Guidelines for Using Plant Tissue Analysis to Justify Additional Waste Applications and/or Extending Application Windows

These suggestions for supplemental applications of RYE-based, plant-available nitrogen (PAN) rates (over and above certified animal waste management plan limits) are based on practical experience with diagnostic field interpretations of NCDA&CS plant tissue analysis index values.

When nitrogen deficiency is suspected in a receiving crop, plant tissue analysis is an essential diagnostic tool. To use a plant analysis report to support recommendations for the application of PAN to a crop receiving livestock waste in NC, the sample should be collected 1) at the proper growth stage for accurate analysis, and 2) past or approaching the maximum allowed PAN application.

- **How to collect the proper tissue sample**
  [see also www.ncagr.com/agronomi/pictorial.htm]

Crop & Stage of Growth*	What to Sample (plant size)	Size of Sample
coastal bermuda (vegetative stage)	upper portion of plant	10–15 handfuls
corn, grain (seedlings < 12 in tall)	entire above-ground plant	20–30 stalks
corn, grain (plants > 12 in tall)	1st fully developed leaf below whorl	10–15 leaves
soybean (seedlings)	entire above-ground plant	20–30 plants
soybean (prior to bloom)	1st fully developed trifoliate below tip	20 leaves

* Plant tissue nutrient concentrations change with the growth stage of the crop. This requires that specific plant tissue samples be collected at the specific stages of growth for which sufficiency ranges have been developed.

- **How to adjust waste application based on tissue sample results**

For the major annual row crops corn, soybeans, and small grains, advisors should utilize growth stage/N uptake curves in figures 1, 2, and 3, to estimate the amount of additional PAN that should be applied. A correct determination of stage of growth is essential for using these curves. Advisors may refer to tables 1, 2, and 3 for assistance in determining stage of growth. When growth stage is ascertained, the portion of plant N that would likely be taken up (from that point until the crop reaches physiological maturity) can be estimated. That percentage may then be applied to the PAN rate given for the crop and field(s) in the WUP.

It will also be necessary for the advisor to estimate the date by which the additional PAN must be applied (estimated maturity of the crop) if the normal application window ends prior to the application of needed supplemental PAN. The uptake curves and growth stage tables may be utilized for this. However, because the rate of crop maturity may vary from that projected by the curves, a conservative estimate is advisable.

Please note that soybeans, as normally grown, can obtain all required nitrogen through biological fixation, and, therefore, will rarely be deficient in nitrogen.

Suggested method for estimating supplemental PAN:

1) Determine the current growth stage of the crop (see descriptions).
2) Plot the corresponding point on the N line. This reflects the portion of the crop's N that should have been taken up by that stage of development.
3) Multiply the RYE based PAN rate assigned to the crop and field by the difference [(100 - % of total N) * assigned PAN rate]. This is the suggested rate of PAN supplementation.
4) The application window for supplemental PAN remains as assigned in the WUP for crops planted on time. For crops planted late, an extension of the application window may be justified in conjunction with supplemental PAN based on plant analysis. For late-planted crops where N is found to be sufficient, an extension of the application window may be made, but applied PAN may not exceed limits given in the WUP.

Example: A farm applying waste effluent to corn grown on a Norfolk loamy sand soil has applied most of the allowed PAN prior to a period of excessive (leaching) rainfall occurring between the V6 and V14 growth stages. The farm has completed applying all allowed PAN by the time the crop has reached the V16 growth stage. A tissue sample (ear leaves) is collected at tasseling (stage V18 to R1) by an authorized advisor (RA or CCA).

The plant report shows a tissue N index of 42, suggesting that the crop could take up and utilize additional N. A current growth stage determination is promptly made, indicating the crop is approximately R2 stage. Using the uptake curve, it is determined that corn normally takes up about 20 to 25% of its total N between R2 and physiological maturity, which, in this example, roughly translates into 25 to 35 lbs/ac PAN. The advisor must then estimate the time frame until the crop will reach R5, the stage at which little, if any, N will be taken up.

