# The **ammistability** package: A brief introduction

*Ajay, B. C.[1], Aravind, J. [2], and Abdul Fiyaz, R.[3]*

*2018-08-09*

1. RRS, ICAR-Directorate of Groundnut Research, Anantapur.
2. ICAR-National Bureau of Plant Genetic Resources, New Delhi.
3. ICAR-Indian Institute of Rice Research, Hyderabad.

---

## Contents

### Overview

The package `ammistability` is a collection of functions for the computation of various stability parameters from the results of Additive Main Effects and Multiplicative Interaction (AMMI) analysis computed by the `AMMI` function of `agricolae` package.

The goal of this vignette is to introduce the users to these functions and get started in describing sequentially recorded germination count data. This document assumes a basic knowledge of `R` programming language.

### Installation

The package can be installed using the following functions:

```
# Install from CRAN
install.packages('ammistability', dependencies=TRUE)

# Install development version from Github
devtools::install_github("ajaygpb/ammistability")
```

Then the package can be loaded using the function

```
library(ammistability)
```

```
--------------------------------------------------------------------------------
Welcome to ammistability version 0.1.0


# To know how to use this package type:
  browseVignettes(package = 'ammistability')
  for the package vignette.

# To know whats new in this version type:
  news(package='ammistability')
  for the NEWS file.

# To cite the methods in the package type:
  citation(package='ammistability')

# To suppress this message use:
  suppressPackageStartupMessages(library(ammistability))
--------------------------------------------------------------------------------
```

## AMMI model

The difference in response of genotypes to different environmental conditions is known as Genotype-Environment Interaction (GEI). Understanding the nature and structure of this interaction is critical for plant breeders to select for genotypes with wide or specific adaptability. One of the most popular techniques to achieve this is by fitting the Additive Main Effects and Multiplicative Interaction (AMMI) model to the results of multi environment trials (Gauch, 1988, 1992).

The AMMI equation is described as follows.

$$Y_{ij} = \mu + \alpha_i + \beta_j + \sum_{n=1}^{N} \lambda_n \gamma_{in} \delta_{jn} + \rho_{ij}$$

Where, $Y_{ij}$ is the yield of the $i$th genotype in the $j$th environment, $\mu$ is the grand mean, $\alpha_i$ is the genotype deviation from the grand mean, $\beta_j$ is the environment deviation, $N$ is the total number of interaction principal components (IPCs), $\lambda_n$ is the is the singular value for $n$th IPC and correspondingly $\lambda_n^2$ is its eigen value, $\gamma_{in}$ is the eigenvector value for $i$th genotype, $\delta_{jn}$ is the eigenvector value for the $j$th environment and $\rho_{ij}$ is the residual.

## AMMI stability parameters

Although the AMMI model can aid in determining genotypes with wide or specific adaptability, it fails to rank genotypes according to their stability. Several measures have been developed over the years to indicate the stability of genotypes from the results of AMMI analysis (Table 1.).

The details about AMMI stability parameters/indices implemented in `ammistability` are described in Table 1.

**Table 1 :** AMMI stability parameters/indices implemented in `ammistability`.

| AMMI stability parameter | function | Details | Reference |
|---|---|---|---|
| Sum across environments of GEI modelled by AMMI ($AMGE$) | `AMGE.AMMI` | $$AMGE = \sum_{j=1}^{E}\sum_{n=1}^{N'}\lambda_n\gamma_{in}\delta_{jn}$$ | Sneller et al. (1997) |
| AMMI Stability Index ($ASI$) | `ASI.AMMI` and `MASI.AMMI` | $$ASI = \sqrt{\left[PC_1^2 \times \theta_1^2\right] + \left[PC_2^2 \times \theta_2^2\right]}$$ | Jambhulkar et al. (2014); Jambhulkar et al. (2015); Jambhulkar et al. (2017) |
| AMMI Based Stability Parameter ($ASTAB$) | `ASTAB.AMMI` | $$ASTAB = \sum_{n=1}^{N'}\lambda_n\gamma_{in}^2$$ | Rao and Prabhakaran (2005) |
| AMMI stability value ($ASV$) * | `agricolae::index.AMMI` and `MASV.AMMI` | Distance from the coordinate point to the origin in a two dimensional scattergram generated by plotting of IPC1 score against IPC2 score. $$ASV = \sqrt{\left(\frac{SSIPC_1}{SSIPC_2} \times PC_1\right)^2 + (PC_2)^2}$$ | Purchase (1997); Purchase et al. (1999); Purchase et al. (2000) |
| $AV_{(AMGE)}$ | `AVAMGE.AMMI` | $$AV_{(AMGE)} = \sum_{j=1}^{E}\sum_{n=1}^{N'}\lvert\lambda_n\gamma_{in}\delta_{jn}\rvert$$ | Zali et al. (2012) |
| Annicchiarico's D parameter ($D_a$) | `DA.AMMI` | The unsquared Euclidean distance from the origin of significant IPC axes in the AMMI model. $$D_a = \sqrt{\sum_{n=1}^{N'}(\lambda_n\gamma_{in})^2}$$ | Annicchiarico (1997) |

| AMMI stability parameter | function | Details | Reference |
|---|---|---|---|
| Zhang's D parameter or AMMI statistic coefficient or AMMI distance or AMMI stability index ($D_z$) | `DZ.AMMI` | The distance of IPC point from origin in space. $$D_z = \sqrt{\sum_{n=1}^{N'} \gamma_{in}^2}$$ | Zhang et al. (1998) |
| Averages of the squared eigenvector values $EV$ | `EV.AMMI` | $$EV = \sum_{n=1}^{N'} \frac{\gamma_{in}^2}{N'}$$ | Zobel (1994) |
| Stability measure based on fitted AMMI model $FA$ | `FA.AMMI` | $$FA = \sum_{n=1}^{N'} \lambda_n^2 \gamma_{in}^2$$ | Raju (2002); Zali et al. (2012) |
| $FP$ | `FA.AMMI` | Equivalent to $FA$, when only the first IPC axis is considered for computation. $$FP = \lambda_1^2 \gamma_{i1}^2$$ As $\lambda_1^2$ will be same for all the genotypes, the absolute value of $\gamma_{i1}$ alone is sufficient for comparison. So this is also equivalent to the comparison based on biplot with first IPC axis. | Raju (2002); Zali et al. (2012) |
| $B$ | `FA.AMMI` | Equivalent to $FA$, when only the first two IPC axes are considered for computation. $$B = \sum_{n=1}^{2} \lambda_n^2 \gamma_{in}^2$$ Stability comparisons based on this measure will be equivalent to the comparisons based on biplot with first two IPC axes. | Raju (2002); Zali et al. (2012) |

| AMMI stability parameter | function | Details | Reference |
|---|---|---|---|
| $W_{(AMMI)}$ | `FA.AMMI` | Equivalent to $FA$, when all the IPC axes in the AMMI model are considered for computation. $W_{(AMMI)} = \sum_{n=1}^{N} \lambda_n^2 \gamma_{in}^2$ Equivalent to Wricke's ecovalence. | Wricke (1962); Raju (2002); Zali et al. (2012) |
| Modified AMMI Stability Index ($MASI$) | `MASI.AMMI` | $MASI = \sqrt{\sum_{n=1}^{N'} PC_n^2 \times \theta_n^2}$ | |
| Modified AMMI stability value ($MASV$) | `MASV.AMMI` | $MASV = \sqrt{\sum_{n=1}^{N'-1} \left( \frac{SSIPC_n}{SSIPC_{n+1}} \times PC_n \right)^2 + (PC_{N'})^2}$ | Zali et al. (2012) |
| Sums of the absolute value of the IPC scores ($SIPC$) | `SIPC.AMMI` | $SIPC = \sum_{n=1}^{N'} \left\| \lambda_n^{0.5} \gamma_{in} \right\|$ $SIPC = \sum_{n=1}^{N'} \|PC_n\|$ | Sneller et al. (1997) |
| Absolute value of the relative contribution of IPCs to the interaction $Za$ | `ZA.AMMI` | $Za = \sum_{i=1}^{N'} \|\theta_n \gamma_{in}\|$ | Zali et al. (2012) |

Where, $N$ is the total number of interaction principal components (IPCs); $N'$ is the number of significant IPCAs (number of IPC that were retained in the AMMI model via F tests); $\lambda_n$ is the is the singular value for $n$th IPC and correspondingly $\lambda_n^2$ is its eigen value; $\gamma_{in}$ is the eigenvector value for $i$th genotype; $\delta_{jn}$ is the eigenvector value for the $j$th environment; $SSIPC_1$, $SSIPC_2$, $\cdots$, $SSIPC_n$ are the sum of squares of the 1st, 2th, ..., and $n$th IPC; $PC_1$, $PC_2$, $\cdots$, $PC_n$ are the scores of 1st, 2th, ..., and $n$th IPC; $\theta_n$ is the percentage sum of squares explained by $n$th principal component interaction effect; and $E$ is the number of environments.

### Examples

#### AMMI model from agricolae::AMMI

```r
library(agricolae)
data(plrv)

# AMMI model
model <- with(plrv, AMMI(Locality, Genotype, Rep, Yield, console = FALSE))

# ANOVA
model$ANOVA
```

```
Analysis of Variance Table

Response: Y
           Df Sum Sq Mean Sq  F value    Pr(>F)
ENV         5 122284 24456.9 257.0382  9.08e-12 ***
REP(ENV)   12   1142    95.1   2.5694  0.002889 **
GEN        27  17533   649.4  17.5359 < 2.2e-16 ***
ENV:GEN   135  23762   176.0   4.7531 < 2.2e-16 ***
Residuals 324  11998    37.0
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# IPC F test
model$analysis
```

```
    percent  acum Df     Sum.Sq   Mean.Sq F.value   Pr.F
PC1    56.3  56.3 31 13368.5954 431.24501   11.65 0.0000
PC2    27.1  83.3 29  6427.5799 221.64069    5.99 0.0000
PC3     9.4  92.7 27  2241.9398  83.03481    2.24 0.0005
PC4     4.3  97.1 25  1027.5785  41.10314    1.11 0.3286
PC5     2.9 100.0 23   696.1012  30.26527    0.82 0.7059
```

```r
# Mean yield and IPC scores
model$biplot
```

```
        type    Yield         PC1          PC2         PC3         PC4
102.18   GEN 26.31947 -1.50828851  1.258765244 -0.19220309  0.48738861
104.22   GEN 31.28887  0.32517729 -1.297024517 -0.63695749 -0.44159957
121.31   GEN 30.10174  0.95604605  1.143461054 -1.28777348  2.22246913
141.28   GEN 39.75624  2.11153737  0.817810467  1.45527701  0.25257620
157.26   GEN 36.95181  1.05139017  2.461179974 -1.97208942 -1.96538800
163.9    GEN 21.41747 -2.12407441 -0.284381234 -0.21791137 -0.50743629
221.19   GEN 22.98480 -0.84981828  0.347983673 -0.82400783 -0.11451944
233.11   GEN 28.66655  0.07554203 -1.046497338  1.04040485  0.22868362
235.6    GEN 38.63477  1.20102029 -2.816581184  0.80975361  1.02013062
241.2    GEN 26.34039 -0.79948495  0.220768053 -0.98538801  0.30004421
255.7    GEN 30.58975 -1.49543817 -1.186549449  0.92552519 -0.32009239
314.12   GEN 28.17335  1.39335380 -0.332786322 -0.73226877  0.05987348
317.6    GEN 35.32583  1.05170769  0.002555823 -0.81561907  0.58180433
319.20   GEN 38.75767  3.08338144  1.995946966  0.87971668 -1.11908943
320.16   GEN 26.34808 -1.55737097  0.732314249 -0.41432567  1.32097009
342.15   GEN 26.01336 -1.35880873 -0.741980068  0.87480105 -1.12013125
346.2    GEN 23.84175 -2.48453928 -0.397045286  1.07091711 -0.90974484
```

```
351.26   GEN 36.11581  1.22670345  1.537183139  1.79835728 -0.03516368
364.21   GEN 34.05974  0.27328985 -0.447941156  0.03139543  0.77920500
402.7    GEN 27.47748 -0.12907269 -0.080086669  0.01934016 -0.36085862
405.2    GEN 28.98663 -1.90936369  0.309047963  0.57682642  0.51163370
406.12   GEN 32.68323  0.90781100 -1.733433781 -0.24223050 -0.38596144
427.7    GEN 36.19020  0.42791957 -0.723190970 -0.85381724 -0.53089914
450.3    GEN 36.19602  1.38026196  1.279525147  0.16025163  0.61270137
506.2    GEN 33.26623 -0.33054261 -0.302588536 -1.58471588 -0.04659416
Canchan  GEN 27.00126  1.47802905  0.380553178  1.67423900  0.07718375
Desiree  GEN 16.15569 -3.64968796  1.720025405  0.43761089  0.04648011
Unica    GEN 39.10400  1.25331924 -2.817033826 -0.99510845 -0.64366599
Ayac     ENV 23.70254 -2.29611851  0.966037760  1.95959116  2.75548057
Hyo-02   ENV 45.73082  3.85283195 -5.093371615  1.16967118 -0.08985538
LM-02    ENV 34.64462 -1.14575146 -0.881093222 -4.56547274  0.55159099
LM-03    ENV 53.83493  5.34625518  4.265275487 -0.14143931 -0.11714533
SR-02    ENV 14.95128 -2.58678337  0.660309540  0.89096920 -3.25055305
SR-03    ENV 11.15328 -3.17043379  0.082842050  0.68668051  0.15048221
                PC5
102.18  -0.04364115
104.22   0.95312506
121.31  -1.30661916
141.28  -0.25996142
157.26  -0.59719268
163.9    0.18563390
221.19  -0.57504816
233.11   0.65754266
235.6   -0.40273415
241.2    0.07555258
255.7   -0.46344763
314.12   0.54406154
317.6    0.39627052
319.20   0.29657050
320.16   2.29506737
342.15  -0.10776433
346.2   -0.12738693
351.26   0.30191335
364.21  -0.95811256
402.7   -0.28473777
405.2   -0.34397623
406.12  -0.49796296
427.7    1.00677993
450.3   -0.34325251
506.2    0.87807441
Canchan  0.49381313
Desiree -0.86767477
Unica   -0.90489253
Ayac     1.67177210
Hyo-02   0.01540152
LM-02    0.52350416
LM-03   -0.40285728
SR-02    1.37283488
SR-03   -3.18065538
```

```r
# G*E matrix (deviations from mean)
array(model$genXenv, dim(model$genXenv), dimnames(model$genXenv))
```

```
         ENV
GEN             Ayac      Hyo-02        LM-02        LM-03         SR-02
  102.18     5.5726162 -12.4918224   1.7425251  -2.7070438   2.91734869
  104.22    -2.8712076   7.1684102   3.9336218  -4.0358373   0.47881580
  121.31     0.3255230  -3.8666836   4.3182811  10.4366135 -11.88343843
  141.28    -0.9451837   5.6454825  -9.7806639  14.6463104  -4.80337115
  157.26   -10.3149711 -10.6241677   4.2336365  16.8683612   2.71710210
  163.9      3.0874931  -6.9416721   3.4963790 -12.5533271   7.01688164
  221.19    -0.6041752  -6.0090018   4.0648518  -2.6974743   1.27671246
  233.11     2.5837535   6.8277609  -3.4440645  -4.4985717   0.19989490
  235.6     -1.7541523  19.8225025  -2.2394463  -5.6643239  -8.11400542
  241.2      1.0710975  -5.3831118   5.4253097  -3.2588271   0.46433086
  255.7      2.4443155   1.3860497  -1.8857757 -12.9626594   4.31373929
  314.12    -3.8812099   6.2098482   2.3577759   5.9071782  -3.92419060
  317.6     -1.7450319   3.0388540   3.0448064   5.5211634  -4.79271565
  319.20    -6.0155949   2.8477540  -9.7697504  24.8850017  -1.82949467
  320.16    10.9481796 -10.2982108   4.9608280  -6.2233088   2.99984918
  342.15     0.8508002  -0.3338618  -2.4575390 -10.3783871   7.29753151
  346.2      4.7000495  -6.2178087  -2.2612391 -14.9700672   9.90123888
  351.26     2.6002030  -0.9918665 -10.8315931  12.7429121  -0.02713985
  364.21    -0.4533734   3.2864208  -0.1335527  -0.1592533  -4.82292664
  402.7     -1.2134573  -0.0387229  -0.2179557  -0.8774011   1.08032472
  405.2      6.6477681  -8.3071271  -0.6159895  -8.8927189   3.52179705
  406.12    -6.1296667  12.0703469   1.1195092  -2.2601009  -3.13776595
  427.7     -3.1340922   4.3967072   4.2792028  -1.0194744   0.76266844
  450.3     -0.5047010  -1.0720791  -3.2821761  12.8806007  -5.04562407
  506.2     -1.2991912  -1.5682154   8.3142802  -3.1819279   0.60021498
  Canchan    1.2929442   5.7152780  -9.3713622   9.0803035  -1.65332869
  Desiree    9.5767845 -22.3280421   0.2396387 -11.8935722   9.62433886
  Unica    -10.8355195  18.0569790   4.7604622  -4.7341684  -5.13878822
         ENV
GEN             SR-03
  102.18     4.9663762
  104.22    -4.6738028
  121.31     0.6697043
  141.28    -4.7625741
  157.26    -2.8799609
  163.9      5.8942454
  221.19     3.9690870
  233.11    -1.6687730
  235.6     -2.0505746
  241.2      1.6812008
  255.7      6.7043306
  314.12    -6.6694018
  317.6     -5.0670763
  319.20   -10.1179157
  320.16    -2.3873373
  342.15     5.0214562
  346.2      8.8478267
  351.26    -3.4925156
  364.21     2.2826853
```

```
  402.7      1.2672123
  405.2      7.6462704
  406.12    -1.6623226
  427.7     -5.2850119
  450.3     -2.9760204
  506.2     -2.8651608
  Canchan   -5.0638348
  Desiree   14.7808522
  Unica     -2.1089651
```

