# Package 'NUETON'

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**Type** Package

**Title** Nitrogen Use Efficiency Toolkit on Numerics

**Version** 0.2.0

**Description**

A comprehensive toolkit for calculating and visualizing Nitrogen Use Efficiency (NUE) indicators in agricultural research. The package implements 23 parameters categorized into fertilizer-based, plant-based, soil-based, isotope-based, ecology-based, and system-based indicators based on Congreves et al. (2021) <doi:10.3389/fpls.2021.637108>. Key features include vectorized calculations for paired-plot experimental designs, batch processing capabilities for handling large datasets, and built-in visualization tools using 'ggplot2'. Designed to streamline the workflow from raw agronomic data to publication-ready metrics and plots.

**License** GPL-3

**Encoding** UTF-8

**Imports** dplyr, ggplot2, magrittr, rlang

**RoxygenNote** 7.3.3

**Config/testthat/edition** 3

**NeedsCompilation** no

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**Repository** CRAN

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## Contents

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NUETON-package *NUETON: Nitrogen Use Efficiency Toolkit on Numerics*

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## Description

The NUETON package provides a comprehensive suite of tools for calculating Nitrogen Use Efficiency (NUE) indicators from agricultural experimental data. It includes vector-based calculations for 23 different parameters, batch processing capabilities, and automated visualization tools.

## Getting Started

The quickest way to learn the package is to run the included demo script, which demonstrates the batch processing and visualization features on a built-in dataset.

```
# Run the master walkthrough
demo("nueton_walkthrough", package = "NUETON")
```

## Key Functions

- calculate_nue_batch: Automatically calculates all 23 indicators from a dataframe.
- plot_nue_compare: Visualizes the results with error bars.
- AE, NRE, NUEsoil: Individual parameter calculators.

## Author(s)

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

## AE *Calculate Agronomic Efficiency (AE)*

### Description

The contribution of fertilizer N towards yield, compared to a non-fertilized control. Formula: AE = (YieldF - Yield0) / FertN

### Usage

```
AE(YieldF, Yield0, FertN)
```

### Arguments

| | |
|---|---|
| YieldF | A numeric vector for yield in fertilized conditions. |
| Yield0 | A numeric vector of non-fertilized control yield values. |
| FertN | A numeric value or vector for fertilizer N input. |

### Value

A numeric vector of AE values.

### Examples

```
YieldF <- c(10, 12, 15)
Yield0 <- c(5, 5, 5)
FertN <- 50
AE(YieldF, Yield0, FertN)
```

## calculate_nue_batch *Calculate All NUE Indicators (Batch Processing)*

### Description

Automatically detects available data columns and calculates all 23 NUE indicators.

### Usage

```
calculate_nue_batch(
  data,
  yield_f = "YieldF",
  yield_0 = "Yield0",
  fert_n = "FertN",
  plant_n_f = "PlantNf",
  plant_n_0 = "PlantN0",
```

```
  yield_n = "YieldN",
  soil_n = "SoilN",
  plant_bm = "PlantBM",
  plant_15n = "Plant15N",
  fert_15n = "Fert15N",
  gr = "GR",
  n_con = "Ncon",
  n_rec = "Nrec",
  n_loss = "Nloss",
  n_in = "Ni",
  n_out = "No",
  delta_soil_n = "delSoilN",
  mrt = "MRT"
)
```

## Arguments

| | |
|---|---|
| data | A dataframe containing experimental data. |
| yield_f | Column name for Fertilized Yield. Default: "YieldF" |
| yield_0 | Column name for Control Yield. Default: "Yield0" |
| fert_n | Column name for Fertilizer N input. Default: "FertN" |
| plant_n_f | Column name for Plant N (fertilized). Default: "PlantNf" |
| plant_n_0 | Column name for Plant N (control). Default: "PlantN0" |
| yield_n | Column name for N removed as yield. Default: "YieldN" |
| soil_n | Column name for Soil N. Default: "SoilN" |
| plant_bm | Column name for Plant Biomass. Default: "PlantBM" |
| plant_15n | Column name for Plant 15N excess. Default: "Plant15N" |
| fert_15n | Column name for Fertilizer 15N excess. Default: "Fert15N" |
| gr | Column name for Plant Growth Rate. Default: "GR" |
| n_con | Column name for N available for consumption. Default: "Ncon" |
| n_rec | Column name for N recycled. Default: "Nrec" |
| n_loss | Column name for N lost from system. Default: "Nloss" |
| n_in | Column name for Total N Input (System). Default: "Ni" |
| n_out | Column name for Total N Output (System). Default: "No" |
| delta_soil_n | Column name for Change in Soil N. Default: "delSoilN" |
| mrt | Column name for Mean Residency Time. Default: "MRT" |

## Value

A dataframe with new columns appended for every calculable metric.

