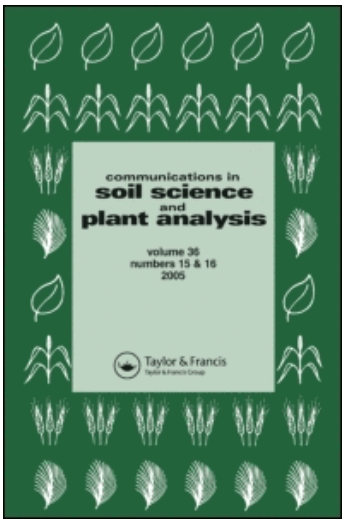
This article was downloaded by: *[USDA Natl Agricultul Lib]*
On: *22 June 2009*
Access details: *Access Details: [subscription number 908592849]*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Communications in Soil Science and Plant Analysis
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597241

CORN, WHEAT, AND POTATO CROP RESIDUE DECOMPOSITION AND NITROGEN MINERALIZATION IN SANDY SOILS UNDER AN IRRIGATED POTATO ROTATION

A. K. Alva [a]; H. P. Collins [a]; R. A. Boydston [a]
[a] Vegetable and Forage Crops Research Unit, USDA-ARS, Prosser, WA, U.S.A.

Online Publication Date: 01 November 2002

To cite this Article Alva, A. K., Collins, H. P. and Boydston, R. A.(2002)'CORN, WHEAT, AND POTATO CROP RESIDUE DECOMPOSITION AND NITROGEN MINERALIZATION IN SANDY SOILS UNDER AN IRRIGATED POTATO ROTATION',Communications in Soil Science and Plant Analysis,33:15,2643 — 2651
To link to this Article: DOI: 10.1081/CSS-120014469
URL: http://dx.doi.org/10.1081/CSS-120014469

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016

©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

COMMUNICATIONS IN SOIL SCIENCE AND PLANT ANALYSIS
Vol. 33, Nos. 15–18, pp. 2643–2651, 2002

POSTER PAPER

CORN, WHEAT, AND POTATO CROP RESIDUE DECOMPOSITION AND NITROGEN MINERALIZATION IN SANDY SOILS UNDER AN IRRIGATED POTATO ROTATION

A. K. Alva,* H. P. Collins, and R. A. Boydston

USDA-ARS, Vegetable and Forage Crops Research Unit,
24106 N. Bunn Rd., Prosser, WA 99350-9687

ABSTRACT

Transformation of organic nitrogen (N) from both soil organic matter and from crop residues into inorganic forms is an important process which determines the pool of available N for the subsequent crop. This study was conducted in the Pacific Northwest (PNW) on an irrigated Quincy fine sand where potato (*Solanum tuberosum*) was grown in three or four year rotations with either corn (*Zea mays L.*) or wheat (*Triticum sativa L.*). The decomposition of crop residue and the mineralization of nitrogen (N) provides a source of plant available N to the next crop. An in-situ column incubation technique was used to determine the N mineralized during January through September 2000 from corn, wheat, and potato crop residues. The soil was sieved to determine

*Corresponding author. Fax: (509) 786-9277; E-mail: aalva@pars.ars.usda.gov

DOI: 10.1081/CSS-120014469 0010-3624 (Print); 1532-2416 (Online)
Copyright © 2002 by Marcel Dekker, Inc. www.dekker.com

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

the amount of crop residues present in the soil which contributes to N mineralization.

The dry weight of the crop residue in January soil samples, taken at the top 30 cm depth, ranged from 8.4 for potato to 26.5 Mg ha^{-1} for corn, but decreased to 4.6 for potato and 12.7 Mg ha^{-1} for corn in March. Total N content in the crop residue was used to estimate potentially mineralizable N (PMN) at the time of sampling. The PMN in the top 30 cm soil depth, on the basis of residues sampled in January, were 398, 378, and 121 kg ha^{-1} for the corn, wheat, and potato crop residues, respectively, but decreased to 189, 114, and 68 kg ha^{-1}, respectively, in March samples. Cumulative N mineralized in the top 30 cm depth of soil during January through September was 172, 128, and 72 kg ha^{-1} for corn, wheat, and potato residues, respectively. Cumulative N mineralized during January through May accounted for 53 percent of the total N mineralized from January through September. The fate of the mineralized N early in the cropping season is uncertain, since this period represents minimal N uptake by crops.