**AMGE.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
AMGE.AMMI(model)
```

```
                 AMGE  SSI rAMGE rY    means
102.18  -8.659740e-15 28.0   5.0 23 26.31947
104.22   1.110223e-15 28.0  15.0 13 31.28887
121.31   4.440892e-16 29.0  14.0 15 30.10174
141.28   1.021405e-14 27.5  26.5  1 39.75624
157.26   2.220446e-15 22.5  17.5  5 36.95181
163.9   -1.243450e-14 28.0   1.0 27 21.41747
221.19  -4.440892e-15 35.0   9.0 26 22.98480
233.11   2.275957e-15 36.0  19.0 17 28.66655
235.6    5.773160e-15 26.5  22.5  4 38.63477
241.2   -5.329071e-15 30.0   8.0 22 26.34039
255.7   -3.774758e-15 24.0  10.0 14 30.58975
314.12   5.773160e-15 40.5  22.5 18 28.17335
317.6    2.220446e-15 26.5  17.5  9 35.32583
319.20   1.731948e-14 31.0  28.0  3 38.75767
320.16  -6.217249e-15 27.0   6.0 21 26.34808
342.15  -2.442491e-15 35.0  11.0 24 26.01336
346.2   -1.110223e-14 28.0   3.0 25 23.84175
351.26   1.021405e-14 34.5  26.5  8 36.11581
364.21   1.415534e-15 26.0  16.0 10 34.05974
402.7   -3.885781e-16 31.0  12.0 19 27.47748
405.2   -1.088019e-14 20.0   4.0 16 28.98663
406.12   3.108624e-15 32.0  20.0 12 32.68323
427.7    1.110223e-16 20.0  13.0  7 36.19020
450.3    6.439294e-15 30.0  24.0  6 36.19602
506.2   -5.773160e-15 18.0   7.0 11 33.26623
Canchan  9.325873e-15 45.0  25.0 20 27.00126
Desiree -1.132427e-14 30.0   2.0 28 16.15569
Unica    5.329071e-15 23.0  21.0  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
AMGE.AMMI(model, n = 4)
```

```
                 AMGE SSI rAMGE rY    means
102.18  -9.992007e-15  28     5 23 26.31947
104.22   2.886580e-15  31    18 13 31.28887
121.31  -3.996803e-15  25    10 15 30.10174
141.28   9.992007e-15  27    26  1 39.75624
157.26   8.881784e-15  29    24  5 36.95181
163.9   -1.065814e-14  29     2 27 21.41747
```

```
221.19  -4.718448e-15  35     9 26 22.98480
233.11   1.387779e-15  32    15 17 28.66655
235.6    3.108624e-15  23    19  4 38.63477
241.2   -6.550316e-15  29     7 22 26.34039
255.7   -3.774758e-15  25    11 14 30.58975
314.12   6.217249e-15  41    23 18 28.17335
317.6    0.000000e+00  22    13  9 35.32583
319.20   2.087219e-14  31    28  3 38.75767
320.16  -1.021405e-14  25     4 21 26.34808
342.15   2.053913e-15  41    17 24 26.01336
346.2   -7.993606e-15  31     6 25 23.84175
351.26   9.159340e-15  33    25  8 36.11581
364.21  -8.881784e-16  22    12 10 34.05974
402.7    2.983724e-16  33    14 19 27.47748
405.2   -1.326717e-14  17     1 16 28.98663
406.12   3.552714e-15  32    20 12 32.68323
427.7    1.887379e-15  23    16  7 36.19020
450.3    5.107026e-15  27    21  6 36.19602
506.2   -5.592748e-15  19     8 11 33.26623
Canchan  1.010303e-14  47    27 20 27.00126
Desiree -1.043610e-14  31     3 28 16.15569
Unica    5.773160e-15  24    22  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
AMGE.AMMI(model, ssi.method = "rao")
```

```
                 AMGE        SSI rAMGE rY    means
102.18  -8.659740e-15  0.5673198   5.0 23 26.31947
104.22   1.110223e-15  3.2887624  15.0 13 31.28887
121.31   4.440892e-16  6.6529106  14.0 15 30.10174
141.28   1.021405e-14  1.5428597  26.5  1 39.75624
157.26   2.220446e-15  2.3391212  17.5  5 36.95181
163.9   -1.243450e-14  0.4957785   1.0 27 21.41747
221.19  -4.440892e-15  0.1822906   9.0 26 22.98480
233.11   2.275957e-15  2.0413097  19.0 17 28.66655
235.6    5.773160e-15  1.6959735  22.5  4 38.63477
241.2   -5.329071e-15  0.3862254   8.0 22 26.34039
255.7   -3.774758e-15  0.3301705  10.0 14 30.58975
314.12   5.773160e-15  1.3548726  22.5 18 28.17335
317.6    2.220446e-15  2.2861050  17.5  9 35.32583
319.20   1.731948e-14  1.4091383  28.0  3 38.75767
320.16  -6.217249e-15  0.4539931   6.0 21 26.34808
342.15  -2.442491e-15 -0.1829870  11.0 24 26.01336
346.2   -1.110223e-14  0.5505176   3.0 25 23.84175
351.26   1.021405e-14  1.4241614  26.5  8 36.11581
364.21   1.415534e-15  2.8898091  16.0 10 34.05974
402.7   -3.885781e-16 -5.5857093  12.0 19 27.47748
405.2   -1.088019e-14  0.7136396   4.0 16 28.98663
406.12   3.108624e-15  1.8758598  20.0 12 32.68323
427.7    1.110223e-16 23.8657048  13.0  7 36.19020
450.3    6.439294e-15  1.5713258  24.0  6 36.19602
506.2   -5.773160e-15  0.6484020   7.0 11 33.26623
Canchan  9.325873e-15  1.1504601  25.0 20 27.00126
Desiree -1.132427e-14  0.3043571   2.0 28 16.15569
Unica    5.329071e-15  1.7476282  21.0  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
AMGE.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
                 AMGE        SSI rAMGE rY    means
102.18  -8.659740e-15  0.7330999   5.0 23 26.31947
104.22   1.110223e-15  1.9956774  15.0 13 31.28887
121.31   4.440892e-16  3.4201982  14.0 15 30.10174
141.28   1.021405e-14  1.4023070  26.5  1 39.75624
157.26   2.220446e-15  1.6925787  17.5  5 36.95181
163.9   -1.243450e-14  0.6112325   1.0 27 21.41747
221.19  -4.440892e-15  0.5055618   9.0 26 22.98480
233.11   2.275957e-15  1.4105366  19.0 17 28.66655
235.6    5.773160e-15  1.4473033  22.5  4 38.63477
241.2   -5.329071e-15  0.6556181   8.0 22 26.34039
255.7   -3.774758e-15  0.7104896  10.0 14 30.58975
314.12   5.773160e-15  1.1062024  22.5 18 28.17335
317.6    2.220446e-15  1.6395625  17.5  9 35.32583
319.20   1.731948e-14  1.3262482  28.0  3 38.75767
320.16  -6.217249e-15  0.6849012   6.0 21 26.34808
342.15  -2.442491e-15  0.4047789  11.0 24 26.01336
346.2   -1.110223e-14  0.6798261   3.0 25 23.84175
351.26   1.021405e-14  1.2836086  26.5  8 36.11581
364.21   1.415534e-15  1.8756248  16.0 10 34.05974
402.7   -3.885781e-16 -1.8911807  12.0 19 27.47748
405.2   -1.088019e-14  0.8455870   4.0 16 28.98663
406.12   3.108624e-15  1.4140438  20.0 12 32.68323
427.7    1.110223e-16 10.9348548  13.0  7 36.19020
450.3    6.439294e-15  1.3483801  24.0  6 36.19602
506.2   -5.773160e-15  0.8970722   7.0 11 33.26623
Canchan  9.325873e-15  0.9965214  25.0 20 27.00126
Desiree -1.132427e-14  0.4311301   2.0 28 16.15569
Unica    5.329071e-15  1.4782355  21.0  2 39.10400
```

**ASI.AMMI()**

```r
# With default ssi.method (farshadfar)
ASI.AMMI(model)
```

```
               ASI SSI rASI rY    means
102.18  0.91512303  43   20 23 26.31947
104.22  0.39631322  19    6 13 31.28887
121.31  0.62108102  25   10 15 30.10174
141.28  1.20927797  26   25  1 39.75624
157.26  0.89176583  22   17  5 36.95181
163.9   1.19833464  51   24 27 21.41747
221.19  0.48765291  34    8 26 22.98480
233.11  0.28677206  21    4 17 28.66655
235.6   1.01971997  25   21  4 38.63477
241.2   0.45406877  29    7 22 26.34039
255.7   0.90124720  33   19 14 30.58975
314.12  0.78962523  30   12 18 28.17335
317.6   0.59211183  18    9  9 35.32583
319.20  1.81826161  30   27  3 38.75767
320.16  0.89897900  39   18 21 26.34808
```

```
342.15  0.79099371  37   13 24 26.01336
346.2   1.40292793  51   26 25 23.84175
351.26  0.80654291  22   14  8 36.11581
364.21  0.19598368  12    2 10 34.05974
402.7   0.07583976  20    1 19 27.47748
405.2   1.07822942  39   23 16 28.98663
406.12  0.69418710  23   11 12 32.68323
427.7   0.31056699  12    5  7 36.19020
450.3   0.85094150  22   16  6 36.19602
506.2   0.20336120  14    3 11 33.26623
Canchan 0.83849670  35   15 20 27.00126
Desiree 2.10698168  56   28 28 16.15569
Unica   1.03956820  24   22  2 39.10400
```

```
# With  ssi.method = "rao"
ASI.AMMI(model, ssi.method = "rao")
```

```
               ASI       SSI rASI rY    means
102.18  0.91512303 1.3832387   20 23 26.31947
104.22  0.39631322 2.2326416    6 13 31.28887
121.31  0.62108102 1.7551519   10 15 30.10174
141.28  1.20927797 1.6936286   25  1 39.75624
157.26  0.89176583 1.7436656   17  5 36.95181
163.9   1.19833464 1.0993106   24 27 21.41747
221.19  0.48765291 1.7347850    8 26 22.98480
233.11  0.28677206 2.6102708    4 17 28.66655
235.6   1.01971997 1.7309273   21  4 38.63477
241.2   0.45406877 1.9170753    7 22 26.34039
255.7   0.90124720 1.5305578   19 14 30.58975
314.12  0.78962523 1.5271379   12 18 28.17335
317.6   0.59211183 1.9633384    9  9 35.32583
319.20  1.81826161 1.5279859   27  3 38.75767
320.16  0.89897900 1.3936010   18 21 26.34808
342.15  0.79099371 1.4556573   13 24 26.01336
346.2   1.40292793 1.1198795   26 25 23.84175
351.26  0.80654291 1.7733422   14  8 36.11581
364.21  0.19598368 3.5623227    2 10 34.05974
402.7   0.07583976 7.2317748    1 19 27.47748
405.2   1.07822942 1.3907733   23 16 28.98663
406.12  0.69418710 1.7578467   11 12 32.68323
427.7   0.31056699 2.7272047    5  7 36.19020
450.3   0.85094150 1.7448731   16  6 36.19602
506.2   0.20336120 3.4475042    3 11 33.26623
Canchan 0.83849670 1.4534532   15 20 27.00126
Desiree 2.10698168 0.7548219   28 28 16.15569
Unica   1.03956820 1.7372299   22  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
ASI.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
               ASI       SSI rASI rY    means
102.18  0.91512303 1.0839450   20 23 26.31947
104.22  0.39631322 1.5415455    6 13 31.28887
121.31  0.62108102 1.3141619   10 15 30.10174
141.28  1.20927797 1.4671376   25  1 39.75624
157.26  0.89176583 1.4365328   17  5 36.95181
```