## Examples

```
# Create a simple dataset
df <- data.frame(
  YieldF = c(3.5, 4.2, 5.0),
  Yield0 = c(2.0, 2.5, 3.0),
  FertN = c(10, 10, 10)
)

# Run the batch calculator
result <- calculate_nue_batch(df)

# View calculated AE column
print(result$AE)
```

---

ecoNUE *Calculate Ecological NUE (ecoNUE)*

---

## Description

The product of N productivity and mean residency time (MRT). Formula: ecoNUE = NP * MRT

## Usage

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

## Arguments

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

## Value

A numeric vector of ecoNUE values.

## Examples

```
NP <- c(10, 12)
MRT <- c(4, 5)
ecoNUE(NP, MRT)
```

## IE *Calculate Internal Efficiency (IE)*

### Description

The fraction of plant tissue N that is contained in the yield component. Formula: IE = YieldNF / PlantNf

### Usage

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

### Arguments

| | |
|---|---|
| YieldNF | A numeric vector for yield N in fertilized conditions. |
| PlantNf | A numeric vector for plant N in fertilized conditions. |

### Value

A numeric vector of IE values.

### Examples

```
YieldNF <- c(80, 90, 100)
PlantNf <- c(3.5, 4.0, 4.2)
IE(YieldNF, PlantNf)
```

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

### Description

The difference between fertilizer N applied and the N removed as yield (N Surplus). Formula: NBI = FertN - YieldN

### Usage

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

### Arguments

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

## Value

A numeric vector of NBI values.

## Examples

```
YieldN <- c(80, 90, 100)
FertN <- 50
NBI(YieldN, FertN)
```

---

NdfF *Calculate N derived from Fertilizer (NdfF)*

---

## Description

The percentage of plant or soil N that is derived from the fertilizer. Formula: NdfF = (Plant15N / Fert15N) * 100

## Usage

```
NdfF(Plant15N, Fert15N)
```

## Arguments

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

## Value

A numeric vector of NdfF percentages.

## Examples

```
Plant15N <- c(0.4, 0.5)
Fert15N <- 2.5
NdfF(Plant15N, Fert15N)
```

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

### Description

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

### Usage

```
NHI(YieldF, PlantNf)
```

### Arguments

| | |
|---|---|
| YieldF | A numeric vector of final yield values. |
| PlantNf | A numeric vector for total plant tissue N. |

### Value

A numeric vector of NHI values.

### Examples

```
YieldF <- c(10, 12, 15)
PlantNf <- c(2.5, 3.0, 3.2)
NHI(YieldF, PlantNf)
```

## NP *Calculate Nitrogen Productivity (NP)*

### Description

The ratio of the relative growth rate to the concentration of N in plant tissues. Formula: NP = GR / PlantN

### Usage

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

### Arguments

| | |
|---|---|
| GR | A numeric vector for Plant relative growth rate. |
| PlantN | A numeric vector for plant N concentration. |

## Value

A numeric vector of NP values.

## Examples

```
GR <- c(0.5, 0.6)
PlantN <- c(2.0, 2.2)
NP(GR, PlantN)
```

---

NRE *Calculate Fertilizer N Recovery Efficiency (NRE)*

---

## Description

The percentage of fertilizer N that is taken up by the plant. Formula: NRE = ((PlantNf - PlantN0) / FertN) * 100

## Usage

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

## Arguments

| | |
|---|---|
| PlantNf | A numeric vector of plant N in fertilized conditions. |
| PlantN0 | A numeric vector of plant N in control conditions. |
| FertN | A numeric value or vector for fertilizer N input. |

## Value

A numeric vector of NRE percentages.

