

# Package ‘NUETON’

July 21, 2025

**Type** Package

**Title** Nitrogen Use Efficiency Toolkit on Numerics

**Version** 0.1.0

**Maintainer** Shubham Love <shubhamlove2101@gmail.com>

**Description** Comprehensive R package designed to facilitate the calculation of Nitrogen Use Efficiency (NUE) indicators using experimentally derived data. The package incorporates 23 parameters categorized into six fertilizer-based, four plant-based, three soil-based, three isotope-based, two ecology-based, and four system-based indicators, providing a versatile platform for NUE assessment. As of the current version, 'NUETON' serves as a starting point for users to compute NUE indicators from their experimental data. Future updates are planned to enhance the package's capabilities, including robust data visualization tools and error margin consideration in calculations. Additionally, statistical methods will be integrated to ensure the accuracy and reliability of the calculated indicators. All formulae used in 'NUETON' are thoroughly referenced within the source code, and the package is released as open source software. Users are encouraged to provide feedback and contribute to the improvement of this package. It is important to note that the current version of 'NUETON' is not intended for rigorous research purposes, and users are responsible for validating their results. The package developers do not assume liability for any inaccuracies in calculations. This package includes content from Congreves KA, Otchere O, Ferland D, Farzadfar S, Williams S and Arcand MM (2021) 'Nitrogen Use Efficiency Definitions of Today and Tomorrow.' Front. Plant Sci. 12:637108. <doi:10.3389/fpls.2021.637108>. The article is available under the Creative Commons Attribution License (CC BY) C. 2021 Congreves, Otchere, Ferland, Farzadfar, Williams and Arcand.

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**Author** Shubham Love [aut, cre]

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|    |                                       |
|----|---------------------------------------|
| AE | <i>Calculate Agronomic Efficiency</i> |
|----|---------------------------------------|

---

### Description

The contribution of fertilizer N towards yield, compared to a non-fertilized control Calculate AE using the formula:  $AE = (YieldF - Yield0) / FertN$

### Usage

`AE(YieldF = NULL, Yield0 = NULL, FertN = NULL, PE = NULL, RE = NULL)`

### Arguments

|        |                                                                                               |
|--------|-----------------------------------------------------------------------------------------------|
| YieldF | A numeric vector for yield in fertilized Conditions.                                          |
| Yield0 | A numeric vector of non-fertilized control yield values.                                      |
| FertN  | The value of inorganic N contained in any form of N input (from synthetic or organic sources) |
| PE     | Physiological Efficiency numeric value                                                        |
| RE     | Recovery Efficiency numeric value                                                             |

**Value**

The calculated AE value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). "Nutrient use efficiency–measurement and management," in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

**Examples**

```
YieldF <- c(2.92, 3.78, 4.68, 4.21)
Yield0 <- c(1.98, 2.66, 4.26, 3.78)
FertN <- 15
AE(YieldF, Yield0, FertN)
PE<-10
RE<-5
AE(PE=PE, RE=RE)
```

---

ecoNUE

---

*Calculate NUEecology*


---

**Description**

The product of N productivity and the mean residency time (MRT) of plant N. Calculate NUEecology using the formula:  $\text{ecoNUE} = \text{NP} * \text{MRT}$

**Usage**

```
ecoNUE(NP, MRT)
```

**Arguments**

|     |                             |
|-----|-----------------------------|
| NP  | Nitrogen Productivity Value |
| MRT | Mean Residency Time value   |

**Value**

The calculated ecoNUE value.

## References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Lambers, H., and Oliveira, R. S. (eds). (2019). “Mineral Nutrition,” in *Plant Physiological Ecology*. Cham: Springer International Publishing, 301–384. doi: 10.1007/978-3-030-29639-1\_9

## Examples

```
NP <- 33.63571
MRT <- 1.009715
ecoNUE(NP, MRT)
```

---

|    |                                           |
|----|-------------------------------------------|
| IE | <i>Calculate Internal Efficiency (IE)</i> |
|----|-------------------------------------------|

---

## Description

The fraction of plant tissue N that is contained in the yield component. Calculate IE using the formula:  $IE = \text{YieldNF} / \text{PlantNf}$

## Usage

```
IE(YieldNF, PlantNf)
```

## Arguments

|         |                                                          |
|---------|----------------------------------------------------------|
| YieldNF | A numeric vector for yield N in fertilized Conditions.   |
| PlantNf | A numeric vector of non-fertilized control yield values. |

## Value

The calculated IE value.

