

Package ‘seedr’

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Type Package

Title Hydro and Thermal Time Seed Germination Models in R

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Description Analysis of seed germination data using the physiological time modelling approach. Includes functions to fit hydrotime and thermal-time models with the traditional approaches of Bradford (1990) <[doi:10.1104/pp.94.2.840](https://doi.org/10.1104/pp.94.2.840)> and Garcia-Huidobro (1982) <[doi:10.1093/jxb/33.2.288](https://doi.org/10.1093/jxb/33.2.288)>. Allows to fit models to grouped datasets, i.e. datasets containing multiple species, seedlots or experiments.

URL <https://github.com/efernandezpascual/seedr>

License GPL-3

Encoding UTF-8

LazyData true

RoxygenNote 7.1.1

Depends R (>= 4.0.0)

Imports data.table (>= 1.13), binom (>= 1.1), graphics, grDevices, stats

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation no

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bradford	<i>Fits Bradford's hydrotime model</i>
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Description

bradford fits a hydrotime seed germination model using the method of Bradford (Gummerson 1986, Bradford 1990, Bewley et al. 2013). This function can be used only with one-group dataset, i.e. one seed lot of one species. To fit models to grouped datasets (multi-seedlots, multi-species) use the function `physiotime` instead.

Usage

```
bradford(d)
```

Arguments

d	a data.table within a "physiodata" object, containing the cumulative germination proportion at each scoring time and water potential treatment.
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Value

bradford returns a S3 object of class "bradford" with the results of fitting the hydrotime model. The generic functions `summary` and `plot` are used to obtain and visualize the model results.

References

- Bewley, J. D., Bradford, K. J., Hilhorst, H. W., & Nonogaki, H. (2013). Hydrotime Model of Germination. In *Seeds: Physiology of Development, Germination and Dormancy*, 3rd Edition (pp. 303-307). Springer, New York, NY.
- Bradford, K. J. (1990). A water relations analysis of seed germination rates. *Plant Physiology*, 94(2), 840-849.
- Gummerson, R. J. (1986). The effect of constant temperatures and osmotic potentials on the germination of sugar beet. *Journal of Experimental Botany*, 37(6), 729-741.

Examples

```
# format dataset with physiodata
anisantha <- physiodata(subset(grasses, species == "Anisantha rubens"), x = "psi")
# bradford() uses the $proportions element within the physiodata object
b <- bradford(anisantha$proportions)
b # prints the main hydrotime variables
summary(b) # returns the main hydrotime variables as a data.table
plot(b) # plots the fitted model
```

centaury

*Temperature example dataset***Description**

This is a dataset containing information from a germination temperature experiment with centaury seeds. It is used to give examples of the functions dealing with thermal time germination models. It also gives an idea of the format in which germination data should be provided to seedr.

Usage

centaury

Format

A data frame with 896 rows and 7 variables

species Name or code for the species to which the data refers

population Name or code for the seedlot

temperature Temperature treatment (in °C) of the experiment

dish Code for the Petri dish, container, replicate, etc.

times Time of germination scoring since the start of the experiment, in days

germinated Number of germinated seeds recorded at that time

germinable Total number of viable seeds in the replicate

Source

Own data from a laboratory experiment.

 grasses

Water potential example dataset

Description

This is a dataset containing information from a water potential experiment with grass seeds. It is used to give examples of the functions dealing with hydrotime germination models. It also gives an idea of the format in which germination data should be provided to seedr.

Usage

grasses

Format

A data frame with 1605 rows and 7 variables

species Name or code for the species to which the data refers

temperature Temperature treatment (in °C) of the experiment

psi Water potential treatment (in MPa) of the experiment

dish Code for the Petri dish, container, replicate, etc.

times Time of germination scoring since the start of the experiment, in days

germinated Number of germinated seeds recorded at that time

germinable Total number of viable seeds in the replicate

Source

Own data from a laboratory experiment.

 huidobro

Fits Garcia-Huidobro's thermal time model

Description

huidobro fits a thermal time seed germination model using the method of Garcia-Huidobro (Garcia-Huidobro et al. 1982, Gummerson 1986, Bewley et al. 2013). This function can be used only with one-group dataset, i.e. one seed lot of one species. To fit models to grouped datasets (multi-seedlots, multi-species) use the function `physiotime` instead.