## Examples

```
PlantNf <- c(3.5, 4.0, 4.2)
PlantN0 <- c(2.0, 2.0, 2.0)
FertN <- 50
NRE(PlantNf, PlantN0, FertN)
```

## NRE15 *Calculate Isotope-Based Recovery Efficiency (NRE15)*

### Description

The percent recovery of fertilizer-N in plant and/or soil components. Formula: NRE15 = (TNdfF / FertN) * 100

### Usage

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

### Arguments

| | |
|---|---|
| TNdfF | Total N derived from Fertilizer (vector). |
| FertN | Fertilizer N input (numeric vector or single value). |

### Value

A numeric vector of NRE15 percentages.

### Examples

```
TNdfF <- c(5.5, 6.0, 4.8)
FertN <- 50
NRE15(TNdfF, FertN)
```

## NUEbal *Calculate NUE Balance*

### Description

The fraction of N inputs that are removed from the system. Formula: NUEbal = No / Ni

### Usage

```
NUEbal(No, Ni)
```

### Arguments

| | |
|---|---|
| No | Sum total of N outputs. |
| Ni | Sum total of N inputs. |

### Value

A numeric vector of NUEbal values.

### Examples

```
No <- c(50, 60)
Ni <- c(100, 110)
NUEbal(No, Ni)
```

---

## NUEcrop *Calculate NUE Crop*

---

### Description

The fraction of fertilizer N that is utilized and allocated to yield N. Formula: NUEcrop = YieldN / FertN

### Usage

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

### Arguments

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

### Value

A numeric vector of NUEcrop values.

### Examples

```
YieldN <- c(80, 90, 100)
FertN <- 50
NUEcrop(YieldN, FertN)
```

---

## NUEFC *Calculate NUE of a Food Chain (NUEFC)*

---

### Description

The N balance of the entire food chain system. 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

A numeric vector of NUEFC values.

## Examples

```
Ncon <- c(40, 45)
Ni <- c(100, 110)
NUEFC(Ncon, Ni)
```

---

`NUEsoil` *Calculate NUE Soil*

---

## Description

The biomass production per unit of available N. Formula: NUEsoil = PlantBM / (FertN + SoilN)

## Usage

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

## Arguments

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

## Value

A numeric vector of NUEsoil values.

## Examples

```
PlantBM <- c(100, 120, 130)
SoilN <- c(20, 20, 20)
FertN <- 50
NUEsoil(PlantBM, SoilN, FertN)
```

## NUEyield *Calculate NUE Yield*

### Description

The contribution of N supplied from the soil that is allocated to yield. Formula: NUEyield = NUpE * NUtE

### Usage

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

### Arguments

| | |
|---|---|
| NUpE | N Uptake Efficiency value or vector. |
| NUtE | N Utilization Efficiency value or vector. |

### Value

A numeric vector of NUEyield values.

### Examples

```
NUpE <- c(40, 50)
NUtE <- c(20, 25)
NUEyield(NUpE, NUtE)
```

## NUpE *Calculate N Uptake Efficiency (NUpE)*

### Description

The percentage of available soil N that is utilized by the plant. 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 or vector for soil N content. |
| FertN | A numeric value or vector for fertilizer N input. |

## Value

A numeric vector of NUpE percentages.

## Examples

```
PlantN <- c(3.0, 3.5, 3.8)
SoilN <- c(20, 20, 20)
FertN <- 50
NUpE(PlantN, SoilN, FertN)
```

---

NUtE *Calculate N Utilization Efficiency (NUtE)*

---

## Description

The contribution of fertilizer N from the plant tissues towards the yield component. Formula: NUtE = Yield / PlantN

## Usage

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

## Arguments

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

## Value

A numeric vector of NUtE values.

## Examples

```
Yield <- c(10, 12, 15)
PlantN <- c(2.5, 3.0, 3.2)
NUtE(Yield, PlantN)
```

## PE *Calculate Physiological Efficiency (PE)*

### Description

The contribution of fertilizer N from the plant tissues towards the yield component. 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 plant N at the end of the experiment. |
| PlantN0 | A numeric vector of plant N at the beginning/control. |

### Value

A numeric vector of PE values.