## References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). “Nutrient use efficiency—measurement and management,” in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

**Examples**

```
YieldNf <- c(2.92, 3.78, 4.68, 4.21)
PlantNf <- c(2.89, 3.66, 4.73, 4.16)
IE(YieldNf, PlantNf)
```

NBI

*Calculate N Balance Intensity (NBI)***Description**

The difference between fertilizer N applied and the N removed as yield; commonly called N surplus.

Calculate NBI using the formula:  $NBI = YieldN - FertN$

**Usage**

```
NBI(YieldN, FertN)
```

**Arguments**

YieldN            A numeric vector of the N removed as yield values.

FertN            A numeric value for fertilizer N input.

**Value**

The calculated NBI value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: IPNI (2014). Nutrient Performance Indicators: The Importance of Farm Scale Assessments, Linked to Soil Fertility, Productivity, Environmental Impact and the Adoption of Grower Best Management Practices. Available online at: <http://anz.ipni.net/ipniweb/region/anz.nsf/0/9312A2172A0B917CCA257E8>

**Examples**

```
YieldN <- c(5.4, 6.3, 4.8, 7.2)
FertN <- 1.5
NBI(YieldN, FertN)
```

---

|      |                                                   |
|------|---------------------------------------------------|
| NdfF | <i>Calculate N derived from Fertilizer (NdfF)</i> |
|------|---------------------------------------------------|

---

**Description**

The percentage of plant or soil N that is derived from the fertilizer. Calculate NdfF using the formula:  $NdfF = Plant15N / Fert15N$

**Usage**

`NdfF(Plant15N, Fert15N)`

**Arguments**

|          |                                                              |
|----------|--------------------------------------------------------------|
| Plant15N | A vector of 15N atom percent excess in plant or soil values. |
| Fert15N  | 15N atom percent excess of fertilizer N.                     |

**Value**

The calculated NdfF value expressed as a percentage.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: IAEA (1983). *Guide on the Use of Nitrogen-15 and Radioisotopes in Studies of Plant Nutrition: Calculations and Interpretation of Data*. Vienna: IAEA.

**Examples**

```
Plant15N <- c(2.92, 3.78, 4.68, 4.21)
Fert15N <- 15
NdfF(Plant15N, Fert15N)
```

---

|     |                                        |
|-----|----------------------------------------|
| NHI | <i>Calculate N Harvest Index (NHI)</i> |
|-----|----------------------------------------|

---

**Description**

The percent of plant tissue N that is contained in the yield component. Calculate NHI using the formula:  $NHI = YieldF / PlantNf$

**Usage**

`NHI(YieldF, PlantNf)`

**Arguments**

YieldF            A numeric vector of final yield values.  
 PlantNf          A numeric value for plant tissue N.

**Value**

The calculated NHI value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Moll, R. H., Kamprath, E. J., and Jackson, W. A. (1982). Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization 1. *Agron. J.* 74, 562–564. doi: 10.2134/agronj1982.00021962007400030 037x

**Examples**

```
YieldF<- c(2.89, 3.66, 4.73, 4.16)
PlantNf <- c(2.92, 3.78, 4.68, 4.21)
NHI(YieldF, PlantNf)
```

---

 NP

---

*Calculate Nitrogen Productivity (NP)*


---

**Description**

The ratio of the relative growth rate to the concentration of N in plant tissues. Calculate Nitrogen Productivity using the formula:  $NP = GR/PlantN$

**Usage**

```
NP(GR, PlantN)
```

**Arguments**

GR                Plant relative growth rate value  
 PlantN           A numeric vector of values for plant N concentration.

**Value**

The calculated NP value.

References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Berendse, F., and Aerts, R. (1987). Nitrogen-use-efficiency: a biologically meaningful definition? *Funct. Ecol.* 1, 293–296.