```
163.9   1.19833464 0.8707513   24 27 21.41747
221.19  0.48765291 1.1731344    8 26 22.98480
233.11  0.28677206 1.6551898    4 17 28.66655
235.6   1.01971997 1.4623334   21  4 38.63477
241.2   0.45406877 1.3138836    7 22 26.34039
255.7   0.90124720 1.2266562   19 14 30.58975
314.12  0.78962523 1.1802765   12 18 28.17335
317.6   0.59211183 1.5007728    9  9 35.32583
319.20  1.81826161 1.3773527   27  3 38.75767
320.16  0.89897900 1.0889326   18 21 26.34808
342.15  0.79099371 1.1093959   13 24 26.01336
346.2   1.40292793 0.9246517   26 25 23.84175
351.26  0.80654291 1.4337564   14  8 36.11581
364.21  0.19598368 2.1648057    2 10 34.05974
402.7   0.07583976 3.6203374    1 19 27.47748
405.2   1.07822942 1.1367545   23 16 28.98663
406.12  0.69418710 1.3632981   11 12 32.68323
427.7   0.31056699 1.8452998    5  7 36.19020
450.3   0.85094150 1.4230055   16  6 36.19602
506.2   0.20336120 2.1006861    3 11 33.26623
Canchan 0.83849670 1.1268084   15 20 27.00126
Desiree 2.10698168 0.6248300   28 28 16.15569
Unica   1.03956820 1.4737642   22  2 39.10400
```

**ASTAB.AMMI()**

```
# With default n (N') and default ssi.method (farshadfar)
ASTAB.AMMI(model)
```

```
              ASTAB SSI rASTAB rY    means
102.18   3.89636621  39     16 23 26.31947
104.22   2.19372771  21      8 13 31.28887
121.31   3.87988776  29     14 15 30.10174
141.28   7.24523520  23     22  1 39.75624
157.26  11.05196482  31     26  5 36.95181
163.9    4.64005014  46     19 27 21.41747
221.19   1.52227265  30      4 26 22.98480
233.11   2.18330553  24      7 17 28.66655
235.6   10.03128021  28     24  4 38.63477
241.2    1.65890425  27      5 22 26.34039
255.7    4.50083178  32     18 14 30.58975
314.12   2.58839912  27      9 18 28.17335
317.6    1.77133006  15      6  9 35.32583
319.20  14.26494686  30     27  3 38.75767
320.16   3.13335427  32     11 21 26.34808
342.15   3.16217247  36     12 24 26.01336
346.2    7.47744386  48     23 25 23.84175
351.26   7.10182225  29     21  8 36.11581
364.21   0.27632429  12      2 10 34.05974
402.7    0.02344768  20      1 19 27.47748
405.2    4.07390905  33     17 16 28.98663
406.12   3.88758910  27     15 12 32.68323
427.7    1.43512423  10      3  7 36.19020
450.3    3.56798827  19     13  6 36.19602
```

```
506.2    2.71214267  21      10 11 33.26623
Canchan  5.13246683  40      20 20 27.00126
Desiree 16.47021287  56      28 28 16.15569
Unica   10.49672952  27      25  2 39.10400
```

```
# With n = 4 and default ssi.method (farshadfar)
ASTAB.AMMI(model, n = 4)
```

```
              ASTAB SSI rASTAB rY    means
102.18    4.1339139  36     13 23 26.31947
104.22    2.3887379  21      8 13 31.28887
121.31    8.8192568  38     23 15 30.10174
141.28    7.3090299  22     21  1 39.75624
157.26   14.9147148  31     26  5 36.95181
163.9     4.8975417  45     18 27 21.41747
221.19    1.5353874  29      3 26 22.98480
233.11    2.2356017  24      7 17 28.66655
235.6    11.0719467  29     25  4 38.63477
241.2     1.7489308  27      5 22 26.34039
255.7     4.6032909  30     16 14 30.58975
314.12    2.5919840  27      9 18 28.17335
317.6     2.1098263  15      6  9 35.32583
319.20   15.5173080  30     27  3 38.75767
320.16    4.8783163  38     17 21 26.34808
342.15    4.4168665  39     15 24 26.01336
346.2     8.3050795  47     22 25 23.84175
351.26    7.1030587  28     20  8 36.11581
364.21    0.8834847  12      2 10 34.05974
402.7     0.1536666  20      1 19 27.47748
405.2     4.3356781  30     14 16 28.98663
406.12    4.0365553  24     12 12 32.68323
427.7     1.7169781  11      4  7 36.19020
450.3     3.9433912  17     11  6 36.19602
506.2     2.7143137  21     10 11 33.26623
Canchan   5.1384242  39     19 20 27.00126
Desiree  16.4723733  56     28 28 16.15569
Unica    10.9110354  26     24  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
ASTAB.AMMI(model, ssi.method = "rao")
```

```
               ASTAB       SSI rASTAB rY    means
102.18    3.89636621 0.9916073     16 23 26.31947
104.22    2.19372771 1.2572096      8 13 31.28887
121.31    3.87988776 1.1154972     14 15 30.10174
141.28    7.24523520 1.3680406     22  1 39.75624
157.26   11.05196482 1.2518822     26  5 36.95181
163.9     4.64005014 0.8103867     19 27 21.41747
221.19    1.52227265 1.0909958      4 26 22.98480
233.11    2.18330553 1.1728390      7 17 28.66655
235.6    10.03128021 1.3115430     24  4 38.63477
241.2     1.65890425 1.1722749      5 22 26.34039
255.7     4.50083178 1.1129205     18 14 30.58975
314.12    2.58839912 1.1194868      9 18 28.17335
317.6     1.77133006 1.4453573      6  9 35.32583
```

```
319.20  14.26494686  1.3001667     27  3 38.75767
320.16   3.13335427  1.0250358     11 21 26.34808
342.15   3.16217247  1.0126098     12 24 26.01336
346.2    7.47744386  0.8469106     23 25 23.84175
351.26   7.10182225  1.2507915     21  8 36.11581
364.21   0.27632429  2.9922101      2 10 34.05974
402.7    0.02344768 23.0708927      1 19 27.47748
405.2    4.07390905  1.0727560     17 16 28.98663
406.12   3.88758910  1.1994027     15 12 32.68323
427.7    1.43512423  1.5423074      3  7 36.19020
450.3    3.56798827  1.3259199     13  6 36.19602
506.2    2.71214267  1.2763780     10 11 33.26623
Canchan  5.13246683  0.9816986     20 20 27.00126
Desiree 16.47021287  0.5583351     28 28 16.15569
Unica   10.49672952  1.3245441     25  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
ASTAB.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
              ASTAB        SSI rASTAB rY    means
102.18   3.89636621  0.9155436     16 23 26.31947
104.22   2.19372771  1.1221097      8 13 31.28887
121.31   3.87988776  1.0391104     14 15 30.10174
141.28   7.24523520  1.3271348     22  1 39.75624
157.26  11.05196482  1.2250659     26  5 36.95181
163.9    4.64005014  0.7465140     19 27 21.41747
221.19   1.52227265  0.8963051      4 26 22.98480
233.11   2.18330553  1.0370941      7 17 28.66655
235.6   10.03128021  1.2819982     24  4 38.63477
241.2    1.65890425  0.9936194      5 22 26.34039
255.7    4.50083178  1.0470721     18 14 30.58975
314.12   2.58839912  1.0049865      9 18 28.17335
317.6    1.77133006  1.2780410      6  9 35.32583
319.20  14.26494686  1.2793904     27  3 38.75767
320.16   3.13335427  0.9304495     11 21 26.34808
342.15   3.16217247  0.9188855     12 24 26.01336
346.2    7.47744386  0.8072751     23 25 23.84175
351.26   7.10182225  1.2090596     21  8 36.11581
364.21   0.27632429  1.9196572      2 10 34.05974
402.7    0.02344768 10.4311581      1 19 27.47748
405.2    4.07390905  1.0000071     17 16 28.98663
406.12   3.88758910  1.1231672     15 12 32.68323
427.7    1.43512423  1.3357940      3  7 36.19020
450.3    3.56798827  1.2428556     13  6 36.19602
506.2    2.71214267  1.1671018     10 11 33.26623
Canchan  5.13246683  0.9239540     20 20 27.00126
Desiree 16.47021287  0.5403407     28 28 16.15569
Unica   10.49672952  1.2963093     25  2 39.10400
```

**`AVAMGE.AMMI()`**

```r
# With default n (N') and default ssi.method (farshadfar)
AVAMGE.AMMI(model)
```

```
           AVAMGE SSI rAVAMGE rY    means
```

```
102.18   30.229771  40       17 23 26.31947
104.22   21.584579  21        8 13 31.28887
121.31   27.893984  28       13 15 30.10174
141.28   40.486706  24       23  1 39.75624
157.26   44.055803  29       24  5 36.95181
163.9    39.056228  48       21 27 21.41747
221.19   17.905975  33        7 26 22.98480
233.11   16.242635  21        4 17 28.66655
235.6    39.840739  26       22  4 38.63477
241.2    17.101113  28        6 22 26.34039
255.7    29.306918  29       15 14 30.58975
314.12   28.760304  32       14 18 28.17335
317.6    22.700856  18        9  9 35.32583
319.20   55.232023  30       27  3 38.75767
320.16   30.717681  40       19 21 26.34808
342.15   25.538281  34       10 24 26.01336
346.2    46.236590  50       25 25 23.84175
351.26   30.105573  24       16  8 36.11581
364.21    6.742386  12        2 10 34.05974
402.7     2.202291  20        1 19 27.47748
405.2    35.890684  36       20 16 28.98663
406.12   27.272847  24       12 12 32.68323
427.7    16.756971  12        5  7 36.19020
450.3    25.628188  17       11  6 36.19602
506.2    15.760611  14        3 11 33.26623
Canchan  30.515224  38       18 20 27.00126
Desiree  69.096357  56       28 28 16.15569
Unica    47.204593  28       26  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
AVAMGE.AMMI(model, n = 4)
```

```
           AVAMGE SSI rAVAMGE rY    means
102.18   30.431550  39       16 23 26.31947
104.22   21.176775  21        8 13 31.28887
121.31   34.844853  34       19 15 30.10174
141.28   40.382139  24       23  1 39.75624
157.26   49.421992  31       26  5 36.95181
163.9    38.846149  48       21 27 21.41747
221.19   17.858564  33        7 26 22.98480
233.11   17.449539  23        6 17 28.66655
235.6    39.657410  26       22  4 38.63477
241.2    17.225331  27        5 22 26.34039
255.7    29.585043  28       14 14 30.58975
314.12   28.801567  31       13 18 28.17335
317.6    23.101824  18        9  9 35.32583
319.20   55.695327  30       27  3 38.75767
320.16   31.566364  39       18 21 26.34808
342.15   26.310253  35       11 24 26.01336
346.2    46.863568  50       25 25 23.84175
351.26   29.920025  23       15  8 36.11581
364.21    9.635146  12        2 10 34.05974
402.7     3.665565  20        1 19 27.47748
405.2    35.538076  36       20 16 28.98663
406.12   26.916422  24       12 12 32.68323
```

```
427.7   16.266701  11       4  7 36.19020
450.3   25.622916  16      10  6 36.19602
506.2   15.709209  14       3 11 33.26623
Canchan 30.908627  37      17 20 27.00126
Desiree 69.115600  56      28 28 16.15569
Unica   46.610186  26      24  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
AVAMGE.AMMI(model, ssi.method = "rao")
```

```
           AVAMGE       SSI rAVAMGE rY    means
102.18  30.229771 1.4579240      17 23 26.31947
104.22  21.584579 1.8601746       8 13 31.28887
121.31  27.893984 1.6314700      13 15 30.10174
141.28  40.486706 1.7440938      23  1 39.75624
157.26  44.055803 1.6163747      24  5 36.95181
163.9   39.056228 1.1625489      21 27 21.41747
221.19  17.905975 1.7619814       7 26 22.98480
233.11  16.242635 2.0509293       4 17 28.66655
235.6   39.840739 1.7147885      22  4 38.63477
241.2   17.101113 1.9190480       6 22 26.34039
255.7   29.306918 1.6160450      15 14 30.58975
314.12  28.760304 1.5490150      14 18 28.17335
317.6   22.700856 1.9504975       9  9 35.32583
319.20  55.232023 1.5919808      27  3 38.75767
320.16  30.717681 1.4493304      19 21 26.34808
342.15  25.538281 1.5581219      10 24 26.01336
346.2   46.236590 1.1695027      25 25 23.84175
351.26  30.105573 1.7798138      16  8 36.11581
364.21   6.742386 3.7995961       2 10 34.05974
402.7    2.202291 9.1285592       1 19 27.47748
405.2   35.890684 1.4502899      20 16 28.98663
406.12  27.272847 1.7304443      12 12 32.68323
427.7   16.756971 2.2619806       5  7 36.19020
450.3   25.628188 1.8876432      11  6 36.19602
506.2   15.760611 2.2350438       3 11 33.26623
Canchan 30.515224 1.4745437      18 20 27.00126
Desiree 69.096357 0.7891628      28 28 16.15569
Unica   47.204593 1.6590963      26  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
AVAMGE.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
           AVAMGE       SSI rAVAMGE rY    means
102.18  30.229771 1.1160597      17 23 26.31947
104.22  21.584579 1.3813847       8 13 31.28887
121.31  27.893984 1.2609787      13 15 30.10174
141.28  40.486706 1.4888376      23  1 39.75624
157.26  44.055803 1.3817977      24  5 36.95181
163.9   39.056228 0.8979438      21 27 21.41747
221.19  17.905975 1.1848289       7 26 22.98480
233.11  16.242635 1.4146730       4 17 28.66655
235.6   39.840739 1.4553938      22  4 38.63477
241.2   17.101113 1.3147318       6 22 26.34039
255.7   29.306918 1.2634156      15 14 30.58975
314.12  28.760304 1.1896837      14 18 28.17335
```

```
317.6   22.700856 1.4952513       9  9 35.32583
319.20  55.232023 1.4048705      27  3 38.75767
320.16  30.717681 1.1128962      19 21 26.34808
342.15  25.538281 1.1534557      10 24 26.01336
346.2   46.236590 0.9459897      25 25 23.84175
351.26  30.105573 1.4365392      16  8 36.11581
364.21   6.742386 2.2668332       2 10 34.05974
402.7    2.202291 4.4359547       1 19 27.47748
405.2   35.890684 1.1623466      20 16 28.98663
406.12  27.272847 1.3515151      12 12 32.68323
427.7   16.756971 1.6452535       5  7 36.19020
450.3   25.628188 1.4843966      11  6 36.19602
506.2   15.760611 1.5793281       3 11 33.26623
Canchan 30.515224 1.1358773      18 20 27.00126
Desiree 69.096357 0.6395966      28 28 16.15569
Unica   47.204593 1.4401668      26  2 39.10400
```

**DA.AMMI()**