The example presumes that, due to the high rainfall, the farm has a good stand of corn with high yield potential. The advisor therefore may opt for a PAN rate from the higher end of the range. In this example, the advisor authorizes the operator to immediately begin applying waste not to exceed 35 lbs/ac PAN based on the most recent valid waste analysis. If the operator does not have a waste analysis taken within the past 60 days, a sample should be submitted promptly and its reported PAN used to calculate the allowable application quantity. The advisor also sets an application window, 18 days in this example, and instructs the operator not to apply beyond a designated calendar date.

The advisor would then send the written recommendation, stating the basis upon which it was formulated, to the farm's technical specialist along with a request to prepare a conditional amendment for the farm's WUP. If the advisor is also a certified technical specialist, he/she may prepare the amendment containing the recommendation and its

basis. Copies of the amendment should be sent to the county NRCS office, and to appropriate DENR staff, if involved in the situation. The operator should keep a copy of the PA report along with the recommendations and amendment in the farm's records.

For other crops, use the suggested supplementation below. Remember that forage grasses need to be actively growing to take up nitrogen. Grasses must be in vegetative stage for valid sampling. Grasses with rank or mature growth should be harvested prior to receiving supplemental PAN. The potential for vigorous growth is essential, especially when application windows might also be extended.

Plant Tissue Interpretation Index	% RYE-based PAN to Supplement
> 50 (sufficient)	none
45–50 (marginally low)	5–10%
35–44 (moderately low)	10–20%
25–34 (low)	20–30%
< 25 (deficient)	30–35%

Consider the following factors when making supplemental applications.

1) Waterlogged soils may limit root development.
2) More poorly drained soils that are saturated for prolonged periods may lose nitrogen due to denitrification.
3) If other nutritional factors are involved, such as low soil pH, magnesium deficiency, low sulfur, and/or low potassium, then apply corrective fertilizer as soon as possible and limit PAN applications as shown above.

Compiled by NCDA&CS Agronomic Division, June 19, 2003
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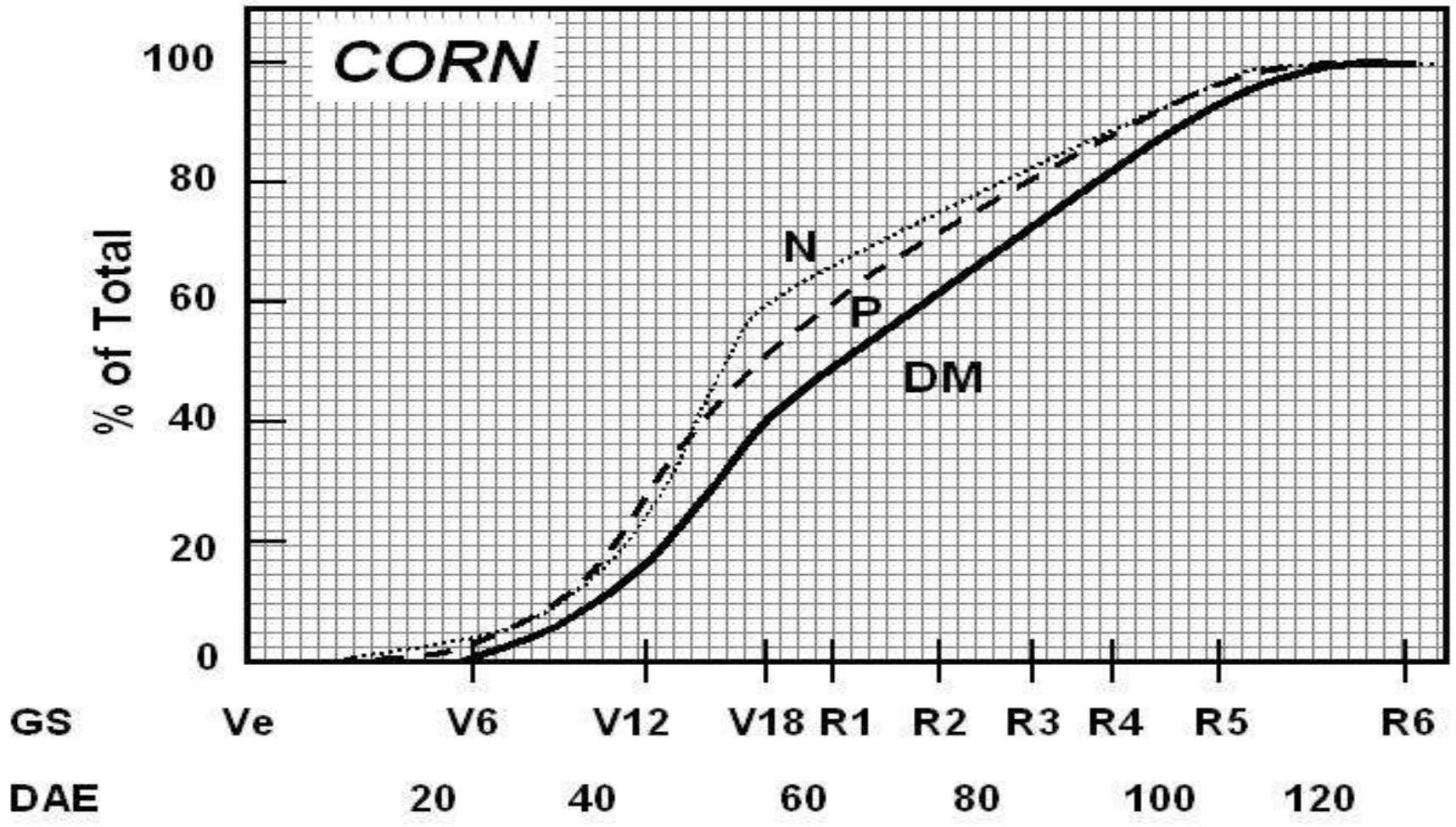
Figure 1. Growth Stage and Nitrogen Uptake Curves for Corn



