# Package 'NUETON'

November 13, 2023

**Type** Package

**Title** Nitrogen Use Efficiency Toolkit on Numerics

**Version** 0.1.0

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**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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---

AE *Calculate Agronomic Efficiency*

---

## 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: ecoNUE = NP * 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 *Calculate Internal Efficiency (IE)*

---

## Description

The fraction of plant tissue N that is contained in the yield component. Calculate IE using the formula: IE = YieldNF / 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 *Calculate N derived from Fertilizer (NdfF)*

### 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 *Calculate N Harvest Index (NHI)*

### 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 *Calculate Fertilizer-N Recovery Efficiency*

---

## 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 = ((PlantNf - PlantN0) / 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-Fertlizer (NRE15)*

---

## Description

The percent recovery, or utilization, of fertilizer-N in plant and/or soil components Calculate NRE15 using the formula: NRE15 = (TNdfF 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: NUEbal = 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: NUEcrop = 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 = Ncon / Ni

### 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: NUEsoil = PlantBM / (FertN + 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: NUEyield = NUpE * 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 *Calculate N Uptake Efficiency (NUpE)*

## 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 *Calculate N Utilization Efficiency (NUtE)*

### 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 *Calculate Physiological Efficiency*

### 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 *Calculate Partial-factor Productivity (PFP)*

---

## 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 = PlantNf/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` *Calculate N Balance Index of a System (sNBI)*

---

## 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) * 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 = Nrec / Ncon

## Usage

```
VNF(Nrec, Ncon)
```

## Arguments

| | |
|---|---|
| Nrec | N used to produce food item that ends up recycled |
| Ncon | 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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