```
# With default n (N') and default ssi.method (farshadfar)
DA.AMMI(model)
```

```
               DA SSI rDA rY    means
102.18  15.040431  39  16 23 26.31947
104.22   9.798867  22   9 13 31.28887
121.31  12.917859  26  11 15 30.10174
141.28  19.659222  23  22  1 39.75624
157.26  21.459064  29  24  5 36.95181
163.9   17.499098  48  21 27 21.41747
221.19   8.507426  31   5 26 22.98480
233.11   8.981297  24   7 17 28.66655
235.6   21.941275  29  25  4 38.63477
241.2    8.453875  26   4 22 26.34039
255.7   15.423064  32  18 14 30.58975
314.12  12.222308  28  10 18 28.17335
317.6    9.592839  17   8  9 35.32583
319.20  28.986374  30  27  3 38.75767
320.16  13.835583  34  13 21 26.34808
342.15  13.025230  36  12 24 26.01336
346.2   21.230207  48  23 25 23.84175
351.26  17.269543  28  20  8 36.11581
364.21   3.781576  12   2 10 34.05974
402.7    1.191312  20   1 19 27.47748
405.2   16.027557  35  19 16 28.98663
406.12  13.989359  26  14 12 32.68323
427.7    7.507408  10   3  7 36.19020
450.3   14.270920  21  15  6 36.19602
506.2    8.954538  17   6 11 33.26623
Canchan 15.138085  37  17 20 27.00126
Desiree 32.114860  56  28 28 16.15569
Unica   22.343936  28  26  2 39.10400
```

```
# With n = 4 and default ssi.method (farshadfar)
DA.AMMI(model, n = 4)
```

```
               DA SSI rDA rY    means
102.18  15.185880  39  16 23 26.31947
104.22   9.981329  22   9 13 31.28887
121.31  16.071287  33  18 15 30.10174
141.28  19.689228  23  22  1 39.75624
157.26  23.064716  31  26  5 36.95181
163.9   17.634737  48  21 27 21.41747
221.19   8.521680  30   4 26 22.98480
233.11   9.035019  24   7 17 28.66655
235.6   22.375871  28  24  4 38.63477
241.2    8.551852  27   5 22 26.34039
255.7   15.484417  31  17 14 30.58975
314.12  12.225021  28  10 18 28.17335
317.6    9.913993  17   8  9 35.32583
319.20  29.383463  30  27  3 38.75767
320.16  14.957211  35  14 21 26.34808
342.15  13.888046  35  11 24 26.01336
346.2   21.587939  48  23 25 23.84175
351.26  17.270205  28  20  8 36.11581
364.21   5.053446  12   2 10 34.05974
402.7    1.956846  20   1 19 27.47748
405.2   16.177987  35  19 16 28.98663
406.12  14.087553  24  12 12 32.68323
427.7    7.847138  10   3  7 36.19020
450.3   14.512302  19  13  6 36.19602
506.2    8.956781  17   6 11 33.26623
Canchan 15.141726  35  15 20 27.00126
Desiree 32.115482  56  28 28 16.15569
Unica   22.514867  27  25  2 39.10400
```

```r
# With default n (N') and ssi.method = "rao"
DA.AMMI(model, ssi.method = "rao")
```

```
               DA       SSI rDA rY    means
102.18  15.040431 1.4730947  16 23 26.31947
104.22   9.798867 1.9640618   9 13 31.28887
121.31  12.917859 1.6974593  11 15 30.10174
141.28  19.659222 1.7667347  22  1 39.75624
157.26  21.459064 1.6358359  24  5 36.95181
163.9   17.499098 1.2268624  21 27 21.41747
221.19   8.507426 1.8365835   5 26 22.98480
233.11   8.981297 1.9644804   7 17 28.66655
235.6   21.941275 1.6812376  25  4 38.63477
241.2    8.453875 1.9528811   4 22 26.34039
255.7   15.423064 1.5970737  18 14 30.58975
314.12  12.222308 1.6753281  10 18 28.17335
317.6    9.592839 2.1159612   8  9 35.32583
319.20  28.986374 1.5827930  27  3 38.75767
320.16  13.835583 1.5275780  13 21 26.34808
342.15  13.025230 1.5582533  12 24 26.01336
346.2   21.230207 1.2130205  23 25 23.84175
351.26  17.269543 1.7131362  20  8 36.11581
364.21   3.781576 3.5563052   2 10 34.05974
402.7    1.191312 8.6595018   1 19 27.47748
405.2   16.027557 1.5221857  19 16 28.98663
```

```
406.12  13.989359 1.7267910  14 12 32.68323
427.7    7.507408 2.4119665   3  7 36.19020
450.3   14.270920 1.8282838  15  6 36.19602
506.2    8.954538 2.1175331   6 11 33.26623
Canchan 15.138085 1.4913580  17 20 27.00126
Desiree 32.114860 0.8147588  28 28 16.15569
Unica   22.343936 1.6889406  26  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
DA.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
               DA       SSI rDA rY    means
102.18  15.040431 1.1225831  16 23 26.31947
104.22   9.798867 1.4260562   9 13 31.28887
121.31  12.917859 1.2893541  11 15 30.10174
141.28  19.659222 1.4985733  22  1 39.75624
157.26  21.459064 1.3901660  24  5 36.95181
163.9   17.499098 0.9255986  21 27 21.41747
221.19   8.507426 1.2169078   5 26 22.98480
233.11   8.981297 1.3775000   7 17 28.66655
235.6   21.941275 1.4409668  25  4 38.63477
241.2    8.453875 1.3292801   4 22 26.34039
255.7   15.423064 1.2552580  18 14 30.58975
314.12  12.222308 1.2439983  10 18 28.17335
317.6    9.592839 1.5664007   8  9 35.32583
319.20  28.986374 1.4009197  27  3 38.75767
320.16  13.835583 1.1465427  13 21 26.34808
342.15  13.025230 1.1535122  12 24 26.01336
346.2   21.230207 0.9647024  23 25 23.84175
351.26  17.269543 1.4078678  20  8 36.11581
364.21   3.781576 2.1622181   2 10 34.05974
402.7    1.191312 4.2342600   1 19 27.47748
405.2   16.027557 1.1932619  19 16 28.98663
406.12  13.989359 1.3499442  14 12 32.68323
427.7    7.507408 1.7097474   3  7 36.19020
450.3   14.270920 1.4588721  15  6 36.19602
506.2    8.954538 1.5287986   6 11 33.26623
Canchan 15.138085 1.1431075  17 20 27.00126
Desiree 32.114860 0.6506029  28 28 16.15569
Unica   22.343936 1.4529998  26  2 39.10400
```

**DZ.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
DZ.AMMI(model)
```

```
                DZ SSI rDZ rY    means
102.18  0.26393535  37  14 23 26.31947
104.22  0.22971564  21   8 13 31.28887
121.31  0.32031744  34  19 15 30.10174
141.28  0.39838535  23  22  1 39.75624
157.26  0.53822924  33  28  5 36.95181
163.9   0.26659011  42  15 27 21.41747
221.19  0.19563325  29   3 26 22.98480
233.11  0.25167755  27  10 17 28.66655
```

```
235.6   0.46581370  28  24  4 38.63477
241.2   0.21481887  28   6 22 26.34039
255.7   0.30862904  31  17 14 30.58975
314.12  0.22603261  25   7 18 28.17335
317.6   0.20224771  14   5  9 35.32583
319.20  0.50675112  29  26  3 38.75767
320.16  0.23280596  30   9 21 26.34808
342.15  0.25989774  36  12 24 26.01336
346.2   0.37125512  45  20 25 23.84175
351.26  0.43805896  31  23  8 36.11581
364.21  0.07409309  12   2 10 34.05974
402.7   0.02004533  20   1 19 27.47748
405.2   0.26238837  29  13 16 28.98663
406.12  0.28179394  28  16 12 32.68323
427.7   0.20176581  11   4  7 36.19020
450.3   0.25465368  17  11  6 36.19602
506.2   0.30899851  29  18 11 33.26623
Canchan 0.37201039  41  21 20 27.00126
Desiree 0.52005815  55  27 28 16.15569
Unica   0.48083049  27  25  2 39.10400
```

```
# With n = 4 and default ssi.method (farshadfar)
DZ.AMMI(model, n = 4)
```

```
                DZ SSI rDZ rY    means
102.18  0.28722309  33  10 23 26.31947
104.22  0.25160706  21   8 13 31.28887
121.31  0.60785568  42  27 15 30.10174
141.28  0.40268829  21  20  1 39.75624
157.26  0.70597721  33  28  5 36.95181
163.9   0.29151868  39  12 27 21.41747
221.19  0.19743603  29   3 26 22.98480
233.11  0.25722999  26   9 17 28.66655
235.6   0.52269682  29  25  4 38.63477
241.2   0.22585722  26   4 22 26.34039
255.7   0.31747123  30  16 14 30.58975
314.12  0.22646067  23   5 18 28.17335
317.6   0.24329787  16   7  9 35.32583
319.20  0.56961794  29  26  3 38.75767
320.16  0.38533472  40  19 21 26.34808
342.15  0.36788692  41  17 24 26.01336
346.2   0.42725798  46  21 25 23.84175
351.26  0.43813521  30  22  8 36.11581
364.21  0.19569373  12   2 10 34.05974
402.7   0.08624291  20   1 19 27.47748
405.2   0.28808268  27  11 16 28.98663
406.12  0.29573097  26  14 12 32.68323
427.7   0.23651352  13   6  7 36.19020
450.3   0.29177451  19  13  6 36.19602
506.2   0.30918827  26  15 11 33.26623
Canchan 0.37244277  38  18 20 27.00126
Desiree 0.52017037  52  24 28 16.15569
Unica   0.50357109  25  23  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
DZ.AMMI(model, ssi.method = "rao")
```

```
                DZ        SSI rDZ rY    means
102.18  0.26393535  1.5536988  14 23 26.31947
104.22  0.22971564  1.8193399   8 13 31.28887
121.31  0.32031744  1.5545939  19 15 30.10174
141.28  0.39838535  1.7570779  22  1 39.75624
157.26  0.53822924  1.5459114  28  5 36.95181
163.9   0.26659011  1.3869397  15 27 21.41747
221.19  0.19563325  1.6878048   3 26 22.98480
233.11  0.25167755  1.6641025  10 17 28.66655
235.6   0.46581370  1.6538090  24  4 38.63477
241.2   0.21481887  1.7134093   6 22 26.34039
255.7   0.30862904  1.5922105  17 14 30.58975
314.12  0.22603261  1.7307783   7 18 28.17335
317.6   0.20224771  2.0595024   5  9 35.32583
319.20  0.50675112  1.6259792  26  3 38.75767
320.16  0.23280596  1.6476346   9 21 26.34808
342.15  0.25989774  1.5545233  12 24 26.01336
346.2   0.37125512  1.2718506  20 25 23.84175
351.26  0.43805896  1.5966462  23  8 36.11581
364.21  0.07409309  3.5881882   2 10 34.05974
402.7   0.02004533 10.0539968   1 19 27.47748
405.2   0.26238837  1.6447637  13 16 28.98663
406.12  0.28179394  1.7171135  16 12 32.68323
427.7   0.20176581  2.0898536   4  7 36.19020
450.3   0.25465368  1.9010808  11  6 36.19602
506.2   0.30899851  1.6787677  18 11 33.26623
Canchan 0.37201039  1.3738642  21 20 27.00126
Desiree 0.52005815  0.8797586  27 28 16.15569
Unica   0.48083049  1.6568004  25  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
DZ.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
                DZ       SSI rDZ rY    means
102.18  0.26393535 1.1572429  14 23 26.31947
104.22  0.22971564 1.3638258   8 13 31.28887
121.31  0.32031744 1.2279220  19 15 30.10174
141.28  0.39838535 1.4944208  22  1 39.75624
157.26  0.53822924 1.3514985  28  5 36.95181
163.9   0.26659011 0.9944318  15 27 21.41747
221.19  0.19563325 1.1529329   3 26 22.98480
233.11  0.25167755 1.2483375  10 17 28.66655
235.6   0.46581370 1.4291726  24  4 38.63477
241.2   0.21481887 1.2263072   6 22 26.34039
255.7   0.30862904 1.2531668  17 14 30.58975
314.12  0.22603261 1.2678419   7 18 28.17335
317.6   0.20224771 1.5421234   5  9 35.32583
319.20  0.50675112 1.4194898  26  3 38.75767
320.16  0.23280596 1.1981670   9 21 26.34808
342.15  0.25989774 1.1519083  12 24 26.01336
346.2   0.37125512 0.9899993  20 25 23.84175
351.26  0.43805896 1.3577771  23  8 36.11581
```

```
364.21  0.07409309 2.1759278   2 10 34.05974
402.7   0.02004533 4.8338929   1 19 27.47748
405.2   0.26238837 1.2459704  13 16 28.98663
406.12  0.28179394 1.3457828  16 12 32.68323
427.7   0.20176581 1.5712389   4  7 36.19020
450.3   0.25465368 1.4901748  11  6 36.19602
506.2   0.30899851 1.3401295  18 11 33.26623
Canchan 0.37201039 1.0925852  21 20 27.00126
Desiree 0.52005815 0.6785528  27 28 16.15569
Unica   0.48083049 1.4391795  25  2 39.10400
```

**EV.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
EV.AMMI(model)
```

```
                  EV SSI rEV rY    means
102.18  0.0232206231  37  14 23 26.31947
104.22  0.0175897578  21   8 13 31.28887
121.31  0.0342010876  34  19 15 30.10174
141.28  0.0529036285  23  22  1 39.75624
157.26  0.0965635719  33  28  5 36.95181
163.9   0.0236900961  42  15 27 21.41747
221.19  0.0127574566  29   3 26 22.98480
233.11  0.0211138628  27  10 17 28.66655
235.6   0.0723274691  28  24  4 38.63477
241.2   0.0153823821  28   6 22 26.34039
255.7   0.0317506280  31  17 14 30.58975
314.12  0.0170302467  25   7 18 28.17335
317.6   0.0136347120  14   5  9 35.32583
319.20  0.0855988994  29  26  3 38.75767
320.16  0.0180662044  30   9 21 26.34808
342.15  0.0225156118  36  12 24 26.01336
346.2   0.0459434537  45  20 25 23.84175
351.26  0.0639652186  31  23  8 36.11581
364.21  0.0018299284  12   2 10 34.05974
402.7   0.0001339385  20   1 19 27.47748
405.2   0.0229492190  29  13 16 28.98663
406.12  0.0264692745  28  16 12 32.68323
427.7   0.0135698145  11   4  7 36.19020
450.3   0.0216161656  17  11  6 36.19602
506.2   0.0318266934  29  18 11 33.26623
Canchan 0.0461305761  41  21 20 27.00126
Desiree 0.0901534938  55  27 28 16.15569
Unica   0.0770659860  27  25  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
EV.AMMI(model, n = 4)
```

```
                 EV SSI rEV rY    means
102.18  0.020624276  33  10 23 26.31947
104.22  0.015826528  21   8 13 31.28887
121.31  0.092372131  42  27 15 30.10174
141.28  0.040539465  21  20  1 39.75624
157.26  0.124600955  33  28  5 36.95181
```