INTRODUCTION

Crop residues decompose and subsequently release inorganic forms of nutrients which are readily available to plants and/or mobile in the soil if no crop is present to utilize the available nutrients. With respect to nitrogen (N) nutrition this process is termed N mineralization and results in the production of ammonium (NH_4) and nitrate (NO_3) forms of N. The release of the NO_3-N in the soil with no crop cover could result in NO_3-N leaching through the soil profile, contributing to groundwater contamination. Elevated levels of NO_3-N in groundwater, in excess of 10 mg L^{-1}, is undesirable as per EPA recommended drinking water quality standards.

Mineralization of N from crop residues and soil organic matter during a crop growing season provides a source of readily available N for crop uptake. Better understanding of the N contribution from mineralization is important to improve the overall N management aimed to increase N uptake efficiency and to minimize the potential negative impacts of NO_3-N into groundwater.[1–5]

The rate of N release from crop residue varies with soil temperature, soil moisture, and the physico-chemical nature of the residue.[6–8] In the irrigated region of the Pacific Northwest (PNW) potato is grown in a three to four year rotation. The common crops used in rotation include corn, wheat, or alfalfa. The management of these rotational crops and knowledge of their nutrient

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

contribution from the residues is needed to fine tune the nutrient requirements of potato. The objective of this study was to determine the contribution of N from corn, wheat, and potato crop residue mineralization. An estimate of N mineralized from crop residues is needed to better understand the amount and rate at which N becomes available to subsequent crops. Likewise, it is also important to understand the N transformation potentials from potato residues, which contribute to available N for rotational crops in the potato rotation systems.

MATERIALS AND METHODS

The study was conducted on a Quincy fine sand (mixed, mesic Xeric Torripsamments) near Paterson in Benton County, WA. The technique used in this study has been widely recognized and used in several in-situ mineralization studies.[3,8,9,10] Incubation columns made of PVC (20 cm diameter × 35 cm height) were driven into soil to a 30 cm depth (Fig. 1). The incubation columns

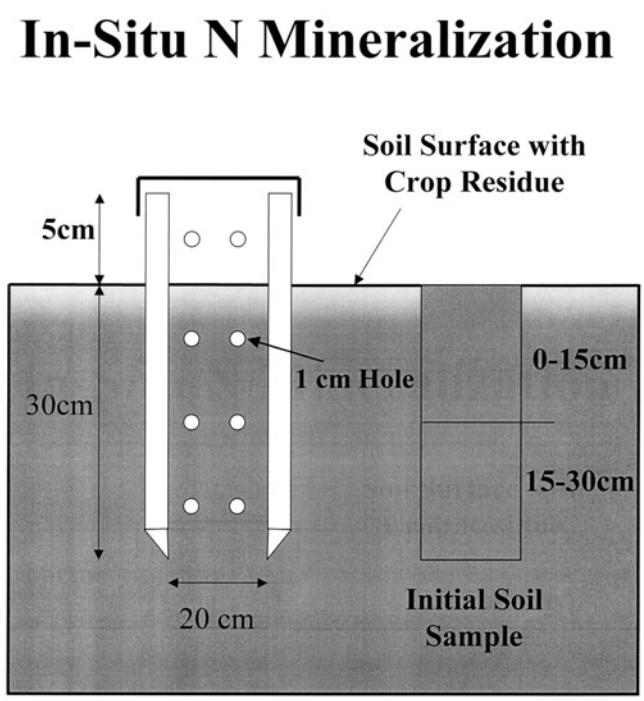


Figure 1. Installation of in-situ nitrogen mineralization column and soil sampling for evaluation of nitrogen mineralization from crop residues.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

had six holes (1 cm diameter) along the wall in the 30 cm portion of the column which was underground. The portion of the column above ground (5 cm height) also had 2 holes (1 cm diameter). These holes facilitated exchange of air and moisture between the soil inside the column and that outside the column. This was necessary to provide the ambient condition in the soil inside the incubation column so that the mineralization rate inside the column was not limited by the factors that contribute to microbial and chemical processes. The incubation columns were installed after potato, corn, or wheat harvest and the respective crop residues incorporated to simulate the common cultivation practices under the commercial production conditions. The crop residues in the amount of soil within the incubation column provided the source for N mineralization. This represents the amount of crop residue in the soil at both depths of sampling from the previous crop. The study area was kept free of new vegetative growth which would uptake the mineralized N during the course of the study, thus could contribute to underestimation of the N being mineralized. Furthermore, the new vegetation could contribute additional biomass for mineralization, thus could over-estimate the N mineralization from the previous crop residue. The sampling area was irrigated using a center-pivot irrigation system. The irrigation was done during May through September only. The scheduling of irrigation was to replenish daily evapotranspiration (ET) of potato.