Usage

```
huidobro(d, min.ptos = 3, tops = c("Max R2", "Max value"), fractions =
(1:9)/10)
```

Arguments

d	a data.table within a "physiodata" object, containing the cumulative germination proportion at each scoring time and temperature treatment.
min.ptos	minimal number of data points (i.e. different temperature treatments) needed to fit the suboptimal and supraoptimal germination models. If the number of points available in the dataset is less than min.ptos, then the suboptimal or the supraoptimal models are not fitted.
tops	method used to divide the dataset in suboptimal and supraoptimal sections. "Max value" splits the data by the temperature that produces the highest seed germination rate. "Max R2" splits the data by the temperature that maximises the R2 of the suboptimal and supraoptimal linear regressions.
fractions	percentiles into which the seed population is split to fit the thermal time model. The default is the 9 deciles (i.e. t10, t20.. t90) as used by Garcia-Huidobro.

Value

huidobro returns a S3 object of class "huidobro" with the results of fitting the thermal time model. The generic functions `summary` and `plot` are used to obtain and visualize the model results.

References

Bewley, J. D., Bradford, K. J., Hilhorst, H. W., & Nonogaki, H. (2013). Thermal Time Models. In *Seeds: Physiology of Development, Germination and Dormancy*, 3rd Edition (pp. 312-317). Springer, New York, NY. Bradford, K. J. (1990). A water relations analysis of seed germination rates. *Plant Physiology*, 94(2), 840-849.

Garcia-Huidobro, J., Monteith, J. L., & Squire, G. R. (1982). Time, temperature and germination of pearl millet (*Pennisetum typhoides* S. & H.) I. Constant temperature. *Journal of Experimental Botany*, 33(2), 288-296.

Gummerson, R. J. (1986). The effect of constant temperatures and osmotic potentials on the germination of sugar beet. *Journal of Experimental Botany*, 37(6), 729-741.

Examples

```
# format dataset with physiodata
malva <- physiodata(subset(centaury, population == "La Malva"), x = "temperature")
# huidobro() uses the $proportions element within the physiodata object
h <- huidobro(malva$proportions)
h # prints the main thermal time variables
summary(h) # returns the main thermal time variables as a data.table
plot(h) # plots the fitted model
```

 physiodata

Transforms dataset to physiodata format

Description

physiodata takes the user's dataset and transforms it to an object of class "physiodata". This object will be used by the model-fitting functions, and it can also be used to explore the data.

Usage

```
physiodata(d, t = "times", g = "germinated", pg = "germinable", x =
  "treatment", groups = NULL)
```

Arguments

d	a data.frame containing the results of a germination experiment. The data frame should include columns with scoring times, germination counts (not cumulative), number of potentially germinable seeds, and the environmental variable of interest. (e.g. temperature or water potential) (see grasses example dataset for appropriate structure).
t	the name of a column in d containing a vector of numeric scoring times.
g	the name of a column in d containing a vector of integer germination counts (non cumulative).
pg	the name of a column in d containing a vector of integer numbers of potentially germinable seeds.
x	the name of a column in d containing a vector of numeric values for the environmental variable of interest (e.g. temperature, water potential).
groups	optional, the names of columns in d containing grouping variables for the experiment that have to be analysed separately (e.g. different species or populations, different temperatures in a water potential experiment, different treatments to break seed dormancy).

Value

physiodata returns a S3 object of class "physiodata". The object is a list containing, for each group, treatment and scoring time: the cumulative germination count; the cumulative germination proportion; and the lower and upper bounds of the 95 calculated with the Wilson method as implemented in the package binom. The object can be used to explore the data using the generic functions summary, barplot and plot.