```
163.9   0.021245785  39  12 27 21.41747
221.19  0.009745247  29   3 26 22.98480
233.11  0.016541818  26   9 17 28.66655
235.6   0.068302992  29  25  4 38.63477
241.2   0.012752871  26   4 22 26.34039
255.7   0.025196996  30  16 14 30.58975
314.12  0.012821109  23   5 18 28.17335
317.6   0.014798464  16   7  9 35.32583
319.20  0.081116150  29  26  3 38.75767
320.16  0.037120712  40  19 21 26.34808
342.15  0.033835196  41  17 24 26.01336
346.2   0.045637346  46  21 25 23.84175
351.26  0.047990616  30  22  8 36.11581
364.21  0.009574009  12   2 10 34.05974
402.7   0.001859460  20   1 19 27.47748
405.2   0.020747907  27  11 16 28.98663
406.12  0.021864201  26  14 12 32.68323
427.7   0.013984661  13   6  7 36.19020
450.3   0.021283092  19  13  6 36.19602
506.2   0.023899346  26  15 11 33.26623
Canchan 0.034678404  38  18 20 27.00126
Desiree 0.067644303  52  24 28 16.15569
Unica   0.063395960  25  23  2 39.10400
```

```r
# With default n (N') and ssi.method = "rao"
EV.AMMI(model, ssi.method = "rao")
```

```
                  EV         SSI rEV rY    means
102.18  0.0232206231  0.9920136  14 23 26.31947
104.22  0.0175897578  1.1968926   8 13 31.28887
121.31  0.0342010876  1.0723629  19 15 30.10174
141.28  0.0529036285  1.3550266  22  1 39.75624
157.26  0.0965635719  1.2370234  28  5 36.95181
163.9   0.0236900961  0.8295284  15 27 21.41747
221.19  0.0127574566  0.9930645   3 26 22.98480
233.11  0.0211138628  1.0818975  10 17 28.66655
235.6   0.0723274691  1.3026828  24  4 38.63477
241.2   0.0153823821  1.0609011   6 22 26.34039
255.7   0.0317506280  1.0952885  17 14 30.58975
314.12  0.0170302467  1.1011148   7 18 28.17335
317.6   0.0136347120  1.3797760   5  9 35.32583
319.20  0.0855988994  1.3000274  26  3 38.75767
320.16  0.0180662044  1.0311353   9 21 26.34808
342.15  0.0225156118  0.9862240  12 24 26.01336
346.2   0.0459434537  0.8450255  20 25 23.84175
351.26  0.0639652186  1.2261684  23  8 36.11581
364.21  0.0018299284  2.8090292   2 10 34.05974
402.7   0.0001339385 24.1014741   1 19 27.47748
405.2   0.0229492190  1.0805609  13 16 28.98663
406.12  0.0264692745  1.1830798  16 12 32.68323
427.7   0.0135698145  1.4090495   4  7 36.19020
450.3   0.0216161656  1.3239797  11  6 36.19602
506.2   0.0318266934  1.1823230  18 11 33.26623
Canchan 0.0461305761  0.9477687  21 20 27.00126
Desiree 0.0901534938  0.5612418  27 28 16.15569
```

```
Unica   0.0770659860  1.3153400  25  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
EV.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
                  EV        SSI rEV rY    means
102.18  0.0232206231  0.9157183  14 23 26.31947
104.22  0.0175897578  1.0961734   8 13 31.28887
121.31  0.0342010876  1.0205626  19 15 30.10174
141.28  0.0529036285  1.3215387  22  1 39.75624
157.26  0.0965635719  1.2186766  28  5 36.95181
163.9   0.0236900961  0.7547449  15 27 21.41747
221.19  0.0127574566  0.8541946   3 26 22.98480
233.11  0.0211138628  0.9979893  10 17 28.66655
235.6   0.0723274691  1.2781883  24  4 38.63477
241.2   0.0153823821  0.9457286   6 22 26.34039
255.7   0.0317506280  1.0394903  17 14 30.58975
314.12  0.0170302467  0.9970866   7 18 28.17335
317.6   0.0136347120  1.2498410   5  9 35.32583
319.20  0.0855988994  1.2793305  26  3 38.75767
320.16  0.0180662044  0.9330723   9 21 26.34808
342.15  0.0225156118  0.9075396  12 24 26.01336
346.2   0.0459434537  0.8064645  20 25 23.84175
351.26  0.0639652186  1.1984717  23  8 36.11581
364.21  0.0018299284  1.8408895   2 10 34.05974
402.7   0.0001339385 10.8743081   1 19 27.47748
405.2   0.0229492190  1.0033632  13 16 28.98663
406.12  0.0264692745  1.1161483  16 12 32.68323
427.7   0.0135698145  1.2784931   4  7 36.19020
450.3   0.0216161656  1.2420213  11  6 36.19602
506.2   0.0318266934  1.1266582  18 11 33.26623
Canchan 0.0461305761  0.9093641  21 20 27.00126
Desiree 0.0901534938  0.5415905  27 28 16.15569
Unica   0.0770659860  1.2923516  25  2 39.10400
```

**FA.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
FA.AMMI(model)
```

```
                FA SSI rFA rY    means
102.18  226.214559  39  16 23 26.31947
104.22   96.017789  22   9 13 31.28887
121.31  166.871081  26  11 15 30.10174
141.28  386.485026  23  22  1 39.75624
157.26  460.491413  29  24  5 36.95181
163.9   306.218437  48  21 27 21.41747
221.19   72.376305  31   5 26 22.98480
233.11   80.663694  24   7 17 28.66655
235.6   481.419528  29  25  4 38.63477
241.2    71.468008  26   4 22 26.34039
255.7   237.870912  32  18 14 30.58975
314.12  149.384801  28  10 18 28.17335
317.6    92.022551  17   8  9 35.32583
319.20  840.209886  30  27  3 38.75767
```

```
320.16   191.423345  34  13 21 26.34808
342.15   169.656627  36  12 24 26.01336
346.2    450.721670  48  23 25 23.84175
351.26   298.237108  28  20  8 36.11581
364.21    14.300314  12   2 10 34.05974
402.7      1.419225  20   1 19 27.47748
405.2    256.882577  35  19 16 28.98663
406.12   195.702153  26  14 12 32.68323
427.7     56.361179  10   3  7 36.19020
450.3    203.659148  21  15  6 36.19602
506.2     80.183743  17   6 11 33.26623
Canchan  229.161607  37  17 20 27.00126
Desiree 1031.364210  56  28 28 16.15569
Unica    499.251489  28  26  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
FA.AMMI(model, n = 4)
```

```
                 FA SSI rFA rY    means
102.18   230.610963  39  16 23 26.31947
104.22    99.626933  22   9 13 31.28887
121.31   258.286270  33  18 15 30.10174
141.28   387.665704  23  22  1 39.75624
157.26   531.981114  31  26  5 36.95181
163.9    310.983953  48  21 27 21.41747
221.19    72.619025  30   4 26 22.98480
233.11    81.631564  24   7 17 28.66655
235.6    500.679624  28  24  4 38.63477
241.2     73.134171  27   5 22 26.34039
255.7    239.767170  31  17 14 30.58975
314.12   149.451148  28  10 18 28.17335
317.6     98.287259  17   8  9 35.32583
319.20   863.387913  30  27  3 38.75767
320.16   223.718164  35  14 21 26.34808
342.15   192.877830  35  11 24 26.01336
346.2    466.039106  48  23 25 23.84175
351.26   298.259992  28  20  8 36.11581
364.21    25.537314  12   2 10 34.05974
402.7      3.829248  20   1 19 27.47748
405.2    261.727258  35  19 16 28.98663
406.12   198.459140  24  12 12 32.68323
427.7     61.577580  10   3  7 36.19020
450.3    210.606905  19  13  6 36.19602
506.2     80.223923  17   6 11 33.26623
Canchan  229.271862  35  15 20 27.00126
Desiree 1031.404193  56  28 28 16.15569
Unica    506.919240  27  25  2 39.10400
```

```r
# With default n (N') and ssi.method = "rao"
FA.AMMI(model, ssi.method = "rao")
```

```
                 FA       SSI rFA rY    means
102.18   226.214559 0.9902913  16 23 26.31947
104.22    96.017789 1.3314840   9 13 31.28887
121.31   166.871081 1.1606028  11 15 30.10174
```

```
141.28   386.485026  1.3736129  22  1 39.75624
157.26   460.491413  1.2697440  24  5 36.95181
163.9    306.218437  0.7959379  21 27 21.41747
221.19    72.376305  1.1624072   5 26 22.98480
233.11    80.663694  1.3052353   7 17 28.66655
235.6    481.419528  1.3217963  25  4 38.63477
241.2     71.468008  1.2770668   4 22 26.34039
255.7    237.870912  1.1230515  18 14 30.58975
314.12   149.384801  1.1186933  10 18 28.17335
317.6     92.022551  1.4766266   8  9 35.32583
319.20   840.209886  1.2992910  27  3 38.75767
320.16   191.423345  1.0152386  13 21 26.34808
342.15   169.656627  1.0243579  12 24 26.01336
346.2    450.721670  0.8436895  23 25 23.84175
351.26   298.237108  1.2777984  20  8 36.11581
364.21    14.300314  3.2006702   2 10 34.05974
402.7      1.419225 21.9563817   1 19 27.47748
405.2    256.882577  1.0614812  19 16 28.98663
406.12   195.702153  1.2183859  14 12 32.68323
427.7     56.361179  1.7103246   3  7 36.19020
450.3    203.659148  1.3269556  15  6 36.19602
506.2     80.183743  1.4574286   6 11 33.26623
Canchan  229.161607  1.0108222  17 20 27.00126
Desiree 1031.364210  0.5557465  28 28 16.15569
Unica    499.251489  1.3348781  26  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
FA.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
                 FA       SSI rFA rY    means
102.18   226.214559 0.9149776  16 23 26.31947
104.22    96.017789 1.1540477   9 13 31.28887
121.31   166.871081 1.0585058  11 15 30.10174
141.28   386.485026 1.3295309  22  1 39.75624
157.26   460.491413 1.2327465  24  5 36.95181
163.9    306.218437 0.7403010  21 27 21.41747
221.19    72.376305 0.9270120   5 26 22.98480
233.11    80.663694 1.0940246   7 17 28.66655
235.6    481.419528 1.2864071  25  4 38.63477
241.2     71.468008 1.0386799   4 22 26.34039
255.7    237.870912 1.0514284  18 14 30.58975
314.12   149.384801 1.0046453  10 18 28.17335
317.6     92.022551 1.2914868   8  9 35.32583
319.20   840.209886 1.2790139  27  3 38.75767
320.16   191.423345 0.9262367  13 21 26.34808
342.15   169.656627 0.9239372  12 24 26.01336
346.2    450.721670 0.8058900  23 25 23.84175
351.26   298.237108 1.2206726  20  8 36.11581
364.21    14.300314 2.0092951   2 10 34.05974
402.7      1.419225 9.9519184   1 19 27.47748
405.2    256.882577 0.9951589  19 16 28.98663
406.12   195.702153 1.1313300  14 12 32.68323
427.7     56.361179 1.4080414   3  7 36.19020
450.3    203.659148 1.2433009  15  6 36.19602
506.2     80.183743 1.2449536   6 11 33.26623
```

```
Canchan   229.161607 0.9364771  17 20 27.00126
Desiree 1031.364210 0.5392276  28 28 16.15569
Unica    499.251489 1.3007530  26  2 39.10400
```

**MASV.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
MASV.AMMI(model)
```

```
             MASV SSI rMASV rY    means
102.18  4.7855876  42    19 23 26.31947
104.22  3.8328358  25    12 13 31.28887
121.31  4.0446758  29    14 15 30.10174
141.28  5.1867706  21    20  1 39.75624
157.26  7.6459224  29    24  5 36.95181
163.9   4.4977055  43    16 27 21.41747
221.19  2.1905344  31     5 26 22.98480
233.11  3.1794345  26     9 17 28.66655
235.6   8.4913020  29    25  4 38.63477
241.2   2.0338659  26     4 22 26.34039
255.7   4.7013868  32    18 14 30.58975
314.12  3.1376678  26     8 18 28.17335
317.6   2.3345492  15     6  9 35.32583
319.20  8.6398087  30    27  3 38.75767
320.16  3.8822326  34    13 21 26.34808
342.15  3.6438425  34    10 24 26.01336
346.2   5.3987165  47    22 25 23.84175
351.26  5.4005468  31    23  8 36.11581
364.21  1.4047546  12     2 10 34.05974
402.7   0.3537818  20     1 19 27.47748
405.2   4.1095727  31    15 16 28.98663
406.12  5.3218165  33    21 12 32.68323
427.7   2.4124676  14     7  7 36.19020
450.3   4.6608954  23    17  6 36.19602
506.2   1.9330143  14     3 11 33.26623
Canchan 3.6665608  31    11 20 27.00126
Desiree 9.0626072  56    28 28 16.15569
Unica   8.5447632  28    26  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
MASV.AMMI(model, n = 4)
```

```
             MASV SSI rMASV rY    means
102.18  4.8247593  39    16 23 26.31947
104.22  4.0510711  23    10 13 31.28887
121.31  5.2473236  34    19 15 30.10174
141.28  5.9101338  23    22  1 39.75624
157.26  8.7719153  30    25  5 36.95181
163.9   4.5459209  41    14 27 21.41747
221.19  2.7137861  29     3 26 22.98480
233.11  3.7724279  26     9 17 28.66655
235.6   8.6953084  28    24  4 38.63477
241.2   2.8067193  26     4 22 26.34039
255.7   5.0424601  32    18 14 30.58975
314.12  3.4445298  25     7 18 28.17335
```

```
317.6   2.8792321  14      5  9 35.32583
319.20  8.8774217  30     27  3 38.75767
320.16  4.1787768  33     12 21 26.34808
342.15  4.1725070  35     11 24 26.01336
346.2   5.8554350  46     21 25 23.84175
351.26  6.4286626  31     23  8 36.11581
364.21  1.6075453  12      2 10 34.05974
402.7   0.5067415  20      1 19 27.47748
405.2   4.2896919  29     13 16 28.98663
406.12  5.3564283  32     20 12 32.68323
427.7   2.9737174  13      6  7 36.19020
450.3   4.7112537  21     15  6 36.19602
506.2   3.6306466  19      8 11 33.26623
Canchan 4.8979104  37     17 20 27.00126
Desiree 9.1023670  56     28 28 16.15569
Unica   8.7835476  28     26  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
MASV.AMMI(model, ssi.method = "rao")
```

