Agricultural Systems 162 (2018) 28–33

Contents lists available at ScienceDirect

Agricultural Systems

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

Short Communication

A free online tool to calculate three nitrogen-related indicators for farming systems

Matthieu Carof*, Olivier Godinot

SAS, AGROCAMPUS OUEST, INRA, 35042 Rennes, France

A R T I C L E I N F O

Keywords:
Farming system
Indicator
Nitrogen efficiency
Nitrogen balance
Online calculator

A B S T R A C T

Reactive nitrogen (N) is a key agricultural input, essential for crop growth and production, but excess N in the environment causes problems for human and ecological health. One of the most promising solutions for reducing environmental impacts of excess N levels and feeding a growing population is to improve N efficiency of farming systems i.e., increase the ratio of their N output to N input. Assessing promising solutions involves calculating N efficiency, which is not trivial. For this reason, a free online tool was developed – the SyNE calculator, https://www.nefficiencycalculator.fr/en/ – to allow farmers, farm advisors, researchers, and policy makers to calculate three N-related indicators of farming systems: SyNE, an N efficiency indicator; SyNB, an N balance indicator; and RNE, a relative N efficiency indicator. After entering information about a farming system, the SyNE calculator produces two main outputs: first, values of the three indicators (SyNE, SyNB, and RNE) and those of related variables (N inputs, N losses during production and transport of inputs, N outputs, and change in soil N); second, a downloadable diagram showing these values. The main advantages of this tool are that it (i) simplifies N indicator calculation, using the same scientific framework for all farming systems, and (ii) includes many reference values that are difficult to obtain (e.g., N losses during production and transport of inputs). Furthermore, this tool allows advanced users to modify the values and equations used to calculate the three N-related indicators. The SyNE calculator is currently available for farms producing dairy cattle, beef cattle, and field crops; in the near future, it will be available for farms producing pigs and broilers. If used, this online tool will contribute to the development of N efficiency evaluation by farmers, farm advisors, and researchers, which may result in improved agricultural N management practices.

1. Introduction

Anthropogenic disruption of the biogeochemical nitrogen (N) cycle is one of the most pressing threats to the environment: the current level of reactive N use is estimated at 240% of the planetary boundary (Steffen et al., 2015). Agriculture is by far the main user of N, in the forms of synthetic fertilizers and biological N fixation for food production (de Vries et al., 2013). At the global scale, N efficiency (defined as N output/N input) is 38% for crop production and approximately 10% for animal production (de Vries et al., 2013; Gerber et al., 2014). To feed a growing population while reducing N burden on the environment, one of the most promising solutions is to improve N efficiency in agriculture (Bodirsky et al., 2014; Sutton et al., 2013, 2011), although this will not be sufficient alone to counteract the increase in N losses due to increased food production (Bouwman et al., 2013; Regan et al., 2016).

Decision aid tools are quite common in agriculture (see for example, Rose et al., 2016): they help end users manage, understand, and share knowledge about complex agricultural systems (Yost et al., 2011). For farmers and farm advisors, decision aid tools facilitate farm management by analyzing on-farm data and generating evidence-based recommendations (Rose et al., 2016). For researchers, decision aid tools allow them to evaluate agronomic and environmental efficiency of agricultural systems in order to build more sustainable ones (Bockstaller et al., 1997). For policy makers, decision aid tools are of particular interest to understand consequences of their decisions, which are often long term and irreversible, and to present them in a transparent way (Serrat-Capdevila et al., 2011). Decision aid tools may be based on indicators which, by condensing scientific information, help to simplify reality and make it accessible to decision makers (Girardin et al., 1999).

N Balance and N Use Efficiency (NUE) are the two N indicators most used at the farm scale (Langeveld et al., 2007; Rasmussen et al., 2017). They have some significant limitations, however: farm gate system boundaries are not large enough to assess farms with substantial N inputs (Einarsson et al., 2018); change in soil N is usually not

* Corresponding author: AGROCAMPUS OUEST, 65 rue de Saint-Brieuc, CS 84215, F-35042 Rennes cedex, France.
E-mail address: matthieu.carof@agrocampus-ouest.fr (M. Carof).

https://doi.org/10.1016/j.agsy.2018.01.015
Received 18 July 2017; Received in revised form 17 January 2018; Accepted 17 January 2018
0308-521X/ © 2018 Elsevier Ltd. All rights reserved.