The columns were capped to prevent precipitation or irrigation water from entering the soil inside the column. Excess water application to the soil inside the column could contribute to leaching of mineralized N below the depth of sampling. This would underestimate the total amount of N being mineralized. Although the incubation columns were capped, the holes along the wall of the column facilitated some transport of water to the soil inside the column. This provided soil conditions somewhat similar to those outside the column under routine irrigation.

During installation of the columns, soil samples were taken adjacent to each column at 0–15 and 15–30 cm depth increments that represented a soil volume similar to the volume of the incubation column. The initial soil sample was sieved to remove all plant residues. Residues were cleaned in tap water with a final rinse in distilled water, dried at 74°C for 72 hours, and the dry weight recorded. These soil samples at the field soil moisture condition were used to determine the concentrations of 2 M KCl extractable nitrate (NO_3-N) and ammonium (NH_4-N) using a Flow Injection Analyzer 8000 (Lachat Instruments, Milwaukee, WI). The concentrations of available N forms in the soil sampled at day zero of incubation provide baseline conditions at the beginning of incubation. A change in concentrations of the available N forms at the end of a given duration of incubation thus represents the amount of N being mineralized from crop residues in the soil as well as from the soil organic matter. The gravimetric soil moisture content was then determined. The dried crop residues were ground to

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

pass a 40 mesh screen and concentration of total nitrogen was determined using a CNS 2000 analyzer (LECO Corporation, St. Joseph, MI). The soil was air dried and the dry weight recorded. The N concentration and dry weight of the plant residue were used to calculate the total amount of N present in the plant residue at the beginning of the experiment within the area of the soil column. This represented the potentially mineralizable N (PMN) for each depth increment for each crop residue.

The incubation columns were excavated at the end of each incubation period. The duration of incubation was four to eight weeks during January to May and two weeks during June through September. The soil in the incubation column was separated into 0–15 and 15–30 cm depth increments, and air dried. The concentrations of 2 M KCl extractable NH_4-N and NO_3-N were determined as described above. The differences in concentrations of NH_4-N and NO_3-N in the soil sample at the end of incubation period and those of the initial sampling represent the amount of N mineralized from the crop residues as well as from the soil organic matter.

The above procedure was repeated (over several time intervals) to determine N mineralization over the cropping season. Summation of mineralized N (NH_4-N plus NO_3-N) for each incubation period represents the total N mineralized over the duration of the study. The mineralized N as percent of total N in the plant residue at the beginning of the study (i.e., potentially mineralizable N) provides an estimate of percent mineralization. The experiment included three sites representing each of the three crop residues, two depths of sampling (0–15 and 15–30 cm), and four incubation columns (replications) for each sampling.

RESULTS AND DISCUSSION

Unlike the laboratory soil incubation method, this study provides an in-situ measurement of crop residue decomposition and mineralization of N into crop available forms, i.e., NO_3-N and NH_4-N. This study provides information on the peak periods of N mineralization. However, the fate of mineralized N is not clear from this study. During the course of this study, the sampling site was kept free of plant cover, but was irrigated on a schedule generally followed for potato production. This was necessary to mimic soil moisture levels under typical potato production conditions to preclude the possibility of soil moisture deficit adversely impacting N mineralization. The incubation column was capped to minimize leaching of mineralized N below the depth of sampling. Under PNW production conditions, the N mineralized could be leached during the off-season, while N mineralized during active plant growth is taken up by the crop. The total quantity of mineralized N (i.e., NH_4-N plus

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

NO_3-N) in the top 30 cm depth soil was measured in this study. The measured quantity is an estimate of plant available N.