```
             MASV       SSI rMASV rY    means
102.18  4.7855876 1.4296717    19 23 26.31947
104.22  3.8328358 1.7337655    12 13 31.28887
121.31  4.0446758 1.6576851    14 15 30.10174
141.28  5.1867706 1.8235808    20  1 39.75624
157.26  7.6459224 1.5625443    24  5 36.95181
163.9   4.4977055 1.3064192    16 27 21.41747
221.19  2.1905344 1.9979910     5 26 22.98480
233.11  3.1794345 1.7949089     9 17 28.66655
235.6   8.4913020 1.5818054    25  4 38.63477
241.2   2.0338659 2.2035784     4 22 26.34039
255.7   4.7013868 1.5791422    18 14 30.58975
314.12  3.1376678 1.7902786     8 18 28.17335
317.6   2.3345492 2.3233562     6  9 35.32583
319.20  8.6398087 1.5802761    27  3 38.75767
320.16  3.8822326 1.5635888    13 21 26.34808
342.15  3.6438425 1.5987650    10 24 26.01336
346.2   5.3987165 1.2839782    22 25 23.84175
351.26  5.4005468 1.6840095    23  8 36.11581
364.21  1.4047546 3.0575043     2 10 34.05974
402.7   0.3537818 8.6266993     1 19 27.47748
405.2   4.1095727 1.6106479    15 16 28.98663
406.12  5.3218165 1.5795802    21 12 32.68323
427.7   2.4124676 2.3137009     7  7 36.19020
450.3   4.6608954 1.7669921    17  6 36.19602
506.2   1.9330143 2.4995588     3 11 33.26623
Canchan 3.6665608 1.6263253    11 20 27.00126
Desiree 9.0626072 0.8285565    28 28 16.15569
Unica   8.5447632 1.5950896    26  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
MASV.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
             MASV       SSI rMASV rY    means
102.18  4.7855876 1.1039112    19 23 26.31947
104.22  3.8328358 1.3270288    12 13 31.28887
```

```
121.31  4.0446758 1.2722512    14 15 30.10174
141.28  5.1867706 1.5230171    20  1 39.75624
157.26  7.6459224 1.3586506    24  5 36.95181
163.9   4.4977055 0.9598080    16 27 21.41747
221.19  2.1905344 1.2863130     5 26 22.98480
233.11  3.1794345 1.3045842     9 17 28.66655
235.6   8.4913020 1.3982110    25  4 38.63477
241.2   2.0338659 1.4370799     4 22 26.34039
255.7   4.7013868 1.2475474    18 14 30.58975
314.12  3.1376678 1.2934270     8 18 28.17335
317.6   2.3345492 1.6555805     6  9 35.32583
319.20  8.6398087 1.3998375    27  3 38.75767
320.16  3.8822326 1.1620273    13 21 26.34808
342.15  3.6438425 1.1709323    10 24 26.01336
346.2   5.3987165 0.9952142    22 25 23.84175
351.26  5.4005468 1.3953434    23  8 36.11581
364.21  1.4047546 1.9477337     2 10 34.05974
402.7   0.3537818 4.2201550     1 19 27.47748
405.2   4.1095727 1.2313006    15 16 28.98663
406.12  5.3218165 1.2866435    21 12 32.68323
427.7   2.4124676 1.6674932     7  7 36.19020
450.3   4.6608954 1.4325166    17  6 36.19602
506.2   1.9330143 1.6930696     3 11 33.26623
Canchan 3.6665608 1.2011435    11 20 27.00126
Desiree 9.0626072 0.6565359    28 28 16.15569
Unica   8.5447632 1.4126439    26  2 39.10400
```

**SIPC.AMMI()**

```
# With default n (N') and default ssi.method (farshadfar)
SIPC.AMMI(model)
```

```
             SIPC SSI rSIPC rY    means
102.18  2.9592568  39    16 23 26.31947
104.22  2.2591593  22     9 13 31.28887
121.31  3.3872806  33    18 15 30.10174
141.28  4.3846248  23    22  1 39.75624
157.26  5.4846596  31    26  5 36.95181
163.9   2.6263670  38    11 27 21.41747
221.19  2.0218098  32     6 26 22.98480
233.11  2.1624442  24     7 17 28.66655
235.6   4.8273551  28    24  4 38.63477
241.2   2.0056410  27     5 22 26.34039
255.7   3.6075128  34    20 14 30.58975
314.12  2.4584089  28    10 18 28.17335
317.6   1.8698826  12     3  9 35.32583
319.20  5.9590451  31    28  3 38.75767
320.16  2.7040109  33    12 21 26.34808
342.15  2.9755899  41    17 24 26.01336
346.2   3.9525017  46    21 25 23.84175
351.26  4.5622439  31    23  8 36.11581
364.21  0.7526264  12     2 10 34.05974
402.7   0.2284995  20     1 19 27.47748
405.2   2.7952381  29    13 16 28.98663
```

```
406.12  2.8834753  27     15 12 32.68323
427.7   2.0049278  11      4  7 36.19020
450.3   2.8200387  20     14  6 36.19602
506.2   2.2178470  19      8 11 33.26623
Canchan 3.5328212  39     19 20 27.00126
Desiree 5.8073242  55     27 28 16.15569
Unica   5.0654615  27     25  2 39.10400
```

```
# With n = 4 and default ssi.method (farshadfar)
SIPC.AMMI(model, n = 4)
```

```
             SIPC SSI rSIPC rY    means
102.18  3.4466455  38     15 23 26.31947
104.22  2.7007589  23     10 13 31.28887
121.31  5.6097497  38     23 15 30.10174
141.28  4.6372010  22     21  1 39.75624
157.26  7.4500476  33     28  5 36.95181
163.9   3.1338033  38     11 27 21.41747
221.19  2.1363292  29      3 26 22.98480
233.11  2.3911278  23      6 17 28.66655
235.6   5.8474857  29     25  4 38.63477
241.2   2.3056852  27      5 22 26.34039
255.7   3.9276052  31     17 14 30.58975
314.12  2.5182824  26      8 18 28.17335
317.6   2.4516869  16      7  9 35.32583
319.20  7.0781345  30     27  3 38.75767
320.16  4.0249810  39     18 21 26.34808
342.15  4.0957211  43     19 24 26.01336
346.2   4.8622465  47     22 25 23.84175
351.26  4.5974075  28     20  8 36.11581
364.21  1.5318314  12      2 10 34.05974
402.7   0.5893581  20      1 19 27.47748
405.2   3.3068718  29     13 16 28.98663
406.12  3.2694367  24     12 12 32.68323
427.7   2.5358269  16      9  7 36.19020
450.3   3.4327401  20     14  6 36.19602
506.2   2.2644412  15      4 11 33.26623
Canchan 3.6100050  36     16 20 27.00126
Desiree 5.8538044  54     26 28 16.15569
Unica   5.7091275  26     24  2 39.10400
```

```
# With default n (N') and ssi.method = "rao"
SIPC.AMMI(model, ssi.method = "rao")
```

```
             SIPC       SSI rSIPC rY    means
102.18  2.9592568 1.5124653    16 23 26.31947
104.22  2.2591593 1.8772594     9 13 31.28887
121.31  3.3872806 1.5531093    18 15 30.10174
141.28  4.3846248 1.7378762    22  1 39.75624
157.26  5.4846596 1.5578664    26  5 36.95181
163.9   2.6263670 1.4355650    11 27 21.41747
221.19  2.0218098 1.7071153     6 26 22.98480
233.11  2.1624442 1.8300896     7 17 28.66655
235.6   4.8273551 1.6608098    24  4 38.63477
241.2   2.0056410 1.8242469     5 22 26.34039
```

```
255.7    3.6075128 1.5341245    20 14 30.58975
314.12   2.4584089 1.7062126    10 18 28.17335
317.6    1.8698826 2.1873134     3  9 35.32583
319.20   5.9590451 1.5886436    28  3 38.75767
320.16   2.7040109 1.5751613    12 21 26.34808
342.15   2.9755899 1.4988930    17 24 26.01336
346.2    3.9525017 1.2672546    21 25 23.84175
351.26   4.5622439 1.6019853    23  8 36.11581
364.21   0.7526264 3.6831976     2 10 34.05974
402.7    0.2284995 9.3696848     1 19 27.47748
405.2    2.7952381 1.6378227    13 16 28.98663
406.12   2.8834753 1.7371554    15 12 32.68323
427.7    2.0049278 2.1457493     4  7 36.19020
450.3    2.8200387 1.8667975    14  6 36.19602
506.2    2.2178470 1.9576974     8 11 33.26623
Canchan  3.5328212 1.4284673    19 20 27.00126
Desiree  5.8073242 0.8601813    27 28 16.15569
Unica    5.0654615 1.6572552    25  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
SIPC.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
              SIPC       SSI rSIPC rY    means
102.18   2.9592568 1.1395125    16 23 26.31947
104.22   2.2591593 1.3887312     9 13 31.28887
121.31   3.3872806 1.2272836    18 15 30.10174
141.28   4.3846248 1.4861641    22  1 39.75624
157.26   5.4846596 1.3566391    26  5 36.95181
163.9    2.6263670 1.0153407    11 27 21.41747
221.19   2.0218098 1.1612364     6 26 22.98480
233.11   2.1624442 1.3197119     7 17 28.66655
235.6    4.8273551 1.4321829    24  4 38.63477
241.2    2.0056410 1.2739673     5 22 26.34039
255.7    3.6075128 1.2281898    20 14 30.58975
314.12   2.4584089 1.2572786    10 18 28.17335
317.6    1.8698826 1.5970821     3  9 35.32583
319.20   5.9590451 1.4034355    28  3 38.75767
320.16   2.7040109 1.1670035    12 21 26.34808
342.15   2.9755899 1.1279873    17 24 26.01336
346.2    3.9525017 0.9880230    21 25 23.84175
351.26   4.5622439 1.3600729    23  8 36.11581
364.21   0.7526264 2.2167818     2 10 34.05974
402.7    0.2284995 4.5396387     1 19 27.47748
405.2    2.7952381 1.2429858    13 16 28.98663
406.12   2.8834753 1.3544008    15 12 32.68323
427.7    2.0049278 1.5952740     4  7 36.19020
450.3    2.8200387 1.4754330    14  6 36.19602
506.2    2.2178470 1.4600692     8 11 33.26623
Canchan  3.5328212 1.1160645    19 20 27.00126
Desiree  5.8073242 0.6701345    27 28 16.15569
Unica    5.0654615 1.4393751    25  2 39.10400
```

**ZA.AMMI()**

```r
# With default n (N') and default ssi.method (farshadfar)
ZA.AMMI(model)
```

```
                Za SSI rZa rY    means
102.18  0.15752787  41  18 23 26.31947
104.22  0.08552245  20   7 13 31.28887
121.31  0.13457796  26  11 15 30.10174
141.28  0.20424009  23  22  1 39.75624
157.26  0.20593889  28  23  5 36.95181
163.9   0.16161024  46  19 27 21.41747
221.19  0.08723440  34   8 26 22.98480
233.11  0.06559491  21   4 17 28.66655
235.6   0.20950908  29  25  4 38.63477
241.2   0.08160010  28   6 22 26.34039
255.7   0.16694984  34  20 14 30.58975
314.12  0.12243347  28  10 18 28.17335
317.6   0.08723605  18   9  9 35.32583
319.20  0.30778801  30  27  3 38.75767
320.16  0.14393358  35  14 21 26.34808
342.15  0.13891478  37  13 24 26.01336
346.2   0.20627243  49  24 25 23.84175
351.26  0.17809076  29  21  8 36.11581
364.21  0.03723882  12   2 10 34.05974
402.7   0.01243185  20   1 19 27.47748
405.2   0.15425031  33  17 16 28.98663
406.12  0.13595705  24  12 12 32.68323
427.7   0.07364374  12   5  7 36.19020
450.3   0.14895835  22  16  6 36.19602
506.2   0.06332050  14   3 11 33.26623
Canchan 0.14710608  35  15 20 27.00126
Desiree 0.32787182  56  28 28 16.15569
Unica   0.21646330  28  26  2 39.10400
```

```r
# With n = 4 and default ssi.method (farshadfar)
ZA.AMMI(model, n = 4)
```

```
                Za SSI rZa rY    means
102.18  0.16239946  41  18 23 26.31947
104.22  0.08993636  21   8 13 31.28887
121.31  0.15679216  30  15 15 30.10174
141.28  0.20676466  23  22  1 39.75624
157.26  0.22558350  31  26  5 36.95181
163.9   0.16668221  46  19 27 21.41747
221.19  0.08837906  33   7 26 22.98480
233.11  0.06788066  21   4 17 28.66655
235.6   0.21970557  28  24  4 38.63477
241.2   0.08459913  28   6 22 26.34039
255.7   0.17014926  34  20 14 30.58975
314.12  0.12303192  28  10 18 28.17335
317.6   0.09305134  18   9  9 35.32583
319.20  0.31897363  30  27  3 38.75767
320.16  0.15713705  37  16 21 26.34808
342.15  0.15011080  37  13 24 26.01336
346.2   0.21536559  48  23 25 23.84175
351.26  0.17844223  29  21  8 36.11581
```

```
364.21  0.04502719  12   2 10 34.05974
402.7   0.01603874  20   1 19 27.47748
405.2   0.15936424  33  17 16 28.98663
406.12  0.13981485  23  11 12 32.68323
427.7   0.07895023  12   5  7 36.19020
450.3   0.15508247  20  14  6 36.19602
506.2   0.06378622  14   3 11 33.26623
Canchan 0.14787755  32  12 20 27.00126
Desiree 0.32833640  56  28 28 16.15569
Unica   0.22289692  27  25  2 39.10400
```

```r
# With default n (N') and ssi.method = "rao"
ZA.AMMI(model, ssi.method = "rao")
```

```
                Za       SSI rZa rY    means
102.18  0.15752787 1.4309653  18 23 26.31947
104.22  0.08552245 2.0752658   7 13 31.28887
121.31  0.13457796 1.6519700  11 15 30.10174
141.28  0.20424009 1.7380721  22  1 39.75624
157.26  0.20593889 1.6429878  23  5 36.95181
163.9   0.16161024 1.2566633  19 27 21.41747
221.19  0.08723440 1.7838011   8 26 22.98480
233.11  0.06559491 2.3102920   4 17 28.66655
235.6   0.20950908 1.6903953  25  4 38.63477
241.2   0.08160010 1.9646329   6 22 26.34039
255.7   0.16694984 1.5378736  20 14 30.58975
314.12  0.12243347 1.6556010  10 18 28.17335
317.6   0.08723605 2.1861684   9  9 35.32583
319.20  0.30778801 1.5568815  27  3 38.75767
320.16  0.14393358 1.4859985  14 21 26.34808
342.15  0.13891478 1.4977340  13 24 26.01336
346.2   0.20627243 1.2148178  24 25 23.84175
351.26  0.17809076 1.6842433  21  8 36.11581
364.21  0.03723882 3.5336141   2 10 34.05974
402.7   0.01243185 8.1540882   1 19 27.47748
405.2   0.15425031 1.5301007  17 16 28.98663
406.12  0.13595705 1.7293399  12 12 32.68323
427.7   0.07364374 2.4052596   5  7 36.19020
450.3   0.14895835 1.7859494  16  6 36.19602
506.2   0.06332050 2.5096775   3 11 33.26623
Canchan 0.14710608 1.4937760  15 20 27.00126
Desiree 0.32787182 0.8019725  28 28 16.15569
Unica   0.21646330 1.6918583  26  2 39.10400
```

```r
# Changing the ratio of weights for Rao's SSI
ZA.AMMI(model, ssi.method = "rao", a = 0.43)
```

