

Estimating N contribution from organic fertilizers and cover crop residues using online Calculators

Dan M. Sullivan^A and Nick A. Andrews^B, John M. Luna^C, and John P.G. McQueen^D

^A Associate Professor, Dept. Crop & Soil Science, Oregon State University, Corvallis, OR USA, Email: Dan.Sullivan@oregonstate.edu

^B Metro Area Small Farms Extension Agent: Horticulture Crops, OSU Extension Service, North Willamette Research and Extension Center. Aurora, OR Email: Nick.Andrews@oregonstate.edu

^C Associate Professor, Dept. Horticulture, OSU, Corvallis, OR. Email: John.Luna@oregonstate.edu

^D Faculty Research Assistant, Dept. Horticulture, OSU, Corvallis, OR. Email: mcqueenj@hort.oregonstate.edu

Abstract

Satisfying crop nitrogen (N) requirements efficiently requires accounting for plant-available N (PAN) release from organic inputs. Relatively simple PAN regression models based on total N concentration of organic inputs have been developed (Organic Fertilizer Calculator) or are in development (Cover Crop Calculator). The Calculators are distributed to agricultural professionals and farmers via Web download as a spreadsheet with accompanying instructions/examples. Regression equations implemented in the Calculators are similar or identical to those reported in world literature; they have been verified by aerobic incubations in the laboratory and by N fertilizer equivalency trials in the field. The Calculators predict PAN for 28 d and 70 d after spring or early summer incorporation of organic material, assuming typical field conditions for our summer irrigated vegetable crops (moist soil; 20 to 25°C). Because most fresh organic amendments and cover crop residues decompose rapidly, PAN release is also rapid. For a given organic material, PAN was consistent across several soil textures. Calculator predictions can be verified in the field by soil sampling early in the growing season, prior to significant crop N uptake and opportunity for PAN loss. We welcome collaborators wanting to verify PAN Calculator predictions in diverse environments.

Key Words

Nutrient management, nitrogen, organic fertilizer, cover crops

Introduction

Adoption of national rules for Certified Organic food production in the USA in 2002 has stimulated greater interest in organic farming and meeting crop N needs using manures, cover crops and other organic materials. Typical guidance for manure use in organic crop production (Kuepper, 2003) provides only typical total nitrogen analyses for manures with no estimate of PAN. Many correlations between N analyses of organic materials and the amount and timing of available N release have been reported for animal manures, crop residues, and other organic materials (Vigil and Kissel, 1991; Trinsoutrot et al., 2000). This paper provides a brief summary of our efforts to provide farmers and agricultural professionals in the maritime Pacific Northwest USA with improved estimates of PAN provided by organic inputs, using Web-based Calculators. The Calculators combine PAN estimates with economic analysis (not discussed here).

Methods

Both Calculators require users to specify application rate, dry matter content, and total N analysis of fertilizer or cover crop. The Calculators assume that for fresh organic materials, C concentration is relatively constant (near 40%), so that total N concentration is a useful indicator of C:N ratio.

Organic Fertilizer Calculator

This Calculator utilizes linear regression equations with two time steps (28 and 70d; Figure 1). The time steps are equivalent to approx. 600 and 1500 degree days (0 °C base temperature) after soil incorporation:

Prediction equation for PAN at 28 d after soil incorporation (600 degree days) (1)

For fertilizer total N < 6% dry wt. basis, %PAN = -30 + 15 (fertilizer total N%)

For fertilizer total N ≥ 6% dry wt. basis, %PAN = 60%

Prediction equation for PAN at 70 d after soil incorporation (1500 degree days) (2)

%PAN = 28d PAN + 15%

Cover Crop Calculator

This Calculator (in development, Sullivan and Andrews) uses a published regression equation (Vigil and Kissel, 1991) for estimating PAN at 70 d (1500 degree days) after soil incorporation:

PAN (% of cover crop total N) = -53.44 + 16.98 (cover crop %N x 10)^{1/2} (3)