Examples

```
GR <- 15
PlantN <- c(12.1, 8.99, 12.89, 13.11)
NP(GR, PlantN)
```

|     |                                                   |
|-----|---------------------------------------------------|
| NRE | <i>Calculate Fertilizer-N Recovery Efficiency</i> |
|-----|---------------------------------------------------|

Description

The percentage of fertilizer N that is taken up by the plant, accounting for background soil N levels; also sometimes referred to as apparent recovery. Calculate NRE using the formula:  $NRE = ((PlantN_f - PlantN_0) / FertN) * 100$

Usage

```
NRE(PlantNf, PlantN0, FertN)
```

Arguments

- PlantNf            A numeric vector of values for plant N at the end of the experiment.
- PlantN0           A numeric vector of values for plant N at the beginning of the experiment.
- FertN             A numeric value for fertilizer N input.

Value

The calculated NRE value as a percentage.

References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). “Nutrient use efficiency–measurement and management,” in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

**Examples**

```
PlantNf <- c(2.92, 3.78, 4.68, 4.21)
PlantN0 <- c(1.22, 2.66, 3.99, 2.58)
FertN <- 15
NRE(PlantNf, PlantN0, FertN)
```

NRE15

*Calculate Isotope-Based Recovery Efficiency of N-Fertilizer (NRE15)***Description**

The percent recovery, or utilization, of fertilizer-N in plant and/or soil components Calculate NRE15 using the formula:  $NRE15 = (TNdfF \text{ in Plant or Soil} / FertN) * 100$

**Usage**

```
NRE15(TNdfF, FertN)
```

**Arguments**

|       |                                                         |
|-------|---------------------------------------------------------|
| TNdfF | Total N derived from Fertilizer in plant or soil value. |
| FertN | A numeric value for fertilizer N input.                 |

**Value**

The calculated NRE15 value as a percentage.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: IAEA (1983). *Guide on the Use of Nitrogen-15 and Radioisotopes in Studies of Plant Nutrition: Calculations and Interpretation of Data*. Vienna: IAEA.

**Examples**

```
TNdfF <- 3.058888
FertN <- 15
NRE15(TNdfF, FertN)
```

---

NUEbal

*Calculate NUEbalance*


---

### Description

The fraction of N inputs that are removed from the system (either as yield or N losses) Calculate NUEbalance using the formula:  $NUE_{bal} = No/Ni$

### Usage

`NUEbal(No, Ni)`

### Arguments

|    |                                                        |
|----|--------------------------------------------------------|
| No | Sum total of N outputs (enter each value individually) |
| Ni | Sum total of N inputs (enter each value individually)  |

### Value

The calculated NUEbalance value.

### References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Martinez-Feria, R. A., Castellano, M. J., Dietzel, R. N., Helmers, M. J., Liebman, M., Huber, I., et al. (2018). Linking crop- and soil-based approaches to evaluate system nitrogen-use efficiency and tradeoffs. *Agric. Ecosyst. Environ.* 256, 131– 143. doi: 10.1016/j.agee.2018.01.002

### Examples

```
No <- c(2.89, 3.66, 4.73, 4.16)
Ni <- c(2.92, 3.78, 4.68, 4.21)
NUEbal(No, Ni)
```

---

NUEcrop

*Calculate NUEcrop*


---

### Description

The fraction of fertilizer N that is utilized and allocated to yield N. Calculate NUEcrop using the formula:  $NUE_{crop} = YieldN/FertN$

**Usage**

```
NUEcrop(YieldN, FertN)
```

**Arguments**

|        |                                                    |
|--------|----------------------------------------------------|
| YieldN | A numeric vector of the N removed as yield values. |
| FertN  | A numeric value for fertilizer N input.            |

**Value**

The calculated NUEcrop value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Martinez-Feria, R. A., Castellano, M. J., Dietzel, R. N., Helmers, M. J., Liebman, M., Huber, I., et al. (2018). Linking crop- and soil-based approaches to evaluate system nitrogen-use efficiency and tradeoffs. *Agric. Ecosyst. Environ.* 256, 131– 143. doi: 10.1016/j.agee.2018.01.002