Examples

```
cent <- physiodata(centaury, x = "temperature")
cent
summary(cent) # average final germination proportions and germination rates per treatment
barplot(cent) # bar plots for the final germination proportions and germination rates
```

```
plot(cent) # cumulative germination curves
physiodata(grasses, x = "psi", groups = "species") # grouping dataset by species
```

 physiotime

Fits physiological time seed germination models

Description

physiotime fits physiological time models (thermal time, hydrottime) to seed germination data. It is a wrapper function that transforms data to class "physiodata" and allows to specify the physiological time model to be fitted (i.e. Bradford's hydrottime model or Garcia-Huidobro's thermal time model).

Usage

```
physiotime(d, t = "times", g = "germinated", pg = "germinable", x =
  "treatment", groups = NULL, method = "bradford", min.ptos = 3, tops =
  c("Max R2", "Max value"), fractions = (1:9)/10)
```

Arguments

d	a data.frame containing the results of a germination experiment. The data frame should include columns with scoring times, germination counts (not cumulative), number of potentially germinable seeds, and the environmental variable of interest. (e.g. temperature or water potential) (see grasses example dataset for appropriate structure).
t	the name of a column in d containing a vector of numeric scoring times.
g	the name of a column in d containing a vector of integer germination counts (non cumulative).
pg	the name of a column in d containing a vector of integer numbers of potentially germinable seeds.
x	the name of a column in d containing a vector of numeric values for the environmental variable of interest (e.g. temperature, water potential).
groups	optional, the names of columns in d containing grouping variables for the experiment that have to be analysed separately (e.g. different species or populations, different temperatures in a water potential experiment, different treatments to break seed dormancy).
method	the method to be used to fit the models, can be "bradford" to fit a hydrottime model or "huidobro" to fit a thermal time model.
min.ptos	minimal number of data points (i.e. different temperature treatments) needed to fit the suboptimal and supraoptimal germination models if fitting a thermal time model. If the number of points available in the dataset is less than min.ptos, then the suboptimal or the supraoptimal models are not fitted.

tops	method used to divide the dataset in suboptimal and supraoptimal sections if fitting a thermal time model. "Max value" splits the data by the temperature that produces the highest seed germination rate. "Max R2" splits the data by the temperature that maximises the R2 of the suboptimal and supraoptimal linear regressions.
fractions	percentiles into which the seed population is split if fitting a thermal time model. The default is the 9 deciles (i.e. t10, t20.. t90) as used by Garcia-Huidobro.

Value

physiotime returns a S3 object of class "physiotime". The object is a list containing, for each group (seedlot, species, etc.) the results of fitting the physiological time models. The generic functions summary and plot are used to obtain and visualize the model results.

Examples

```
m <- physiotime(centaury, x = "temperature",
               method = "huidobro", groups = c("species", "population"))
m
summary(m)
plot(m)
```

 seedr

seedr: Hydro and Thermal Time Seed Germination Models in R

Description

The seedr package provides functions to fit hydro and thermal time germination models. These models characterize seed lots by two sets of parameters: (i) the physiological thresholds (water, temperature) between which the seed lot can germinate, and (ii) the physiological-time units that the seed lot needs to accumulate before it can germinate. seedr allows to fit the hydro time model of Bradford (Gummerson 1986, Bradford 1990, Bewley et al. 2013) and the thermal time model of Garcia-Huidobro (Garcia-Huidobro et al. 1982, Gummerson 1986, Bewley et al. 2013). seedr also allows to quickly fit models to multi-seedlot or multi-species datasets.

References

- Bewley, J. D., Bradford, K. J., Hilhorst, H. W., & Nonogaki, H. (2013). Environmental Control of Germination. In *Seeds: Physiology of Development, Germination and Dormancy*, 3rd Edition (pp. 302-317). Springer, New York, NY.
- Bradford, K. J. (1990). A water relations analysis of seed germination rates. *Plant Physiology*, 94(2), 840-849.
- Garcia-Huidobro, J., Monteith, J. L., & Squire, G. R. (1982). Time, temperature and germination of pearl millet (*Pennisetum typhoides* S. & H.) I. Constant temperature. *Journal of Experimental Botany*, 33(2), 288-296.
- Gummerson, R. J. (1986). The effect of constant temperatures and osmotic potentials on the germination of sugar beet. *Journal of Experimental Botany*, 37(6), 729-741.

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