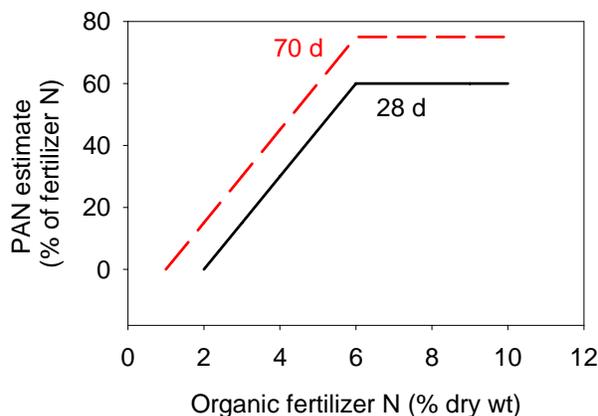


Figure 1. Plant-available N estimates given as Extension guidance in OSU Organic Fertilizer Calculator (Eq. 1 and 2; Andrews and Foster, 2007) for approximately 28d and 70d following a late spring incorporation of organic fertilizer. Expressed as degree days with 0 °C base temperature, the 28d prediction is for approximately 600 degree days, and the 70d prediction is for 1500 degree days after organic fertilizer incorporation.

Results

Organic Fertilizer Calculator

This Calculator arose as a byproduct of a larger project that evaluated simulation modelling to predict N availability (Gale et al., 2006). Growers and grower advisors wanted a tool that was simpler to use than a simulation model and allowed economic comparison of fertilizers. We decided to look at our existing data with a grower-friendly Calculator in mind.

We found reasonable linear correlation between organic fertilizer total N% (dry weight basis) and PAN measured in field trials (Figure 2) and in laboratory incubations. We found similar PAN for the same organic material applied to a sandy loam and a silt loam soil. PAN from stable composts in the Gale et al. (2006) dataset was not related to compost total N percentage, so the equation given in the Organic Fertilizer Calculator is to be used only for fresh organic materials. We found that dry-stacked poultry litter (sold as “compost”) had decomposition in soil and %PAN similar to fresh organic materials (Gale et al., 2006).

Limitations to the Calculator are described in the Extension publication (Andrews and Foster, 2007). The Calculator does not account for ammonia that may be lost at application. It also assumes that PAN is not lost via leaching or denitrification. Under our summer Mediterranean climate with crops grown under sprinkler irrigation, the assumption of insignificant PAN loss under good management has been supported by field PAN being equivalent to lab incubation PAN in our field trials (Gale et al., 2006).

We lacked data on higher N analysis specialty products available for use in USDA Certified Organic production. To gain additional data on high N specialty products, we performed a 28-d laboratory incubation using fertilizers offered for sale to organic farmers in Portland, Oregon including: seed meals, fish byproducts, and animal byproducts (Table 1). Most of the specialty products decomposed rapidly. Most specialty products with greater than 6% total N released 60+% PAN in 28 d. Decomposition (%) for specialty products with 6+% total N was similar to PAN (%). Plant-available N (%) was similar for most fertilizers with total N percentage > 6%. Experimental data for PAN release from high N concentration organic fertilizers (>6% total N) typically ranged from 60 to near 100% (Figure 2 and unpublished data). Therefore, the Calculator estimate of 75% PAN for 70 d after application is on the conservative side.

Cover Crop Calculator

We have conducted laboratory incubations and field trials, and to date, our data appears to be a reasonable fit with a published equation (Vigil and Kissel, 1991) for laboratory incubations at 70-d (Figure 3) and for post-application field soil nitrate-N (Figure 4). In the lab incubation (Figure 3), PAN increased substantially for cover crop residues having < 2.5% total N between 28 d and 70 d. We are collecting additional data in lab and field that will determine what equation should be used to estimate cover crop PAN at 28 d.

Table 1. Decomposition and PAN from organic specialty products in a 28-d aerobic incubation in Chehalis silt loam soil at 22 °C, 25% gravimetric water content.

Fertilizer N source ^A	Fertilizer		PAN 28 d	Decomposition	
	Total N	C:N		7 d	28 d
	%		% of fertilizer N	% of fertilizer C	
seaweed extract	1	29	0	21	38
kelp meal	1	26	-6	8	14
alfalfa meal	2	17	4	32	48
ground fish bone	5	3	33	20	33
meat and bone meal	8	5	44	41	53
soybean meal	8	5	68	49	69
fish/feather/alfalfa meal	8	5	58	43	59
bone meal	9	5	58	49	59
feather meal, bone meal	9	4	63	27	54
fish meal	9	4	62	50	65
corn gluten meal	10	5	72	49	69
granulated feather meal	11	4	65	31	55
fish protein digest	12	4	64	52	61
feather meal	13	4	63	41	59
blood meal	14	4	63	39	57

^AMost organic fertilizer products contained additional salts supplying other nutrients (blended fertilizers). Fertilizers incorporated at 300 mg total N kg⁻¹ soil in incubation.