**Examples**

```
YieldN <- c(2.88, 4.54, 3.62, 4.21)
FertN <- 15
NUEcrop(YieldN, FertN)
```

---

NUEFC

*Calculate NUE of a Food Chain (NUEFC)*

---

**Description**

The N balance of the entire food chain system, in terms of N consumed as protein relative to N inputs. Calculate NUEFC using the formula:  $NUEFC = N_{con} / N_i$

**Usage**

```
NUEFC(Ncon, Ni)
```

**Arguments**

|      |                                          |
|------|------------------------------------------|
| Ncon | The value of N available for consumption |
| Ni   | Sum total of new N input                 |

**Value**

The calculated NUEFC value.

## References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Erisman, J. W., Sutton, M. A., Galloway, J., Klimont, Z., and Winiwarter, W. (2008). How a century of ammonia synthesis changed the world. *Nat. Geosci.* 1, 636–639. doi: 10.1038/ngeo325

## Examples

```
Ncon <- 15.574
Ni <- c(2.92, 3.78, 4.68, 4.21)
NUEFC(Ncon, Ni)
```

---

NUEsoil

*Calculate NUEsoil*

---

## Description

The biomass production per unit of available N. Calculate NUEsoil using the formula:  $\text{NUEsoil} = \text{PlantBM} / (\text{FertN} + \text{SoilN})$

## Usage

```
NUEsoil(PlantBM, SoilN, FertN)
```

## Arguments

|         |                                               |
|---------|-----------------------------------------------|
| PlantBM | A numeric vector of values for plant biomass. |
| SoilN   | A numeric value for soil N content.           |
| FertN   | A numeric value for fertilizer N input.       |

## Value

The calculated NUEsoil value.

## References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Moll, R. H., Kamprath, E. J., and Jackson, W. A. (1982). Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization 1. *Agron. J.* 74, 562–564. doi: 10.2134/agronj1982.00021962007400030 037x

**Examples**

```
PlantBM <- c(12.1, 8.99, 12.89, 13.11)
SoilN <- 20
FertN <- 15
NUEsoil(PlantBM, SoilN, FertN)
```

---

NUEyield

---

*Calculate NUEyield*


---

**Description**

The contribution of N supplied from the soil that is allocated to the yield N; also often referred to as simply NUE. Calculate NUEyield using the formula:  $\text{NUEyield} = \text{NUpE} * \text{NUtE}$

**Usage**

```
NUEyield(NUpE, NUtE)
```

**Arguments**

|      |                          |
|------|--------------------------|
| NUpE | N Uptake Efficiency      |
| NUtE | N Utilization Efficiency |

**Value**

The calculated NUEyield value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Novoa, R., and Loomis, R. S. (1981). Nitrogen and plant production. *Plant Soil* 58, 177–204. doi: 10.1007/BF02180053

**Examples**

```
NUpE <- 33.63571
NUtE <- 1.009715
NUEyield(NUpE, NUtE)
```

---

|      |                                             |
|------|---------------------------------------------|
| NUpE | <i>Calculate N Uptake Efficiency (NUpE)</i> |
|------|---------------------------------------------|

---

### Description

The percentage of available soil N that is utilized by the plant; also conceptualized as apparent recovery efficiency of the N supply. Calculate NUpE using the formula:  $NUpE = (PlantN / (FertN + SoilN)) * 100$

### Usage

```
NUpE(PlantN, SoilN, FertN)
```

### Arguments

|        |                                                 |
|--------|-------------------------------------------------|
| PlantN | A numeric vector of values for plant N content. |
| SoilN  | A numeric value for soil N content.             |
| FertN  | A numeric value for fertilizer N input.         |

### Value

The calculated NUpE value.

