Land Use Policy 36 (2014) 210–218

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Reducing nitrogen fertilizer application as a climate change mitigation strategy: Understanding farmer decision-making and potential barriers to change in the US

D. Stuart[a,*], R.L. Schewe[b,1], M. McDermott[c,2]

[a] Department of Sociology and Kellogg Biological Station, Michigan State University, 3700 East Gull Lake Drive, Hickory Corners, MI 49060, United States
[b] Mississippi State University, 207 Bowen Hall, Hardy Road, Starkville, MS 39762, United States
[c] Department of Community, Agriculture, Recreation and Resource Studies, Michigan State University, 131 Natural Resources Building, East Lansing, MI 48824, United States

ARTICLE INFO

Article history:
Received 6 February 2013
Received in revised form 14 August 2013
Accepted 16 August 2013

Keywords:
Agriculture
Nitrogen fertilizer
Climate change mitigation
Pollution

ABSTRACT

Nitrogen fertilizer use in agriculture is associated with water pollution and greenhouse gas emissions. While practices and programs to reduce nitrogen fertilizer application continue to be developed, inefficient fertilizer use persists and little is known about farmer decision-making regarding application rates. The purpose of this study was to explore farmer decision-making in the context of reducing the application of nitrogen fertilizer as a climate change mitigation strategy and to assess barriers to reduced application and participating in a potential offsets program. Research methods included mail surveys, interviews, and focus groups with corn farmers in Michigan, United States (US). Results indicate that potential barriers to increasing nitrogen use efficiency for climate change mitigation include: perceptions about climate change, limited access to information and technological tools, and constraints imposed by the political economy of US agriculture. Education programs, government subsidies or cost-sharing programs, and including influential market and political actors in discussions about fertilizer use and climate change mitigation may address some of these barriers. Policies and programs focused on nitrogen fertilizer use and climate change mitigation in agriculture should be aware of these barriers and how they might be addressed.

Published by Elsevier Ltd.

Introduction

The widespread application of nitrogen fertilizer in agricultural systems is one reason that crop production has been able to keep up with food demands associated with a rapidly growing human population. Global nitrogen fertilizer application has increased approximately 10 fold between 1950 and 2008 (Robertson and Vitousek, 2009). However, increased application and continued inefficiencies in nitrogen use have resulted in significant negative environmental and social impacts (Mosier et al., 2001). Estimates indicate that nitrogen recovery in global cropping systems is around 50% (Smil, 1999). The other 50% of nitrogen remains in soils or leaves cropping systems through air, surface water, or groundwater pathways (Follett and Delgado, 2002; Eickhout et al., 2006; Robertson and Groffman, 2007). Although management strategies and technologies have been developed to increase nitrogen use efficiency and reduce negative impacts (Robertson and Vitousek, 2009), they have not been widely adopted by farmers. Very little is understood about how farmers make fertilizer use decisions and what barriers exist that may inhibit more efficient use. In this paper, we examine factors influencing nitrogen fertilizer use decisions among farmers in the United States (US) and explore reduced fertilizer application as a climate change mitigation strategy.

We find a number of barriers to reducing fertilizer application, including widespread skepticism about climate change and the link between nitrogen fertilizer and climate change, as well as political and economic constraints. Farmers continue to rely heavily on fertilizer dealers and seed company agronomists for information about nitrogen fertilizer application, while discounting information from university scientists and extension agents. In addition to

* Corresponding author. Tel.: +1 269 671 2264.
E-mail addresses: dstuart@msu.edu (D. Stuart), rls103@msstate.edu (R.L. Schewe), mcderm52@msu.edu (M. McDermott).
[1] Tel.: +1 662 325 5124.
[2] Tel.: +1 517 353 5190.

0264-8377/$ – see front matter. Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.landusepol.2013.08.011

the cost and inconvenience associated with adopting new technologies that increase nitrogen fertilizer efficiency, farmers are wary of reductions in fertilizer application that might result in any yield loss. High corn prices, competitive seed corn contracts, and government and loan programs that emphasize yields over efficiency create significant political and economic barriers to reducing fertilizer application rates. Our findings suggest that there continues to be a need for education and outreach, especially focused on linkages between nitrogen fertilizer and climate change. We also find that a positive approach focused on empowering farmers to help mitigate climate change would minimize defensive reactions and increase participation in mitigation programs. Climate change mitigation programs should take into account the constraints imposed by political and economic systems focused on maximizing production, and engage actors from industry and government in discussions concerning reductions in nitrogen fertilizer application.

Background

Nitrogen loss from fertilizer has become a persistent environmental problem in the US, especially in the Midwest region. In the US, 43% of nitrogen fertilizer is applied for corn production (USDA, 2010). The low nitrogen use efficiency of corn means that a substantial portion of fertilizer applied to fields is not absorbed and can escape as nutrient pollution (Doberman and Cassman, 2002). While fertilizer has increased US crop yields, including corn yields, its use exacerbates many of agriculture's persistent negative environmental impacts such as hypoxia in coastal waters (Pimentel et al., 1995; Vitousek et al., 1997). Largely due to fertilizer use, approximately 60% of coastal rivers and bays in the US have been degraded by nutrient pollution (Howarth et al., 2002). Nowhere is this problem more apparent than in the Gulf of Mexico, where nutrient pollution has led to a substantial "dead zone."