```
                Za       SSI rZa rY    means
102.18  0.15752787 1.1044675  18 23 26.31947
104.22  0.08552245 1.4738739   7 13 31.28887
121.31  0.13457796 1.2697937  11 15 30.10174
141.28  0.20424009 1.4862483  22  1 39.75624
157.26  0.20593889 1.3932413  23  5 36.95181
163.9   0.16161024 0.9384129  19 27 21.41747
221.19  0.08723440 1.1942113   8 26 22.98480
233.11  0.06559491 1.5261989   4 17 28.66655
```

```
235.6   0.20950908 1.4449047  25  4 38.63477
241.2   0.08160010 1.3343333   6 22 26.34039
255.7   0.16694984 1.2298019  20 14 30.58975
314.12  0.12243347 1.2355156  10 18 28.17335
317.6   0.08723605 1.5965898   9  9 35.32583
319.20  0.30778801 1.3897778  27  3 38.75767
320.16  0.14393358 1.1286635  14 21 26.34808
342.15  0.13891478 1.1274889  13 24 26.01336
346.2   0.20627243 0.9654752  24 25 23.84175
351.26  0.17809076 1.3954439  21  8 36.11581
364.21  0.03723882 2.1524610   2 10 34.05974
402.7   0.01243185 4.0169322   1 19 27.47748
405.2   0.15425031 1.1966653  17 16 28.98663
406.12  0.13595705 1.3510402  12 12 32.68323
427.7   0.07364374 1.7068634   5  7 36.19020
450.3   0.14895835 1.4406683  16  6 36.19602
506.2   0.06332050 1.6974207   3 11 33.26623
Canchan 0.14710608 1.1441472  15 20 27.00126
Desiree 0.32787182 0.6451047  28 28 16.15569
Unica   0.21646330 1.4542544  26  2 39.10400
```

## Simultaneous selection indices for yield and stability

The most stable genotype need not necessarily be the highest yielding genotype. Hence, simultaneous selection indices (SSIs) have been proposed for the selection of stable as well as high yielding genotypes.

A family of simultaneous selection indices ($I_i$) were proposed by Rao and Prabhakaran (2005) similar to those proposed by Bajpai and Prabhakaran (2000) by incorporating the AMMI Based Stability Parameter ($ASTAB$) and Yield as components. These indices consist of yield component, measured as the ratio of the average performance of the $i$th genotype to the overall mean performance of the genotypes under test and a stability component, measured as the ratio of stability information ($\frac{1}{ASTAB}$) of the $i$th genotype to the mean stability information of the genotypes under test.

$$I_i = \frac{\overline{Y}_i}{\overline{\overline{Y}}_{..}} + \alpha \frac{\frac{1}{ASTAB_i}}{\frac{1}{T}\sum_{i=1}^{T}\frac{1}{ASTAB_i}}$$

Where $ASTAB_i$ is the stability measure of the $i$th genotype under AMMI procedure; $Y_i$ is mean performance of $i$th genotype; $Y_{..}$ is the overall mean; $T$ is the number of genotypes under test and $\alpha$ is the ratio of the weights given to the stability components ($w_2$) and yield ($w_1$) with a restriction that $w_1 + w_2 = 1$. The weights can be specified as required (Table 2).

**Table 2 :** $\alpha$ and corresponding weights ($w_1$ and $w_2$)

| $\alpha$ | $w_1$ | $w_2$ |
|---|---|---|
| 1.00 | 0.5 | 0.5 |
| 0.67 | 0.6 | 0.4 |
| 0.43 | 0.7 | 0.3 |
| 0.25 | 0.8 | 0.2 |

In `ammistability`, the above expression has been implemented for all the stability parameters ($SP$) including ASTAB.

$$I_i = \frac{\overline{Y}_i}{\overline{Y}_{..}} + \alpha \frac{\frac{1}{SP_i}}{\frac{1}{T}\sum_{i=1}^{T}\frac{1}{SP_i}}$$

Genotype stability index ($GSI$) (Farshadfar, 2008) or Yield stability index ($YSI$) (Farshadfar et al., 2011; Jambhulkar et al., 2017) is a simultaneous selection index for yield and yield stability which is computed by summation of the ranks of the stability index/parameter and the ranks of the mean yields. $YSI$ is computed for all the stability parameters/indices implemented in this package.

$$GSI = YSI = R_{SP} + R_Y$$

Where, $R_{SP}$ is the stability parameter/index rank of the genotype and $R_Y$ is the mean yield rank of the genotype.

The function `SSI` implements both these indices in `ammistability`. Further, for each of the stability parameter functions, the simultaneous selection index is also computed by either of these functions as specified by the argument `ssi.method`.

### Examples

`SSI()`

```r
library(agricolae)
data(plrv)
model <- with(plrv, AMMI(Locality, Genotype, Rep, Yield, console=FALSE))

yield <- aggregate(model$means$Yield, by= list(model$means$GEN),
                   FUN=mean, na.rm=TRUE)[,2]
stab <- DZ.AMMI(model)$DZ
genotypes <- rownames(DZ.AMMI(model))

# With default ssi.method (farshadfar)
SSI(y = yield, sp = stab, gen = genotypes)
```

```
                SP SSI rSP rY    means
102.18  0.26393535  37  14 23 26.31947
104.22  0.22971564  21   8 13 31.28887
121.31  0.32031744  34  19 15 30.10174
141.28  0.39838535  23  22  1 39.75624
157.26  0.53822924  33  28  5 36.95181
163.9   0.26659011  42  15 27 21.41747
221.19  0.19563325  29   3 26 22.98480
233.11  0.25167755  27  10 17 28.66655
235.6   0.46581370  28  24  4 38.63477
241.2   0.21481887  28   6 22 26.34039
255.7   0.30862904  31  17 14 30.58975
314.12  0.22603261  25   7 18 28.17335
317.6   0.20224771  14   5  9 35.32583
319.20  0.50675112  29  26  3 38.75767
320.16  0.23280596  30   9 21 26.34808
342.15  0.25989774  36  12 24 26.01336
346.2   0.37125512  45  20 25 23.84175
351.26  0.43805896  31  23  8 36.11581
```

```
364.21  0.07409309  12   2 10 34.05974
402.7   0.02004533  20   1 19 27.47748
405.2   0.26238837  29  13 16 28.98663
406.12  0.28179394  28  16 12 32.68323
427.7   0.20176581  11   4  7 36.19020
450.3   0.25465368  17  11  6 36.19602
506.2   0.30899851  29  18 11 33.26623
Canchan 0.37201039  41  21 20 27.00126
Desiree 0.52005815  55  27 28 16.15569
Unica   0.48083049  27  25  2 39.10400
```

```
# With  ssi.method = "rao"
SSI(y = yield, sp = stab, gen = genotypes, method = "rao")
```

```
                SP        SSI rSP rY    means
102.18  0.26393535  1.5536988  14 23 26.31947
104.22  0.22971564  1.8193399   8 13 31.28887
121.31  0.32031744  1.5545939  19 15 30.10174
141.28  0.39838535  1.7570779  22  1 39.75624
157.26  0.53822924  1.5459114  28  5 36.95181
163.9   0.26659011  1.3869397  15 27 21.41747
221.19  0.19563325  1.6878048   3 26 22.98480
233.11  0.25167755  1.6641025  10 17 28.66655
235.6   0.46581370  1.6538090  24  4 38.63477
241.2   0.21481887  1.7134093   6 22 26.34039
255.7   0.30862904  1.5922105  17 14 30.58975
314.12  0.22603261  1.7307783   7 18 28.17335
317.6   0.20224771  2.0595024   5  9 35.32583
319.20  0.50675112  1.6259792  26  3 38.75767
320.16  0.23280596  1.6476346   9 21 26.34808
342.15  0.25989774  1.5545233  12 24 26.01336
346.2   0.37125512  1.2718506  20 25 23.84175
351.26  0.43805896  1.5966462  23  8 36.11581
364.21  0.07409309  3.5881882   2 10 34.05974
402.7   0.02004533 10.0539968   1 19 27.47748
405.2   0.26238837  1.6447637  13 16 28.98663
406.12  0.28179394  1.7171135  16 12 32.68323
427.7   0.20176581  2.0898536   4  7 36.19020
450.3   0.25465368  1.9010808  11  6 36.19602
506.2   0.30899851  1.6787677  18 11 33.26623
Canchan 0.37201039  1.3738642  21 20 27.00126
Desiree 0.52005815  0.8797586  27 28 16.15569
Unica   0.48083049  1.6568004  25  2 39.10400
```

```
# Changing the ratio of weights for Rao's SSI
SSI(y = yield, sp = stab, gen = genotypes, method = "rao", a = 0.43)
```

```
                SP       SSI rSP rY    means
102.18  0.26393535 1.1572429  14 23 26.31947
104.22  0.22971564 1.3638258   8 13 31.28887
121.31  0.32031744 1.2279220  19 15 30.10174
141.28  0.39838535 1.4944208  22  1 39.75624
157.26  0.53822924 1.3514985  28  5 36.95181
163.9   0.26659011 0.9944318  15 27 21.41747
221.19  0.19563325 1.1529329   3 26 22.98480
```

```
233.11  0.25167755 1.2483375  10 17 28.66655
235.6   0.46581370 1.4291726  24  4 38.63477
241.2   0.21481887 1.2263072   6 22 26.34039
255.7   0.30862904 1.2531668  17 14 30.58975
314.12  0.22603261 1.2678419   7 18 28.17335
317.6   0.20224771 1.5421234   5  9 35.32583
319.20  0.50675112 1.4194898  26  3 38.75767
320.16  0.23280596 1.1981670   9 21 26.34808
342.15  0.25989774 1.1519083  12 24 26.01336
346.2   0.37125512 0.9899993  20 25 23.84175
351.26  0.43805896 1.3577771  23  8 36.11581
364.21  0.07409309 2.1759278   2 10 34.05974
402.7   0.02004533 4.8338929   1 19 27.47748
405.2   0.26238837 1.2459704  13 16 28.98663
406.12  0.28179394 1.3457828  16 12 32.68323
427.7   0.20176581 1.5712389   4  7 36.19020
450.3   0.25465368 1.4901748  11  6 36.19602
506.2   0.30899851 1.3401295  18 11 33.26623
Canchan 0.37201039 1.0925852  21 20 27.00126
Desiree 0.52005815 0.6785528  27 28 16.15569
Unica   0.48083049 1.4391795  25  2 39.10400
```

## Wrapper function

A function `ammistability` has also been implemented which is a wrapper around all the available functions in the package to compute simultaneously multiple AMMI stability parameters along with the corresponding SSIs. Correlation among the computed values as well as visualization of the differences in genotype ranks for the computed parameters is also generated.

### Examples

**ammistability()**

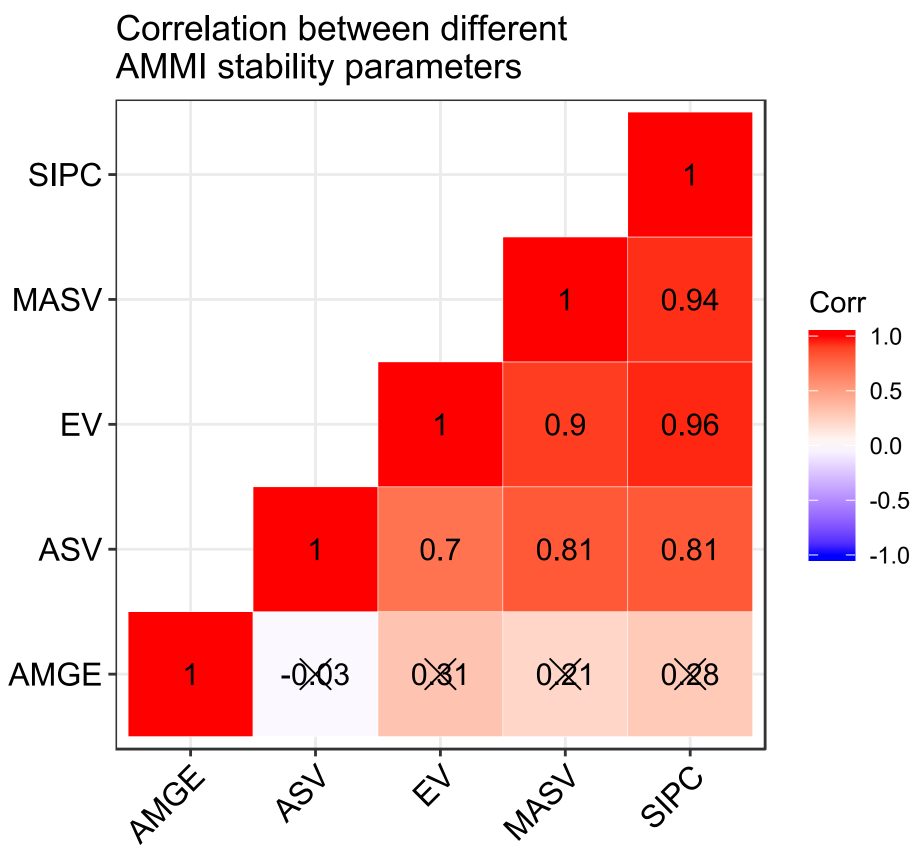
```r
library(agricolae)
data(plrv)

# AMMI model
model <- with(plrv, AMMI(Locality, Genotype, Rep, Yield, console = FALSE))

ammistability(model, AMGE = TRUE, ASI = FALSE, ASV = TRUE, ASTAB = FALSE,
              AVAMGE = FALSE, DA = FALSE, DZ = FALSE, EV = TRUE,
              FA = FALSE, MASI = FALSE, MASV = TRUE, SIPC = TRUE,
              ZA = FALSE)
```

```
$Details
$Details$`Stability parameters estimated`
[1] "AMGE" "ASV"  "EV"   "MASV" "SIPC"

$Details$`SSI method`
[1] "Farshadfar (2008)"