### References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Moll, R. H., Kamprath, E. J., and Jackson, W. A. (1982). Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization 1. *Agron. J.* 74, 562–564. doi: 10.2134/agronj1982.00021962007400030 037x

### Examples

```
PlantN <- c(12.1, 8.99, 12.89, 13.11)
SoilN <- 20
FertN <- 15
NUpE(PlantN, SoilN, FertN)
```

---

|      |                                                  |
|------|--------------------------------------------------|
| NUtE | <i>Calculate N Utilization Efficiency (NUtE)</i> |
|------|--------------------------------------------------|

---

**Description**

The contribution of fertilizer N from the plant tissues towards the yield component. Similar to PE, but does not account for background N. Calculate NUtE using the formula:  $NUtE = Yield / PlantN$

**Usage**

```
NUtE(Yield, PlantN)
```

**Arguments**

|        |                                     |
|--------|-------------------------------------|
| Yield  | A numeric vector of yield values.   |
| PlantN | A numeric value for plant tissue N. |

**Value**

The calculated NUtE value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Moll, R. H., Kamprath, E. J., and Jackson, W. A. (1982). Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization 1. *Agron. J.* 74, 562–564. doi: 10.2134/agronj1982.00021962007400030 037x

**Examples**

```
Yield <- c(2.92, 3.78, 4.68, 4.21)
PlantN <- c(2.89, 3.66, 4.73, 4.16)
NUtE(Yield, PlantN)
```

---

|    |                                           |
|----|-------------------------------------------|
| PE | <i>Calculate Physiological Efficiency</i> |
|----|-------------------------------------------|

---

**Description**

The contribution of fertilizer N from the plant tissues towards the yield component. Calculate PE using the formula:  $PE = (YieldF - Yield0) / (PlantNf - PlantN0)$

Usage

PE(YieldF, Yield0, PlantNf, PlantN0)

Arguments

- YieldF            A numeric vector of final yield values.
- Yield0           A numeric vector of non-fertilized control yield values.
- PlantNf          A numeric vector of values for plant N at the end of the experiment.
- PlantN0          A numeric vector of values for plant N at the beginning of the experiment.

Value

The calculated PE value.

References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). “Nutrient use efficiency–measurement and management,” in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

Examples

```
YieldF <- c(2.92, 3.78, 4.68, 4.21)
Yield0 <- c(1.98, 2.66, 4.26, 3.78)
PlantNf <- c(2.89, 3.66, 4.73, 4.16)
PlantN0 <- c(1.22, 2.66, 3.99, 2.58)
PE(YieldF, Yield0, PlantNf, PlantN0)
```

---

|     |                                                    |
|-----|----------------------------------------------------|
| PFP | <i>Calculate Partial-factor Productivity (PFP)</i> |
|-----|----------------------------------------------------|

---

Description

The expression of yield per unit of fertilizer N applied.

Calculate PFP using the formula:  $PFP = YieldF / FertN$

Usage

PFP(YieldF, FertN)

**Arguments**

YieldF            A numeric vector of final yield values.  
 FertN            A numeric value for fertilizer N input.

**Value**

The calculated PFP value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). “Nutrient use efficiency–measurement and management,” in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

**Examples**

```
YieldF <- c(12.09, 11.99, 15.20, 10.33)
FertN <- 15
PFP(YieldF, FertN)
```

---

 PNB

---

*Calculate Partial N Balance*


---

**Description**

The expression of plant N content per unit of fertilizer N applied Calculate PNB using the formula:  

$$PNB = \text{PlantNf} / \text{FertN}$$

**Usage**

```
PNB(PlantNf, FertN)
```

**Arguments**

PlantNf            Plant N content in fertilized conditons.  
 FertN            A numeric value for fertilizer N input.

**Value**

The calculated PNB value.

References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Dobermann, A. (2007). “Nutrient use efficiency–measurement and management,” in *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, 7–9 March 2007, Brussels, 1–28.

Examples

```
PlantNf <- c(2.92, 3.78, 4.68, 4.21)
FertN <- 15
PNB(PlantNf, FertN)
```

---

|      |                                                     |
|------|-----------------------------------------------------|
| sNBI | <i>Calculate N Balance Index of a System (sNBI)</i> |
|------|-----------------------------------------------------|

---

Description

The accumulation or reduction of soil N over a set time. Calculate sNBI using the formula:  $sNBI = Ni - No - delSoilN$

Usage

```
sNBI(Ni, No, delSoilN)
```

Arguments

|          |                                                        |
|----------|--------------------------------------------------------|
| Ni       | Sum total of N inputs (enter each value individually)  |
| No       | Sum total of N outputs (enter each value individually) |
| delSoilN | Change in total soil N value                           |

Value

The calculated ecoNUE value.

