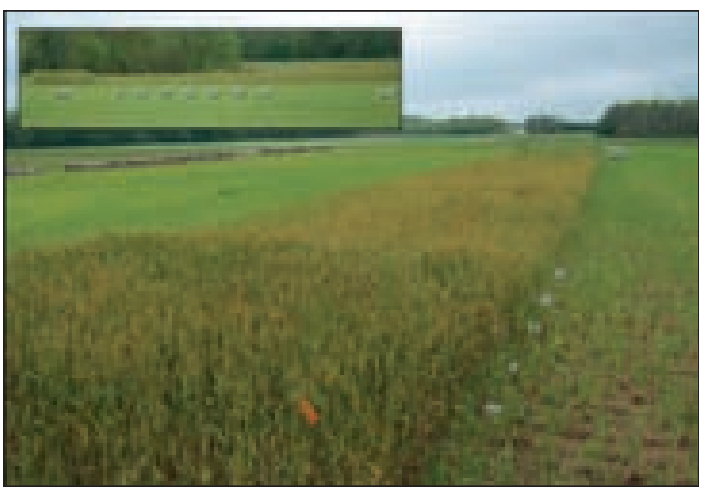
Determining Mid-Season Nitrogen Rates with Ramp Calibration Strip Technology

By D.E. Edmonds, M.C. Daft, W.R. Raun, J.B. Solie, and R.K. Taylor

Methodologies currently available for making mid-season fertilizer N recommendations in most crops are not consistent from one region to the next. The use of chlorophyll meters, economic optimums, optical sensor-based yield prediction models, preplant soil testing, and yield goals have all, to some extent, been limited regionally. The methodology discussed in this article is a simple approach for applying preplant N fertilizer in automated gradients used for determining mid-season N rates based on plant response.

The need to improve N use efficiency (NUE) both in large and small scale operations has become increasingly acute with increased fertilizer N prices and added scrutiny associated with potential adverse affects on our environment from N loss. Similar to that encountered in other regions of the world, Lobell et al., 2004 showed that for wheat farmers in Ciudad Obregon, Mexico, N fertilizer represented the single largest cost of production. They further noted that anything that can be done to match N supply to spatial and temporal variations in crop demand could assist in achieving greater crop yields and improved agricultural sustainability. While seemingly straightforward, Pang and Letey (2000) also noted the difficulty in matching the time of mineral N availability with N uptake in crop production. The ramped calibration strip (RCS) provides a mid-season visual estimation of additional fertilizer N needed, while accounting for N mineralized from planting to time of inspection.

The RCS is based on the concept of visually evaluating plots with incremental rates of preplant N to identify the minimum N rate required for maximum forage production. The lowest preplant N rate that results in maximum midseason forage production (determined visibly or using an active hand-held NDVI sensor) provides an estimate of additional N needed to achieve optimum grain yield. Assuming that maximum or near maximum yields can be achieved from mid-season applied N, producers can evaluate the RCS in-season to determine the optimum rate, prior to applying additional N. The maximum desired application rate where a fertilizer response can be obtained can be estimated visually or calculated from measurements of NDVI. Farmers can observe the point where crop growth reaches a plateau. They can then calculate an N rate by dividing the distance from the start of the 0-N rate to that point by the total ramp length multiplied by the maximum application rate.



Wheat N-ramp at Stillwater, Oklahoma. High N rate (196 lb/A) in the foreground followed by 0 N rate, ramping back up to the high N rate in the background.

Wheat N-ramps at Stillwater, Oklahoma. High N rate (196 lb/A) in the foreground followed by 0 N rate, ramping back up to the high N rate in the background.

The concept of using the RCS to determine the optimum wheat topdress N rate is illustrated in **Figure 1**. By stopping at the point (recording distance in m) where there are no longer visible changes in plant growth or differences in NDVI as measured by the sensor (secondary vertical axis), you can plot or mentally visualize a linear-plateau function. The point where the transition curve reaches the plateau is the recommended topdress N rate. For the field in **Figure 1**, the recommended topdress N rate would have been around 104 lb N/A (140 kg N/ha). This is because the RCS was applied on-top of the farmer practice (whatever that may be) and the point where vegetative growth was maximized beyond that seen for the farmer practice would be the peak in the NDVI curve, and that was associated with the corresponding 104 lb N/A rate. Assuming that we can "catch up" and/or achieve maximum yields from the mid-season N application, and assuming that yield potentials were not severely restricted by early season N stress, the RCS interpolated rate is the application rate needed

Abbreviations and notes for this article: N = nitrogen; NDVI = normalized difference vegetation index.