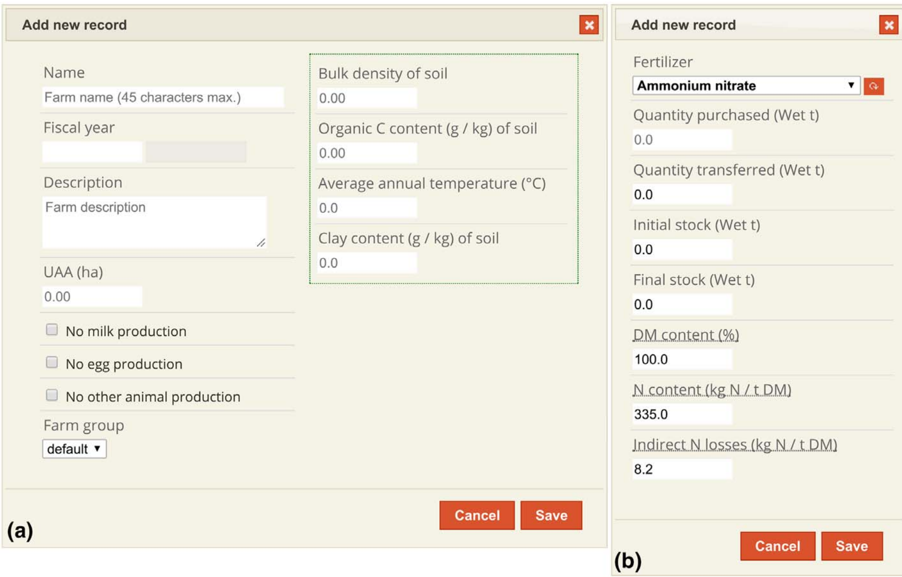

Fig. 1. Examples of two user-accessible forms for entering data in the SyNE calculator. Form (a) allows end users to enter data for a new farming system (e.g., arable land area (UAA), types of production, main soil characteristics). Form (b) allows end users to enter data for purchased nitrogen (N) fertilizers. In this example, purchased N fertilizer is ammonium nitrate: default values are set for three fields – dry matter (DM) content, N content, and indirect N losses (i.e., those during production and transport of inputs) – but end users can change them.

considered (Watson and Atkinson, 1999); manure N can be considered a product or not, which is inconsistent (Godinot et al., 2014); and finally, there is an arithmetic bias in the NUE indicator (Schröder et al., 2003; see the “purchase-resale” bias of NUE, described below).

Three new indicators were developed to address these limitations (Godinot et al., 2015, 2014). In brief, SyNE (System N Efficiency) estimates N efficiency of a farming system i.e., the extent to which N inputs of a farming system are converted into N outputs. SyNE improves NUE (Aarts et al., 1992) in several ways:

- It corrects the “purchase-resale” bias of NUE (i.e., the fact that mathematically, a farming system relying on external inputs has a higher NUE than a self-sufficient one (all else being equal)).
- It considers N losses during production and transport of inputs (based on principles of life-cycle assessment (LCA)).
- It considers changes in soil N, unlike NUE, which assumes that soil N content does not vary.

Since performances of a farming system rely not only on N efficiency but also on N losses it generates, SyNE must be used along with SyNB (System N Balance), which estimates potential N losses in a farming system (i.e., the sum of N inputs, N losses during production and transport of inputs, and change in soil N, minus N outputs). Finally, since animals have lower N efficiency than crops, current N efficiency indicators cannot compare farming systems with different types of production. To address this issue, RNE (Relative N Efficiency) expresses N efficiency relative to that attainable by crop and animal products.

These three new indicators were subjected to a validation phase, as recommended by Girardin et al. (1999). According to Bockstaller and Girardin (2003), an indicator can be validated in three ways:

- “Design validation” evaluates whether the indicator is built on rigorous science. We posit that publication of the development and application of indicators in international peer-reviewed journals is a good guarantee of their scientific quality. Godinot et al. (2015, 2014) have done so, discussing their added value. Moreover, several recent publications have highlighted advantages of using comprehensive N efficiency indicators that include N losses occurring outside farm boundaries (Bodirsky et al., 2014; Mu et al., 2016; Sutton et al., 2013; Uwizeye et al., 2016).
- “Output validation” evaluates the soundness of outputs by comparing them to measures or outputs of other indicators; comparison of these three indicators and other existing indicators for 27 European Union (EU) Member States showed that estimates of the former were consistent with existing knowledge about agriculture of the Member States (Godinot et al., 2016).
- “End-use validation” addresses implementation of the indicator as a decision aid tool, whether it is used, and how. N Balance and similar variants have been used by farmers, farm advisors, researchers, and decision makers for several decades to assess N pressure on the environment (Oenema et al., 2003). In contrast, NUE, although available for at least 25 years (e.g., Aarts et al., 1992), is still almost only used by researchers, although some decision makers are willing to use it (Eurostat, 2017).

If we want end users to use these new indicators, we need to show their utility as decision aid tools, and facilitate their implementation. To this end, we developed the online calculator described here.

2. Overall description of the SyNE calculator

The source code of the SyNE calculator was written using HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, PHP, and Structured Query Language (SQL). The first three languages are used to create multimedia and interactive web pages, while PHP and SQL are used to manage data stored in a MySQL database and to run calculations with these data. Input data and calculated results are stored in the MySQL database.

The SyNE calculator is available online, free of charge, at https://www.nefficiencycalculator.fr/en/. End users need to create an account (using name, e-mail address, and password) to store their data securely on our institution's servers. By default, the ability for end users to modify parameters is limited but can be extended on request; since each account has a copy of the default parameter set, validated by the designers of the SyNE calculator, parameter changes by an end user affect only that user's data and calculations.

The SyNE calculator computes the three N-related indicators (SyNE, SyNB, RNE) for a farming system (i.e., the combination of productive activities at the farm level (Le Gal et al., 2010)). To calculate the three indicators, end users enter data describing (i) main characteristics of a farming system (e.g., arable land area, types of production, main soil characteristics), (ii) crop production (e.g., crop areas, yields, seeding rates, crop residue management), (iii) animal production (e.g., numbers of animals, types of animal housing, lengths of grazing periods), (iv) purchases of animal feed, inorganic fertilizer, and manure, and (v) sales of animal and crop products (Fig. 1). About 15 min are required to enter

Download English Version:

https://daneshyari.com/en/article/8875007

Download Persian Version:

https://daneshyari.com/article/8875007

Daneshyari.com