S.W. Ritchie, J.J. Hanway, and G.O. Benson. 1986. How a Corn Plant Develops, Spec. Rep. #48, Iowa State Univ. Coop. Ext.

Table 1. Vegetative and Reproductive Stages of a Corn Plant

Vegetative Stages	Reproductive Stages
VE - emergence	R1 - Silking: silks visible outside the husks
V1 - first leaf with collar visible	R2 - Blister: kernels are white and resemble a blister in shape (10 to 14 days after silking)
V2 - two leaves with collar visible	R3 - Milk: kernels are yellow on the outside with a milky inner fluid (18 to 22 days after silking)
V3 - three leaves with collar visible	R4 - Dough: milky inner fluid thickens to a pasty consistency (24 to 28 days after silking)
V6 - four leaves with collar visible	R5 - Dent: nearly all kernels are denting (35 to 42 days after silking)
V9 - five leaves with collar visible	R6 - Physiological Maturity: the black abscission layer has formed (50+ days after silking)
V12 - twelve leaves with collar visible	
V15 - fifteen leaves with collar visible	
V18 - eighteen leaves with collar visible	
VT - last branch of tassel is completely visible	

Drawing 1. Corn Growth Stages

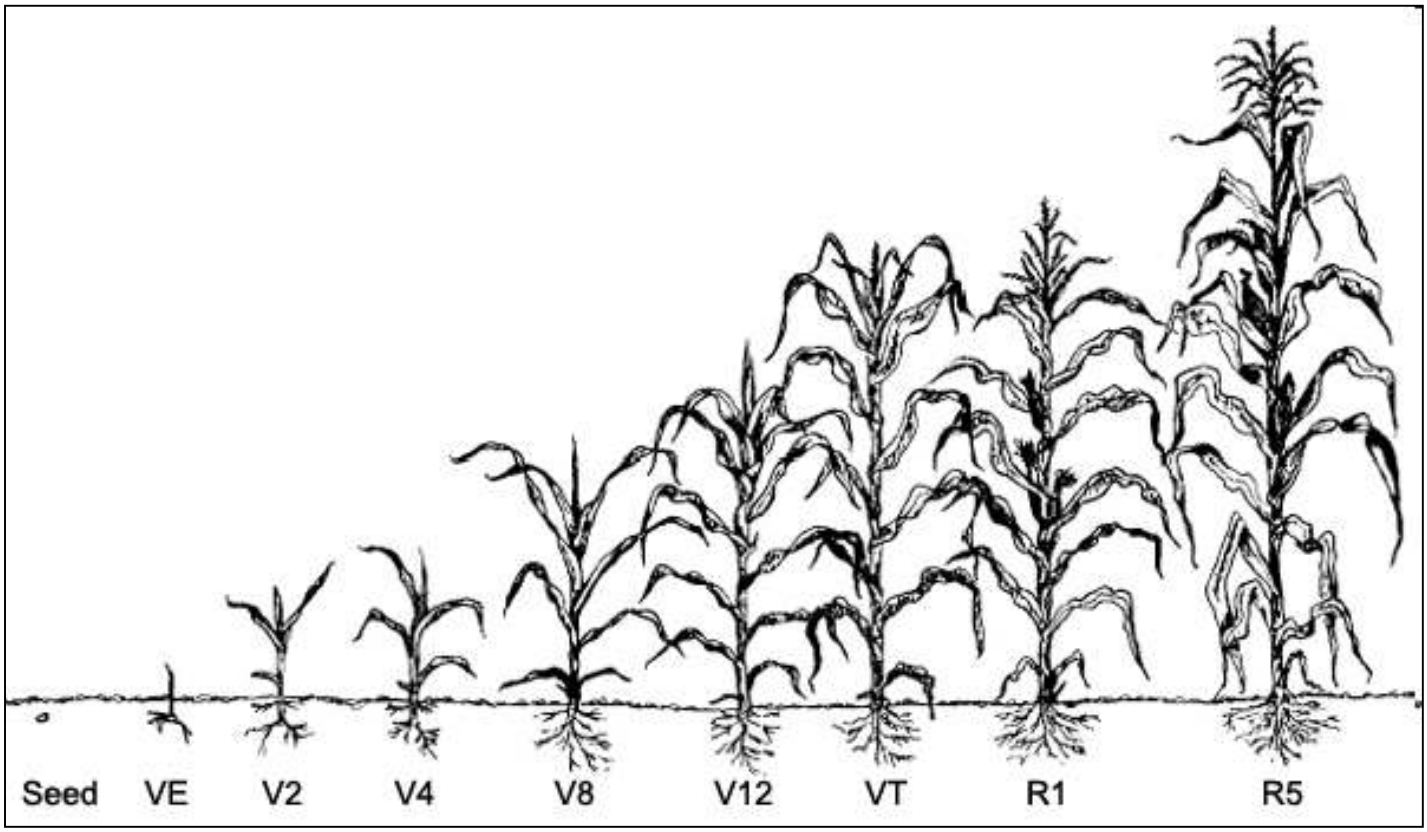
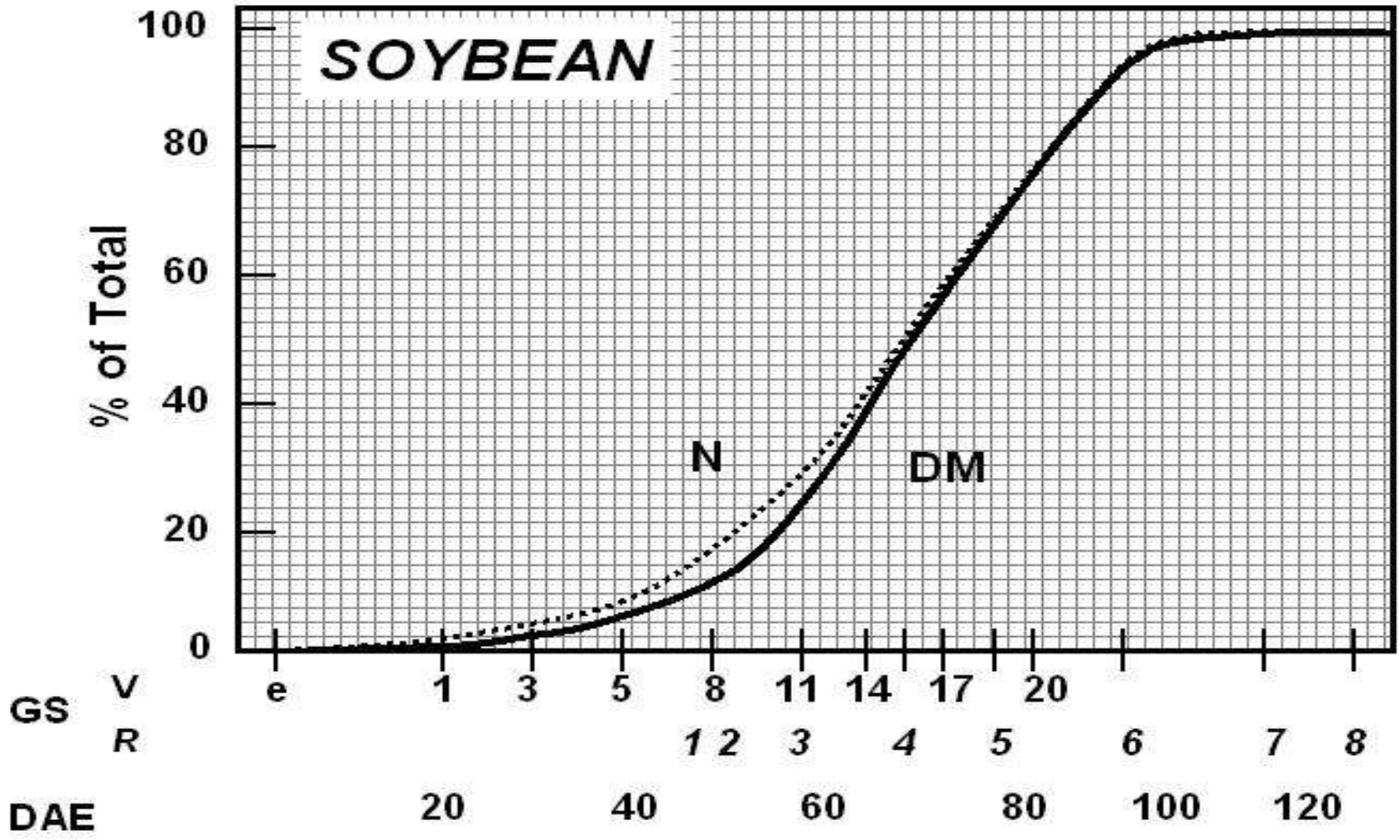