References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Sainju, U. M. (2017). Determination of nitrogen balance in agroecosystems. *MethodsX* 4, 199–208. doi: 10.1016/j.mex.2017.06.001

**Examples**

```
Ni <- c(2.92, 3.78, 4.68, 4.21)
No <- c(2.89, 3.66, 4.73, 4.16)
delSoilN <- 0.085
sNBI(Ni, No, delSoilN)
```

sNUE

*Calculate NUE of a System (sNUE)***Description**

The fraction of system N outputs that are captured as N yield rather than lost to the environment  
 Calculate sNUE using the formula:  $sNUE = (YieldN / (YieldN + Nloss))$

**Usage**

```
sNUE(YieldN, Nloss)
```

**Arguments**

|        |                                                                                    |
|--------|------------------------------------------------------------------------------------|
| YieldN | Observed crop yield vector that is attributed to the nitrogen inputs in the system |
| Nloss  | The value of nitrogen that is lost from the system and not utilized by the crops.  |

**Value**

The calculated sNUE value.

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: Martinez-Feria, R. A., Castellano, M. J., Dietzel, R. N., Helmers, M. J., Liebman, M., Huber, I., et al. (2018). Linking crop- and soil-based approaches to evaluate system nitrogen-use efficiency and tradeoffs. *Agric. Ecosyst. Environ.* 256, 131– 143. doi: 10.1016/j.agee.2018.01.002

**Examples**

```
YieldN <- c(5.4, 6.3, 4.8, 7.2)
Nloss <- 3.574
sNUE(YieldN, Nloss)
```

---

 TNdFF

---

*Calculate Total N derived from Fertilizer (TNdFF)*


---

### Description

The total quantity of plant or soil N that is derived from fertilizer Calculate TNdFF using the formula:  
 $TNdFF = (NdFF/100) * \text{Plant N or Soil N}$

### Usage

```
TNdFF(NdFF, PlantN = NULL, SoilN = NULL)
```

### Arguments

|        |                                                      |
|--------|------------------------------------------------------|
| NdFF   | N derived from Fertilizer expressed as a percentage. |
| PlantN | A numeric vector of values for plant N content.      |
| SoilN  | A numeric value for soil N content.                  |

### Value

The calculated TNdFF value.

### References

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108>

Secondary: IAEA (1983). Guide on the Use of Nitrogen-15 and Radioisotopes in Studies of Plant Nutrition: Calculations and Interpretation of Data. Vienna: IAEA.

### Examples

```
NdFF <- 25.98333
SoilN <- 20
PlantN <- c(12.1, 8.99, 12.89, 13.11)
TNdFF(NdFF, PlantN)
TNdFF(NdFF, SoilN)
```

VNF

*Calculate Virtual N Factor (VNF)***Description**

The portion of the N that is released to the environment during the food production process and is not contained in the food that is consumed Calculate NUEFC using the formula:  $VNF = N_{rec} / N_{con}$

**Usage**

$VNF(N_{rec}, N_{con})$

**Arguments**

|           |                                                   |
|-----------|---------------------------------------------------|
| $N_{rec}$ | N used to produce food item that ends up recycled |
| $N_{con}$ | N in food item that is consumed                   |

**Value**

The calculated VNF value

**References**

Primary: Congreves, K. A., Otchere, O., Ferland, D., Farzadfar, S., Williams, S., & Arcand, M. M. (2021, June 4). Nitrogen Use Efficiency Definitions of Today and Tomorrow. *Frontiers in Plant Science*, 12. <https://doi.org/10.3389/fpls.2021.637108> Secondary: Galloway, J. N., Winiwarter, W., Leip, A., Leach, A. M., Bleeker, A., and Erisman, J. W. (2014). Nitrogen footprints: past, present and future. *Environ. Res. Lett.* 9:115003. doi: 10.1088/1748-9326/9/11/115003

**Examples**

```
Nrec <- 7.314
Ncon <- 15.574
VNF(Nrec, Ncon)
```

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