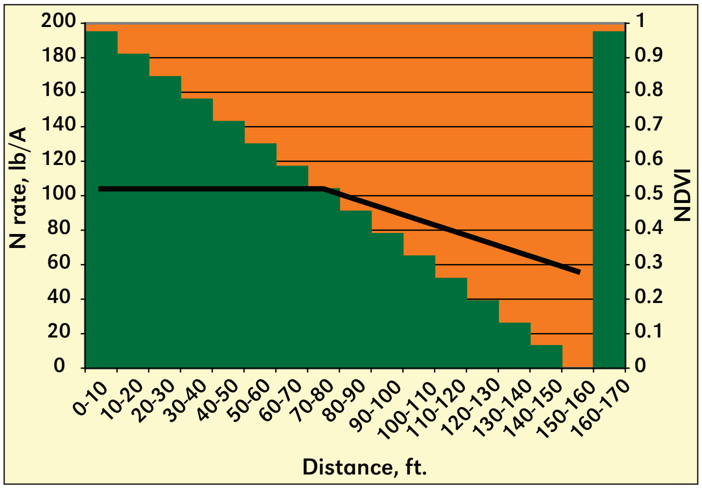


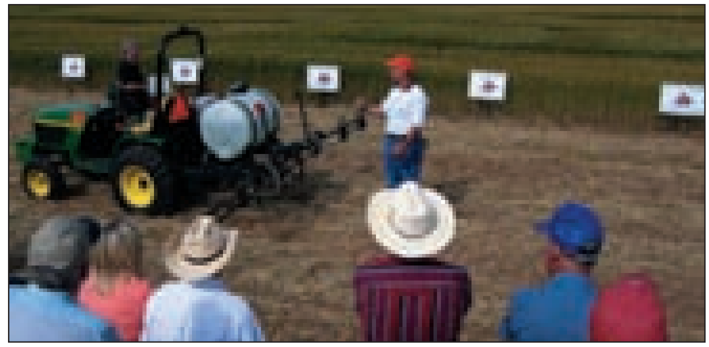
Figure 1. Fertilizer N applied and NDVI over distance traveled. Mid-season fertilizer N application is determined by finding the point where NDVI was maximized, then move horizontally to the desired N rate. In this wheat example from the EFAW Research Experiment Station located in Stillwater, Oklahoma, the optimal N rate in the spring of 2007 was 104 lb/A.

on the rest of the field to achieve the same "visible" or NDVI recorded response. In practice, farmers adjust mid-season N rates based on their experience. However, the RCS application rate provides them with a reasonable maximum target that accounts for temporal variability.

RCS constitutes one observation within a field; therefore, recommended practice calls for establishing more than one RCS per field. Earlier experience with the N Rich Strip (Mullen et al., 2003) showed that measurements of the area with the greatest response to additional N should be used to calculate the topdress N application rate. Similarly, we recommend that the RCS with the greatest response should be used to estimate topdress N application rate. In general, if in-season N is applied at or before V8 and Feekes 5 for corn and wheat, respectively, early season N stress will not result in lost yield potential.

Data from multiple-year corn and wheat experiments documents that in some years zero N check plots can produce near maximum yields (Olson et al., 1986; Bundy, 2003; Bundy, 2006; Johnson and Raun, 2003; Meisinger et al., 1985; Olson, 1980). For cited examples where check plots (0-N) produced near maximum yields, an RCS would have likely visibly illustrated limited differences between the zero N segment and plots in the RCS receiving N. As a result, in-season observation would have recognized limited or no demand for additional N fertilizer.

If check plots with no fertilizer N looked as good as the fertilized plots, where was N coming from? Over the years, we have observed that warm wet winters (winter wheat) and warm wet springs and early summers (corn) are conducive to increasing the amount of N mineralized from soil organic matter and N deposition in rainfall. There are years where the demand for fertilizer N is limited (and highly dependent on the environment), and other years when it is cool and dry and the demand for fertilizer N is greater. Midseason evaluation of the RCS provides an estimate of how much N the environment delivered.



Dr. Randy Taylor, OSU Extension, educates producers on the importance of N-ramp technology. OSU's ramp applicator is also shown in front of wheat N-ramps in Lahoma.

For producers interested in using active NDVI sensors for determining midseason N rates, they can mark the start and end of the RCS (preplant or soon after planting), and collect sensor data using handheld NDVI sensors walking at a constant speed over the length of the ramp. Producers can measure NDVI with the GreenSeeker™ sensor over the entire RCS, then using the Ramp Analyzer 1.12 program (available on the downloads page at www.nue.okstate.edu), read the sensor data file, and the optimum N rate will be computed accordingly (identifies where NDVI peaks within the RCS). Sensors are recommended simply because our eyes are not as sensitive in picking up differences; however, walking the RCS is a viable method of visually inspecting N response.

A number of individuals and companies are interested in building variants of the RCS applicator. Instructions for constructing the Oklahoma State University version of the RCS applicator are available on our website: www.nue.okstate.edu.

Information on several farmer built RCS applicator designs, and names and addresses of companies building the RCS applicators are also included on this site: www.nue.okstate.edu/Index_RI.htm.

Ultimately, applied methodologies that integrate farmer intuition and farmer input within the decision making process could assist in increasing adoption. While the RCS approach may be limited in deciphering exact maximum N rates in high yielding environments, it provides a visual mid-season alternative for N fertilization, in opposition to applying all N preplant in crop production systems that are known to be inefficient. BC

Mr. Edmonds (e-mail: dedmond@okstate.edu) and Mr. Daft are Soil Fertility Graduate Research Assistants, and Dr. Raun is Regents Professor, Department of Plant and Soil Sciences; Dr. Taylor is Associate Professor and Dr. Solie is Professor, Department of Biosystems and Agricultural Engineering, all with Oklahoma State University, Stillwater.

References

Bundy, L.G. 2003. *In* Proc. 33rd North Central Extension-Industry Soil Fert. Conf., Des Moines, IA, 19-20 November 2003. 19:145-150.

Bundy, L.G. 2006. Proc. Wis. Fert. Aglime and Pest Mgmt. Conf. 45:54-60.

Johnson, G.V. and W.R. Raun. 2003. J. Plant Nutr. 26:249-262.

Lobell, David B., et al. 2004. Field Crops Res. 87:155-165.

Meisinger, J.J., et al. 1985. Agron. J. 77:602-611.

Mullen, R.W., et al. 2003. Agron. J. 95:347-351.

Olson, R.A., et al. 1986. Agron. J. 78:856-862.

Olson, R.V. 1980. Soil Sci. Soc. Amer. J. 44:614-517.

Pang, X.P. and J. Letey. 2000. Soil Sci. Soc. Am. J. 64:247-253.