the P and K levels are well above the minimum OSU sufficiency levels for most crops, and indicate the cooperator should think hard before applying large amounts of these type fertilizers on most crops, especially commodity crops. N Levels of 25 pounds per acre in the surface and 30 pounds in the subsurface indicate that there will be a total of 55 pounds available for the teff crop, if teff is an effective scavenger of nitrogen in the deeper sub-surface

Clipping and Plot Ratings

Since the plot layout was designed for maximum visual effects and not designed for statistical analysis (only two repetitions of each treatment not randomly applied), results are presented as the average of the two plots of each treatment. Not shown, but of note, is that the two treatments of 100 pounds additional nitrogen showed the least variability in biomass yield with only 46 lbs difference. No (0) additional nitrogen plots had the greatest variability with 697 lbs difference. The 50 added N plots were intermediate in variability with a 279 lbs difference. The average of the 50 added N plots was very similar to the yield from the heavier fertilized plots. In visual ratings, the more heavily fertilized plots appeared more prone to lodging with an average of 59% recumbence. They appeared less mature. Observers thought that there was a consistent increase in color with 0 added N strips trending towards yellow, 100 added N strips tending towards very dark green, and 50 added N strips not appearing N deficient but not being especially dark green either.



Clipping and Observation Results

	Pounds Added N		
	0	50	100
Biomass Yield, lbs/acre	4,112	4,670	4,623
% Recumbent	29	39	59
% headed	79	74	65
Visual Color [a]	3.0	5.0	7.5

a 10=Very Dark Green, 1=Very Yellow, Obvious N Deficient

Table 2 Demonstration Plots Biomass and Observation Scores

Observations of N-Ramp Strips

Disappointingly, the observers agreed that the results of the N-Ramp applications were not strikingly apparent to visual observation. Without a teff algorithm, the Green Seeker technology could not be applied. It was agreed that, due to the short season nature of teff, it would be hard to apply the technology for making N fertilizer recommendations.

In general, the observers noted that in the first third of the plots (0 to 42 lbs added N), color and stand density increased. This improvement appeared to maximize in the first half of the next third (56 and 70 lbs added N), after which there was no improvement, and in fact the stand became more recumbent, with the stand even appearing to thin at N levels over 126 lbs added N. These observations took a lot of study and could not yield a definitive fertilizer recommendation.

Teff Grain Yield

The demonstrators have read that the name "*tef*" or "*teff*" means "lost" in some Ethiopian dialects. According to the source, it is so named because in hand harvesting, threshing, and winnowing, often more than half of teff seed can be lost. The demonstrators verified this trait trying to separate the grain from the clippings for a meaningful grain yield comparison among fertilizer treatments and were forced to abandon the attempt.

Final Soil Test Results

Surface and subsurface N values were seen to decrease in all plots as shown in Table 3. Residual N was highest in the 100 added N plots. Surprisingly, residual N was higher in the 0 added N plots than the 50 added N plots. OSU K Indexes were even higher in the final soil tests than the initial test. The OSU P Index was lower in the final tests, especially in the 0 added N plot, but even this level is considerably higher than levels considered adequate for production of most crops.

Ending Soil Test Results

	Pounds Added N		
	0	50	100
Surface N	6	2	6
Sub Surface N	9	4	17
OSU P Index	238	274	267
OSU K Index	478	484	491
Soil pH	7.3	7.5	7.4

Table 3 Ending Soil Test Results

Hay Quality/Value Evaluations

Forage samples were sent to the OSU Soil, Forage, and Water Analytical Lab for analysis of crude protein levels. The values were used to determine the value of the hay produced from the plots. Based on the ODAFF hay market report for September 30, 2010, the high range for premium (> 13% crude protein [CP]) grass hay in round bales was $80 per ton. Arbitrarily, a bottom range for utility hay (<5% C) was set at $40 per ton (i.e., $20 a bale for 1,000 # bales). A value equation was developed from this relationship:

Quality and Value of Hay

	0	50	100
% Crude Protein	8.2%	12.8%	15.7%
Calculated Value / Ton	$ 51.64	$ 68.18	$ 78.91
Gross Value/Acre	$ 106.17	$ 159.19	$ 182.40
Cost of Added N @ $0.50/unit	$ -	$ 25.00	$ 50.00
$ Above N Cost	$ 106.17	$ 134.19	$ 132.40

Table 4 Quality and Value of Hay

Value of Hay = $40/ton + ((%CP of the Hay-5%CP base) * $3.64))

Where:

$40.00 is the arbitrary base price for utility hay.

Each % increase in Crude Protein increases the value $3.64/ton, so that 16% CP hay is $80/ton.

The hay from 0 added N was 8.2% CP, or fair quality according to ODAFF grass hay guidelines. It would have a value of $51.64 per ton under the value equation above and when multiplied by the yield from Table 2 gives a gross value per acre of $106.17 per acre. The hay from 50 added N averaged 12.8% CP, in the very high end of good quality, valued by the equation at $68.18 a ton, and had a gross value of $159.19 per acre. The 100 added N plots averaged in the very high end of grass hays (15.7% CP), with the hay value closest to $80/ton, and grossing the highest amount per acre, $182.40 per acre. However, when the cost of the additional N was included at a $0.50 per unit charge, the 50 added N and 100 added N were about the same in value.

Estimate of N Utilization

Nitrogen utilization was estimated by taking the crude percent protein and dividing by 6.25. Traditionally, crude protein has been indirectly estimated as the measured % nitrogen in a sample times 6.25, a constant arising from the average nitrogen content of proteins. This percentage nitrogen was multiplied the dry matter yield in each of the treatments. This value was used in a crude nitrogen balance model shown in Table 5.

Theoretical Nitrogen Balance

Beginning N	55	55	55
Extra N Applied	-	50	100
Total Available	55	105	155
Estimated N Use	49	87	105
Theorectical Residual	6	18	50
Amount Found	15	6	23
N unaccounted for	(9)	12	27

Table 5 Theoretical N balance based on N removal from forage

The highest level of extra N applied, 100 lbs resulted in the greatest amount of carryover nitrogen and the greatest amount of nitrogen unaccounted for.

Conclusions

In spite of a fibrous rather than a tap root system, it appears that teff can be an efficient scavenger of nitrogen in the subsoil after heavily fertilized specialty crops, at least to the 20 inch depth sampled in the demonstration. The production of forage exceeded the theoretical amount that could be produced.

Subsoil N tests should be a part of planning fertility strategies for commodity crops following heavily fertilized specialty crops.

It appears that the 100 lbs of N the cooperator historically applied may represent a desirable N level for total nitrate N for teff under irrigated conditions. Years when lodging or delayed maturity were harvest problems may have been caused by additional nitrogen being available in the soil and not allowed for in nitrogen fertilization management.

Surface and subsurface N levels can be counted as available to teff in fertilizer strategies for teff and should be utilized in calculating the additional N to be applied.

In using teff for forage production, ultimate forage quality for animal consumption is a consideration. Under irrigation, and for one cutting, 105 lbs of available nitrogen produced as much total forage as 155 lbs of available nitrogen, although the higher fertilized plots were of higher quality as measured by forage crude protein. If nitrogen costs are $0.50 or more per unit of N, a producer needs to have a marketing system that captures that added quality better than the system modeled here for the extra fertilization to be profitable.

Teff can be an effective nitrogen catch crop behind heavily fertilized specialty crops such as over wintered spinach.