THE APPLICATION TIMING OF NITROGEN FERTILIZER

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(Received February 11, 1992; accepted January 19, 1993)

Abstract. This paper is concerned with factors affecting a farmer's decision concerning the timing of nitrogen fertilizer application. These factors include the expected nitrogen loss associated with different application times, the expected seasonal fluctuations in nitrogen fertilizer prices and operating costs, and the perceived risk of not being able to apply nitrogen fertilizer during the growing season. This paper shows that a split application of nitrogen fertilizer is an optimal strategy for both risk-neutral and risk-averse cotton farmers in the United States if there is a possibility that they may be unable to apply nitrogen fertilizer after planting. Furthermore, a risk-averse cotton farmer relative to a risk neutral farmer will apply more nitrogen fertilizer prior to planting.

Introduction

High concentration levels of nitrates in ground water have become a public concern because of the real and suspected risks to human health through drinking water with elevated nitrate levels (Cantor, 1988; Nielsen and Lee, 1987). Recent results from the Environmental Protection Agency's (EPA) National Survey of Pesticides in Drinking Water Wells indicate that about 1.2% of all community water system wells nationwide and 2.4% of rural domestic wells have nitrate concentration levels in excess of the EPA's Maximum Contaminant Level of 10 mg L\(^{-1}\) (EPA, 1990).

Application of nitrogen fertilizer by the agricultural sector has been identified as a major contributor to the elevated nitrates concentration levels in ground water (Freshwater Foundation, 1988; Office of Technology Assessment, 1987; and Nielsen and Lee, 1987). A farmer applies nitrogen fertilizer to enhance crop yield. By doing so, he or she insures that there will be an adequate concentration of nitrates in the root zone during the growing season to achieve maximum crop yield, all other things given. In general, however, not all of the nitrogen applied in the form of fertilizer is taken up by the plants (Bock, 1984; Fertilizer Institute, 1976). Thus, the amount of nitrogen applied in excess of the amount taken up by plants and/or removed from the field at harvest will be ultimately lost to the atmosphere, dissipated into the surface water, and/or leached into the ground water (White, 1989).

A farmer can minimize this excess nitrogen emitted into the environment through a variety of practices. For example, applying nitrogen fertilizer during the times when plant uptake is greatest and when the potential for nitrogen losses due to

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soil erosion, rainfall, and other environmental factors are minimized will mitigate nitrogen losses. Thus, the application of nitrogen fertilizer after planting in some areas can be more effective than the pre-planting application in reducing nitrogen losses (Bock, 1984; Kanwar et al., 1988).

Why then would a farmer apply nitrogen prior to planting if applying nitrogen fertilizer after planting can reduce nitrogen losses, and therefore, costs? The objective of the following analysis is to evaluate the factors that affect a farmer's decision concerning the timing of nitrogen fertilizer application and, in turn, answer this question. The key elements considered are the expected nitrogen loss associated with application timing, seasonal variations in nitrogen fertilizer application costs (including the nitrogen fertilizer price and operating costs), and a farmer's perceived risk of being unable to apply nitrogen after planting because of weather and field conditions.

In assessing the issue, behavioral models are employed using the analytical framework of Feinerman et al. (1990) to explain why most farmers might practice the split application of nitrogen fertilizer whereby some nitrogen fertilizer is applied before planting and some after planting. Results of the 1989 Cotton Water Quality Survey conducted by the U.S. Department of Agriculture are used to verify the integrity of the behavioral models considered. The data reflect farming practices with regard to the use and timing of nitrogen fertilizer application in the production of cotton in the United States.

This paper is organized into four sections. In the first section, two different farm-level decision models for production are formulated that include factors that affect a farmer's decision concerning the timing of nitrogen fertilizer application. The models differ based on the assumed risk preference of a farmer. In the second section, the 1989 Cotton Water Quality Survey data are used to estimate nitrogen fertilizer losses due to timing of application and irrigation. These estimates are combined with the farm-level production decision models in the third section to determine an optimal timing for nitrogen fertilizer application to explain the timing decisions of the cotton farmers in the United States. The final section offers the conclusions.

A Farm-Level Decision Model of Production

In this section a farm-level decision model for production will be developed in order to examine the factors affecting the decision concerning the timing of nitrogen fertilizer applied for both irrigated and dryland (non-irrigated) cotton production. Consider the cotton production function

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2 Nitrogen fertilizer prices are, in general, lower in the fall than in the spring. For example, from 1987 to 1991, the spring price of anhydrous ammonia was, on average, 10% higher than the fall price of the preceding year (National Agricultural Statistics Service, 1991).

3 Operating costs include such things as hired labor costs, energy expenses to operate farm machinery, etc.