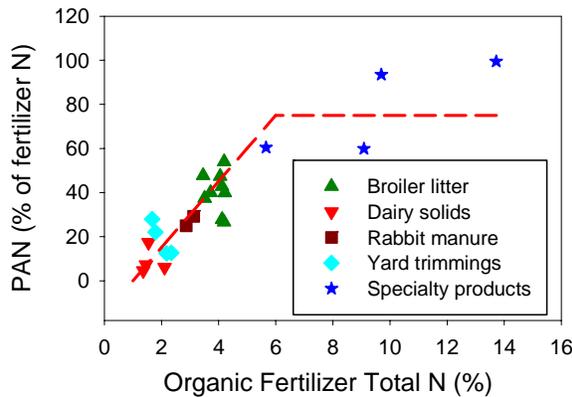


Figure 2. Plant-available N determined in N fertilizer equivalency field trials over 4 site-years with sweet corn vs. total N concentration of preplant-applied organic fertilizers (Gale et al., 2006). Dotted line is the regression equation chosen for implementation as 70-d predicted PAN in Extension guidance (Eq.2; OSU Organic Fertilizer Calculator; Andrews and Foster, 2007).

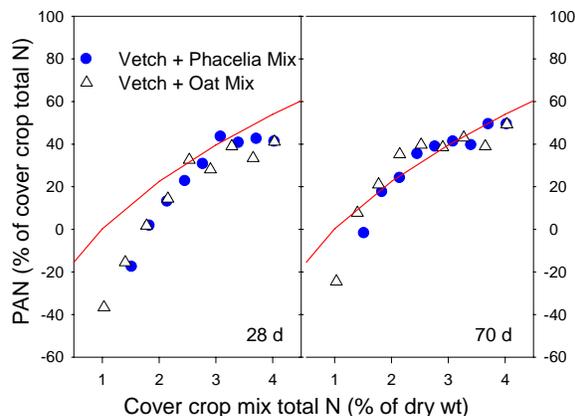


Figure 3. Plant-available N after 28d (left) and 70d (right) following addition of mixtures of cover crop residues to Chehalis silt loam soil (Garrett, 2009) vs. predicted PAN (solid line; Vigil and Kissel, 1991; Eq. 3). Aerobic laboratory incubation (22°C, 25% gravimetric moisture). Unmixed cover crop total N concentrations were 4.0% for vetch, 1.0% for oat, and 1.5% for phacelia. Cover crop residues incorporated at constant rate (5g kg⁻¹soil), with proportions of vetch at 0, 12, 25, 37, 50, 62, 75, 87 and 100%.

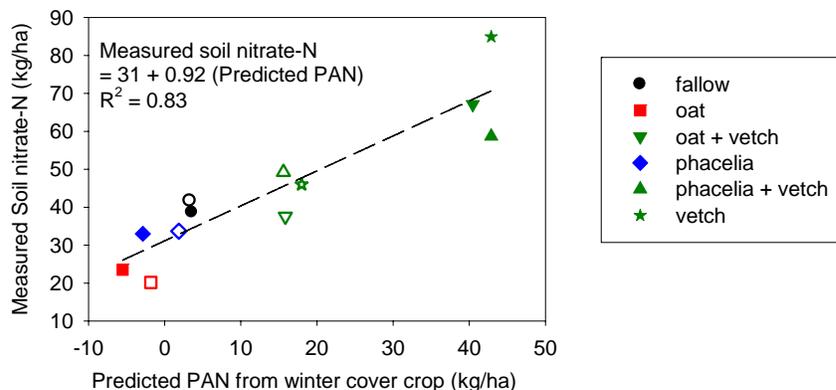


Figure 4. Predicted PAN (Vigil and Kissel, 1991; Eq. 3) from cover crop residues vs. soil nitrate-N (0-30 cm depth; Garrett, 2009) measured in mid-July (approximately 65 d after winter cover crop incorporation). Soil samples collected between rows where crop (broccoli) roots were absent. Filled symbols = 2007, open symbols = 2008 data.

Conclusion

The Organic Fertilizer Calculator is now available (Andrews and Foster, 2007), and the Cover Crop Calculator will soon be available for download from the OSU Extension website. Calculator predictions can be verified in the field by soil sampling early in the growing season, prior to significant crop N uptake and opportunity for PAN loss. We welcome collaborators wanting to verify the applicability of the PAN Calculators in diverse environments.

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