Under the Pacific Northwest growing conditions, soil temperatures are relatively warm in the fall after crop harvest. This provides favorable conditions for rapid N mineralization. The fate of available forms of N is unclear since, during this time of the year, the soil is either left bare or, if cropped, N uptake in the early stages of plant growth is minimal.

The crop residue separated from the soil represents the residue available for decomposition during the rest of the year (Table 1). The total N in the residue on an area basis represents the total N that is available for mineralization, hence, potentially mineralizable nitrogen. Crop residue weights in January 2000 for corn, wheat, and potato were 23.7, 18.2, and 7.8 Mg ha^{-1}, respectively, in the 0–15 cm depth increment, and 2.8., 2.0, and 0.6 Mg ha^{-1}, respectively, in the 15–30 cm depth increment (Table 1). Residues remained at the beginning of the 2000 potato growing season (March) were 9.3, 5.6, and 2.7 Mg ha^{-1}, in the 0–15 cm depth and 3.4, 2.0, and 1.9 Mg ha^{-1}, in the 15–30 cm depth for corn, wheat, and potato residues, respectively (Table 1). This represents significant decomposition of crop residues, especially in the 0–15 cm soil depth during the period January through March. The potentially mineralizable N amounts at the beginning of the crop season (March 2000) were 139, 84, and 40 kg ha^{-1} in the 0–15 cm and 50, 30, and 28 kg ha^{-1} in the 15–30 cm depth soil for corn, wheat, and potato residues, respectively.

Table 1. Dry Weight of Crop Residues and Total N in the Residue (i.e., Potentially Mineralizable N) Sampled from the 0–15 and 15–30 cm Soil Depths at Four Sample Times in Year 2000 Following Crop Harvest in the Fall 1999

		Residue Dry Weight (Mg ha^{-1})				Residue Total N Content (kg ha^{-1})			
Crop Residue	Soil Depth (cm)	Jan	Mar	May	Sept	Jan	Mar	May	Sept
Corn	0–15	23.7	9.3	4.2	2.3	356	139	63	35
	15–30	2.8	3.4	1.3	1.6	42	50	20	24
Total		26.5	12.7	5.5	3.9	398	189	83	59
Wheat	0–15	18.2	5.6	2.0	1.7	340	84	38	31
	15–30	2.0	2.0	1.7	0.7	38	30	31	12
Total		20.2	7.6	3.7	2.4	378	114	69	43
Potato	0–15	7.8	2.7	1.7	2.0	113	40	24	28
	15–30	0.6	1.9	0.5	0.5	8	28	7	8
Total		8.4	4.6	2.2	2.5	121	68	31	36

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

Table 2. Measured Quantities of N Mineralized (Sum of NH_4-N and NO_3-N) from Different Crop Residues in the 0–15 and 15–30 cm Depth Soil Following the Respective Crop Harvest in the Preceding Fall

		N Mineralized (Sum of NH_4-N and NO_3-N) kg ha^{-1}			
Crop Residue	Soil Depth (cm)	Jan–Sept	Jan–May	May–July	May–Sept
Corn	0–15	87.7	55.7	2.2	32.0
	15–30	83.8	40.1	35.8	43.7
Total		171.5	95.8	38.0	75.7
Wheat	0–15	103.5	52.7	23.4	50.8
	15–30	24.4	9.8	5.0	14.6
Total		127.9	62.5	28.4	65.4
Potato	0–15	55.7	30.6	11.9	25.1
	15–30	16.0	6.1	8.6	9.9
Total		71.7	36.7	20.5	35.0

The amount of N mineralized from each crop residue during this study (January through September) are shown in (Table 2). The mineralized N during January through May is likely not being utilized by the crop growth. Under Pacific Northwest climate conditions, potato is generally planted during March–April. The potato seed supplies nutrients for germination and early growth. Therefore, the contribution of soil N for potato plant growth is somewhat low during the initial growth until almost May. The cumulative N mineralized for May through July and May through September represent the amount of available N from N mineralization that could contribute to N requirement of a short and long duration and potato cultivars, respectively.

Cumulative nitrogen mineralized (in the form of NO_3-N and NH_4-N) during January through September 2000 from corn, wheat, and potato residues were 87.7, 103.5, and 55.7 kg ha^{-1}, respectively, in the 0–15 cm depth, and 83.8, 24.4, and 16.0 kg ha^{-1}, respectively, in the 15–30 cm depth.