Figure 2: Growth Stage and Nitrogen Uptake Curves for Soybeans



S.W. Ritchie, J.J. Hanway, H.E. Thompson, and G.O. Benson. 1985. How a Soybean Plant Develops, Spec. Rep. #53, Iowa State Univ. Coop. Ext.

Table 2. Vegetative and Reproductive Stages for Soybeans

Vegetative Stages

VE Emergence - cotyledons above the soil surface

VC Cotyledon - unifoliolate leaves unrolled sufficiently so that the leaf edges are not touching

V1 First-node - fully developed leaves at unifoliolate node

V(n) nth-node - "n" represents the number of nodes on the main stem with fully developed leaves beginning with the unifoliolate leaves

Reproductive Stages

R1 Beginning bloom - one open flower at any node on the main stem

R2 Full bloom - open flower at one of the two uppermost nodes on the main stem with a fully developed flower

R3 Beginning pod - pod 3/16" long at one of the four uppermost nodes on the main stem with a fully developed leaf

R4 Full pod - pod 3/4" long at one of the four uppermost nodes on the main stem with a fully developed leaf

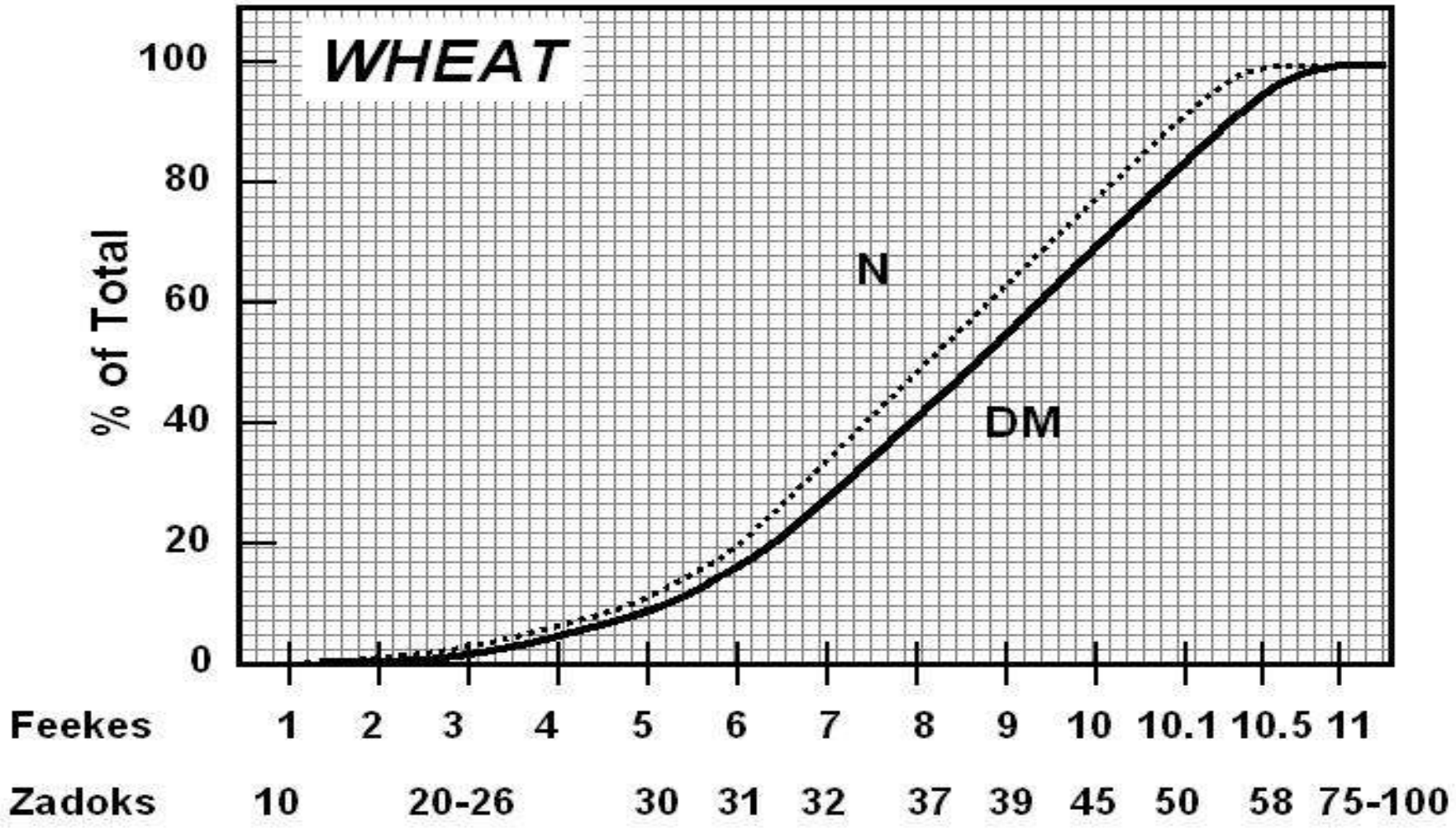
R5 Beginning seed - seed 1/8" long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf

R6 Full seed - pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf

R7 Beginning maturity - one normal pod on the main stem that has reached its mature pod color

R8 Full maturity - ninety-five percent of the pods have reached their mature pod color. Five to ten days of drying weather are required after R8 for the soybean moisture levels to be reduced to less than 15 percent

Figure 3: Growth Stage and Nitrogen Uptake Curves for Wheat



J. Hickman, J. Jacobsen, and D. Lyon. 1994. Best Management Practices for Wheat. NAWG & USDA Coop. Ext. System

Drawing 2. Small Grain Growth Stages