### Examples

```
YieldF <- c(12, 13, 14)
Yield0 <- c(10, 10, 10)
PlantNf <- c(3.5, 4.0, 4.2)
PlantN0 <- c(2.0, 2.0, 2.0)
PE(YieldF, Yield0, PlantNf, PlantN0)
```

## PFP *Calculate Partial Factor Productivity (PFP)*

### Description

The expression of yield per unit of fertilizer N applied. Formula: PFP = YieldF / FertN

### Usage

```
PFP(YieldF, FertN)
```

### Arguments

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

## Value

A numeric vector of PFP values.

## Examples

```
YieldF <- c(10, 12, 15)
FertN <- 50
PFP(YieldF, FertN)
```

---

`plot_nue_compare` *Plot NUE Comparison*

---

## Description

Creates a bar chart comparing NUE metrics across different groups (e.g., Treatments or Sites). Includes error bars (Standard Error).

## Usage

```
plot_nue_compare(data, x_var, y_var)
```

## Arguments

| | |
|---|---|
| `data` | A dataframe containing the results. |
| `x_var` | The column name to group by (e.g., "Treatment", "Year"). |
| `y_var` | The NUE metric to plot (e.g., "AE", "NRE"). |

## Value

A ggplot object.

## Examples

```
# Create dummy data
df <- data.frame(
  Treat = c("A", "A", "B", "B"),
  AE = c(10, 12, 20, 22)
)

# Plot
plot_nue_compare(df, x_var = "Treat", y_var = "AE")
```

## PNB *Calculate Partial N Balance (PNB)*

### Description

The expression of plant N content per unit of fertilizer N applied. Formula: PNB = PlantNf / FertN

### Usage

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

### Arguments

| | |
|---|---|
| PlantNf | A numeric vector of Plant N content in fertilized conditions. |
| FertN | A numeric value or vector for fertilizer N input. |

### Value

A numeric vector of PNB values.

### Examples

```
PlantNf <- c(3.5, 4.0, 4.2)
FertN <- 50
PNB(PlantNf, FertN)
```

## sNBI *Calculate N Balance Index of a System (sNBI)*

### Description

The accumulation or reduction of soil N over a set time. Formula: sNBI = Ni - No - delSoilN

### Usage

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

### Arguments

| | |
|---|---|
| Ni | Sum total of N inputs (vector or value). |
| No | Sum total of N outputs (vector or value). |
| delSoilN | Change in total soil N value. |

### Value

A numeric vector of sNBI values.

## Examples

```
Ni <- c(100, 120)
No <- c(80, 90)
delSoilN <- c(5, -2)
sNBI(Ni, No, delSoilN)
```

---

sNUE *Calculate NUE of a System (sNUE)*

---

## Description

The fraction of system N outputs that are captured as N yield. Formula: sNUE = YieldN / (YieldN + Nloss)

## Usage

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

## Arguments

| | |
|---|---|
| YieldN | Observed crop yield N. |
| Nloss | N lost from the system. |

## Value

A numeric vector of sNUE values.

## Examples

```
YieldN <- c(80, 90, 100)
Nloss <- c(20, 25, 20)
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. Formula: TNdfF = (NdfF/100) * (PlantN or SoilN)

## Usage

```
TNdfF(NdfF, PlantN = NULL, SoilN = NULL)
```

### Arguments

| | |
|---|---|
| NdfF | N derived from Fertilizer expressed as a percentage (0-100). |
| PlantN | Optional numeric vector for plant N content. |
| SoilN | Optional numeric vector for soil N content. |

### Value

A numeric vector of TNdfF values.

### Examples

```
NdfF <- c(15, 20)
PlantN <- c(3.0, 3.5)

# Case 1: Using Plant N
TNdfF(NdfF, PlantN = PlantN)

# Case 2: Using Soil N (must specify SoilN explicitly)
SoilN <- c(100, 120)
TNdfF(NdfF, SoilN = SoilN)
```

---

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

---

### Description

The portion of N released to the environment not contained in food. 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

A numeric vector of VNF values.

### Examples

```
Nrec <- c(10, 12)
Ncon <- c(40, 45)
VNF(Nrec, Ncon)
```

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