Nitrogen fertilizer also converts into nitrous oxide (N_2O), an important greenhouse gas (Bauwman, 1990; Smith and Almaraz, 2004; McSwiney and Robertson, 2005; Meyer-Aurich et al., 2006). Anthropocentric emissions of nitrous oxide are primarily from agricultural sources (USGCRP, 2009). Nitrous oxide is a powerful warming agent: over a 100 year period it is 298 times more effective at heating the atmosphere than carbon dioxide. Agriculture contributes to approximately 70% of US N_2O emissions (EPA, 2009), the majority associated with nitrogen fertilizer (Snyder et al., 2009). Scientists have successfully linked N_2O emission levels to the amount of nitrogen fertilizer applied in cropping systems (McSwiney and Robertson, 2005; Millar et al., 2010). While environmental variability also impacts the rate of transformation, a higher rate of nitrogen fertilizer application results in increased N_2O emissions.

Based on known relationships between nitrogen fertilizer and N_2O emissions, climate change mitigation strategies have emerged that focus on reducing the application of nitrogen fertilizer. Specific measures aim to increase the efficiency of fertilizer use and therefore reduce the total amount of fertilizer that needs to be applied. These measures include: creating application rates based on detailed estimates of plant nutrient use, careful timing of application to reduce loss, more accurate delivery using soil testing, using the appropriate depth for below ground delivery, and using slow or controlled release products (CAST, 2011; Dulal et al., 2011; Robertson, 2004; IPCC, 2007; Snyder et al., 2009). Adopting measures to increase nitrogen fertilizer efficiency could reduce N_2O emissions from 9 to 26% below current emissions levels (Cole et al., 1997). However, most farmers are not applying these strategies and fertilizer use efficiency has not significantly improved over the past few decades. This indicates a need to better understand farmer decision-making and the barriers inhibiting the adoption of practices that increase nitrogen use efficiency. While considerable effort continues to be invested in developing policies, programs, and strategies to reduce nitrogen fertilizer use, relatively little is known about how farmers make decisions regarding application.

In this paper, we focus specifically on opportunities and barriers related to reducing the application of nitrogen fertilizer as a climate change mitigation strategy. Reducing nitrogen fertilizer use represents one of the most effective climate change mitigation strategies farmers can adopt (Scott et al., 2002; Snyder et al., 2009). With this in mind, scientists have developed a protocol for a market-based offsets program that would pay farmers to reduce nitrogen fertilizer application (for details see Millar et al., 2010). The program is not intended to reduce yields, only to increase nitrogen use efficiency. Proponents hope that this program will link reductions in nitrogen fertilizer application to farmer payments through future carbon markets. As N_2O is 298 times more effective than carbon dioxide as a warming agent, payments for farmers would be based on carbon equivalence. Our goal for this study was to investigate willingness to participate in such a program among corn farmers in Michigan, US. We also more broadly explored farmers' perspectives regarding nitrogen fertilizer and climate change, their willingness to reduce fertilizer application in general, and potential barriers.

In addition, through this study we aimed to address a significant void in the climate change mitigation literature. The need to understand farmer decision-making and barriers to climate change mitigation in agriculture has been widely recognized (e.g., Lal et al., 2011; Dulal et al., 2011). However, while many publications mention the importance of addressing social barriers, most provide no empirical data and very few details about these barriers (e.g., the latest Intergovernmental Panel on Climate Change report on agriculture: Smith et al., 2007a). Overall, attention to social barriers remains limited. Our findings begin to address this void through identifying specific barriers to reducing nitrogen fertilizer application as a climate change mitigation strategy and how these barriers might be addressed. As many governments explore policy options and consider market-based programs to encourage climate change mitigation, it is critical to identify barriers that may inhibit farmer participation and program effectiveness.

Study region

This study primarily focused on corn farmers in southwest Michigan in Branch, Calhoun, Kalamazoo, and St. Joseph counties (Fig. 1). These counties contain 1200 farms growing corn over 300,000 acres (US Census of Agriculture, 2007). This includes corn grown for commercial sale and corn grown for contracts with seed companies. Branch and Calhoun counties consist primarily of commercial corn acreage, while Kalamazoo and St. Joseph counties have a significant number of seed corn acres. Commercial corn farmers primarily grow corn for cattle feed, corn syrup, and ethanol production. Seed corn farmers have contracts with seed companies to grow corn varieties that will later be sold to commercial corn farmers. Southwest Michigan represents a prime area for seed corn production: the seed corn production headquarters for both Pioneer and Monsanto are located in St. Joseph County. Seed corn growers typically enter into an exclusive contract with a seed company. These contracts generally offer higher levels of profitability compared to commercial corn production. Most seed corn contracts also have a competitive component: growers receive financial penalties or rewards based on how their production compares to other growers of the same variety. This competitive aspect of seed corn contracts has been shown to result in over-application of nitrogen fertilizer (Preckel et al., 2000).