Mineralized N from corn, wheat, and potato residues during May through September were 32.0, 50.8, and 25.1 kg ha^{-1}, respectively, and the 0–15 cm depth soil, and 43.7, 14.6, and 9.9 kg ha^{-1}, respectively, in the 15–30 cm depth soil. The cumulative amount of N mineralized in the top 30 cm depth soil during May through September was much greater for the corn and wheat residue as compared to that from the potato residue.

During January through May, the cumulative amounts of N mineralized in the top 30 cm depth soil were 95.8, 62.5, and 36.7 kg ha^{-1} for corn, wheat, and potato residues respectively. Since no appreciable N uptake by plants is expected during this period the fate of this available N is of some concern. Further studies

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

are needed to examine the fate of N mineralized during this period and to develop management alternatives to minimize the potential loss of this N by leaching below the rooting zone.

ACKNOWLEDGMENTS

This study was conducted in collaboration with Drs. J. R. Davenport, and R. G. Stevens, Washington State University and was made possible by partial funding from the Washington State Potato Commission. We appreciate the help of Bill Boge, Jay Jabro, John Cochran, Melanie Copenhaver, Kelly Whitley, Melanie Wilson and Diane Medick for various stages of this project and preparation of this manuscript.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009

REFERENCES

1. Hartz, T.K.; Mitchell, J.P.; Giannini, C. Nitrogen and Carbon Mineralization Dynamics of Manures and Composts. HortScience **2000**, *35* (2), 209–212.
2. Hendrickson, O.Q.; Robinson, J.B. Effects of Roots and Litter on Mineralization Processes in Forest Soil. Plant Soil **1984**, *80*, 391–405.
3. Schepers, J.S.; Meisinger, J.J. Field Indicators of Nitrogen Mineralization. In *Soil Testing: Prospects for Improving Nutrient Recommendations*, SSSA Spec. Publ. 40; Havlin, J.L., Jacobsen, J.S., Eds.; ASA, SSSA, and CSSA: Madison, WI, 1994; 31–46.
4. Nicolardot, D.; Denys, D.; Lagacherie, B.; Cheneby, D.; Mariotti, M. Decomposition of ^{15}N-Labeled Catch-Crop Residues in Soil: Evaluation on N Mineralization and Plant-N Uptake Potentials Under Controlled Conditions. Eur. J. Soil Sci. **1995**, *46*, 115–123.
5. Smith, C.J.; Chalk, P.M.; Crawford, D.M.; Wood, J.T. Estimating Gross Nitrogen Mineralization and Immobilization Rates in Anaerobic and Aerobic Soil Suspensions. Soil Sci. Soc. Am. J. **1994**, *58*, 1652–1660.
6. Beck, Th. Mineralization of Soil Nitrogen in Laboratory Incubation Experiments. Z. Pflanzenenähr. Bodenkd. **1983**, *146*, 243–252.
7. Becker, M.; Ladha, J.K.; Simpson, I.C.; Ottow, J.C.G. Parameters Affecting Residue Nitrogen Mineralization in Flooded Soils. Soil Sci. Soc. Am. J. **1994**, *58*, 1666–1671.
8. Cassman, K.G.; Munns, D.N. Nitrogen Mineralization as Affected by Soil Moisture, Temperature and Depths. Soil Sci. Soc. Am. J. **1980**, *44*, 1233–1237.

MARCEL DEKKER, INC. • 270 MADISON AVENUE • NEW YORK, NY 10016
©2002 Marcel Dekker, Inc. All rights reserved. This material may not be used or reproduced in any form without the express written permission of Marcel Dekker, Inc.

9. Cabrera, M.L.; Kissel, D.E.; Vigil, M.F. Potential Nitrogen Mineralization: Laboratory and Field Evaluation. In *Soil Testing: Prospects for Improving Nutrient Recommendations*, SSSA Spec. Pub. 40; Havlin, J.L., Jacobsen, J.S., Eds.; SSSA: Madison, WI, 1994; 15–30.
10. Dou, H.; Alva, A.K.; Khakural, B.R. Nitrogen Mineralization from Citrus Tree Residues Under Different Production Conditions. Soil Sci. Soc. Am. J. **1997**, *61*, 1226–1232.

Downloaded By: [USDA Natl Agricultul Lib] At: 16:39 22 June 2009