$`Stability Parameters`
```

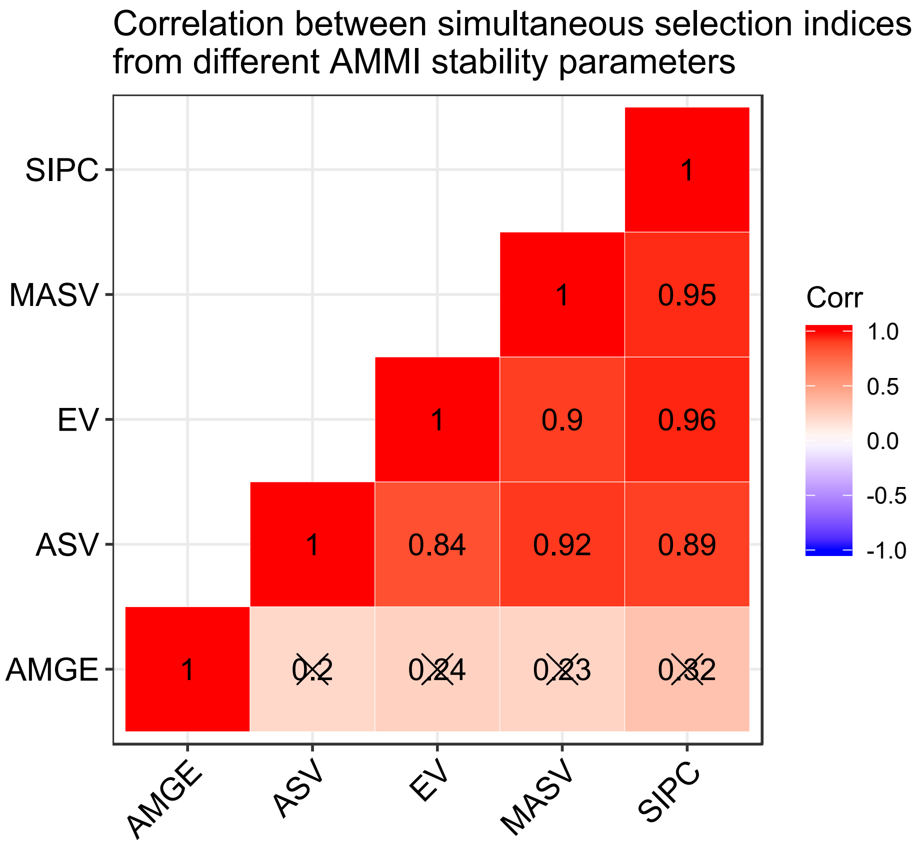
```
   genotype    means          AMGE       ASV           EV      MASV
1    102.18 26.31947 -8.659740e-15 3.3801820 0.0232206231 4.7855876
2    104.22 31.28887  1.110223e-15 1.4627695 0.0175897578 3.8328358
3    121.31 30.10174  4.440892e-16 2.2937918 0.0342010876 4.0446758
4    141.28 39.75624  1.021405e-14 4.4672401 0.0529036285 5.1867706
5    157.26 36.95181  2.220446e-15 3.2923168 0.0965635719 7.6459224
6     163.9 21.41747 -1.243450e-14 4.4269636 0.0236900961 4.4977055
7    221.19 22.98480 -4.440892e-15 1.8014494 0.0127574566 2.1905344
8    233.11 28.66655  2.275957e-15 1.0582263 0.0211138628 3.1794345
9     235.6 38.63477  5.773160e-15 3.7647078 0.0723274691 8.4913020
10    241.2 26.34039 -5.329071e-15 1.6774241 0.0153823821 2.0338659
11    255.7 30.58975 -3.774758e-15 3.3289736 0.0317506280 4.7013868
12   314.12 28.17335  5.773160e-15 2.9170536 0.0170302467 3.1376678
13    317.6 35.32583  2.220446e-15 2.1874274 0.0136347120 2.3345492
14   319.20 38.75767  1.731948e-14 6.7164864 0.0855988994 8.6398087
15   320.16 26.34808 -6.217249e-15 3.3208950 0.0180662044 3.8822326
16   342.15 26.01336 -2.442491e-15 2.9219360 0.0225156118 3.6438425
17    346.2 23.84175 -1.110223e-14 5.1827747 0.0459434537 5.3987165
18   351.26 36.11581  1.021405e-14 2.9786832 0.0639652186 5.4005468
19   364.21 34.05974  1.415534e-15 0.7236998 0.0018299284 1.4047546
20    402.7 27.47748 -3.885781e-16 0.2801470 0.0001339385 0.3537818
21    405.2 28.98663 -1.088019e-14 3.9832546 0.0229492190 4.1095727
22   406.12 32.68323  3.108624e-15 2.5631734 0.0264692745 5.3218165
23    427.7 36.19020  1.110223e-16 1.1467970 0.0135698145 2.4124676
24    450.3 36.19602  6.439294e-15 3.1430174 0.0216161656 4.6608954
25    506.2 33.26623 -5.773160e-15 0.7511331 0.0318266934 1.9330143
26  Canchan 27.00126  9.325873e-15 3.0975884 0.0461305761 3.6665608
27  Desiree 16.15569 -1.132427e-14 7.7833445 0.0901534938 9.0626072
28    Unica 39.10400  5.329071e-15 3.8380782 0.0770659860 8.5447632
        SIPC
1  2.9592568
2  2.2591593
3  3.3872806
4  4.3846248
5  5.4846596
6  2.6263670
7  2.0218098
8  2.1624442
9  4.8273551
10 2.0056410
11 3.6075128
12 2.4584089
13 1.8698826
14 5.9590451
15 2.7040109
16 2.9755899
17 3.9525017
18 4.5622439
19 0.7526264
20 0.2284995
21 2.7952381
22 2.8834753
23 2.0049278
24 2.8200387
```

```
25 2.2178470
26 3.5328212
27 5.8073242
28 5.0654615

$`Simultaneous Selection Indices`
   genotype    means AMGE_SSI ASV_SSI EV_SSI MASV_SSI SIPC_SSI
1    102.18 26.31947     28.0      43     37       42       39
2    104.22 31.28887     28.0      19     21       25       22
3    121.31 30.10174     29.0      25     34       29       33
4    141.28 39.75624     27.5      26     23       21       23
5    157.26 36.95181     22.5      22     33       29       31
6     163.9 21.41747     28.0      51     42       43       38
7    221.19 22.98480     35.0      34     29       31       32
8    233.11 28.66655     36.0      21     27       26       24
9     235.6 38.63477     26.5      25     28       29       28
10    241.2 26.34039     30.0      29     28       26       27
11    255.7 30.58975     24.0      33     31       32       34
12   314.12 28.17335     40.5      30     25       26       28
13    317.6 35.32583     26.5      18     14       15       12
14   319.20 38.75767     31.0      30     29       30       31
15   320.16 26.34808     27.0      39     30       34       33
16   342.15 26.01336     35.0      37     36       34       41
17    346.2 23.84175     28.0      51     45       47       46
18   351.26 36.11581     34.5      22     31       31       31
19   364.21 34.05974     26.0      12     12       12       12
20    402.7 27.47748     31.0      20     20       20       20
21    405.2 28.98663     20.0      39     29       31       29
22   406.12 32.68323     32.0      23     28       33       27
23    427.7 36.19020     20.0      12     11       14       11
24    450.3 36.19602     30.0      22     17       23       20
25    506.2 33.26623     18.0      14     29       14       19
26  Canchan 27.00126     45.0      35     41       31       39
27  Desiree 16.15569     30.0      56     55       56       55
28    Unica 39.10400     23.0      24     27       28       27

$`SP Correlation`
       AMGE    ASV     EV   MASV   SIPC
AMGE 1.00**   <NA>   <NA>   <NA>   <NA>
ASV   -0.03 1.00**   <NA>   <NA>   <NA>
EV     0.31 0.70** 1.00**   <NA>   <NA>
MASV   0.21 0.81** 0.90** 1.00**   <NA>
SIPC   0.28 0.81** 0.96** 0.94** 1.00**

$`SSI Correlation`
       AMGE    ASV     EV   MASV   SIPC
AMGE 1.00**   <NA>   <NA>   <NA>   <NA>
ASV    0.20 1.00**   <NA>   <NA>   <NA>
EV     0.24 0.84** 1.00**   <NA>   <NA>
MASV   0.23 0.92** 0.90** 1.00**   <NA>
SIPC   0.32 0.89** 0.96** 0.95** 1.00**

$`SP and SSI Correlation`
            AMGE    ASV     EV   MASV   SIPC AMGE_SSI ASV_SSI EV_SSI
```

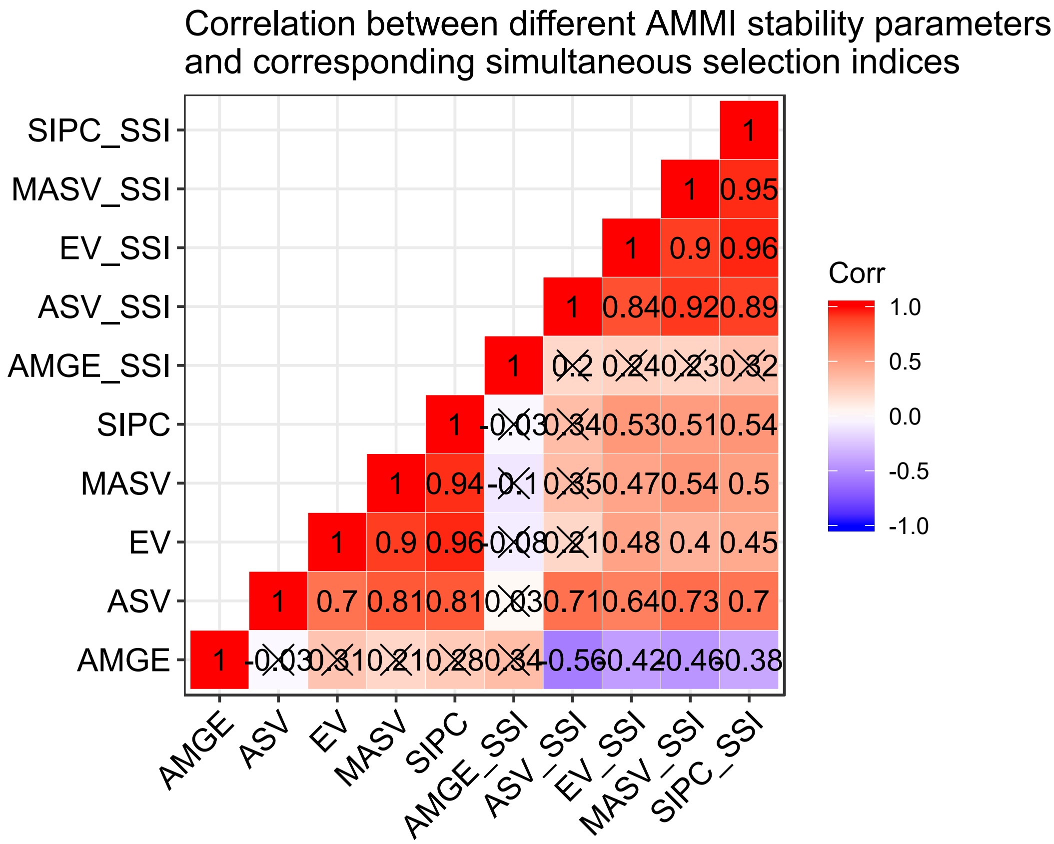
```
AMGE       1.00**   <NA>   <NA>   <NA>   <NA>     <NA>     <NA>   <NA>
ASV        -0.03 1.00**   <NA>   <NA>   <NA>     <NA>     <NA>   <NA>
EV          0.31 0.70** 1.00**   <NA>   <NA>     <NA>     <NA>   <NA>
MASV        0.21 0.81** 0.90** 1.00**   <NA>     <NA>     <NA>   <NA>
SIPC        0.28 0.81** 0.96** 0.94** 1.00**     <NA>     <NA>   <NA>
AMGE_SSI    0.34   0.03  -0.08  -0.10  -0.03   1.00**     <NA>   <NA>
ASV_SSI  -0.56** 0.71**   0.21   0.35   0.34     0.20   1.00**   <NA>
EV_SSI    -0.42* 0.64** 0.48**  0.47* 0.53**     0.24   0.84** 1.00**
MASV_SSI  -0.46* 0.73**  0.40* 0.54** 0.51**     0.23   0.92** 0.90**
SIPC_SSI  -0.38* 0.70**  0.45* 0.50** 0.54**     0.32   0.89** 0.96**
         MASV_SSI SIPC_SSI
AMGE         <NA>     <NA>
ASV          <NA>     <NA>
EV           <NA>     <NA>
MASV         <NA>     <NA>
SIPC         <NA>     <NA>
AMGE_SSI     <NA>     <NA>
ASV_SSI      <NA>     <NA>
EV_SSI       <NA>     <NA>
MASV_SSI   1.00**     <NA>
SIPC_SSI   0.95**   1.00**

$`SP Correlogram`
```



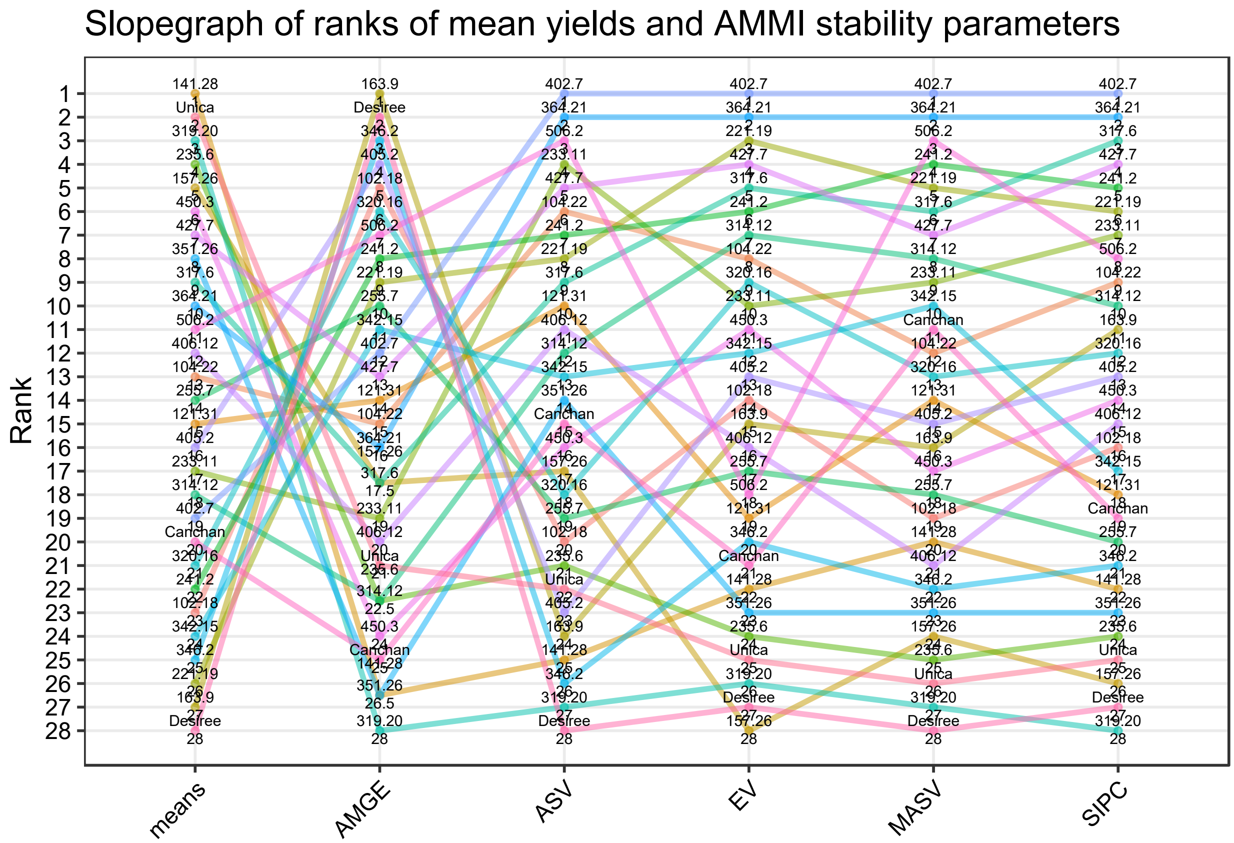

```
$`SSI Correlogram`
```



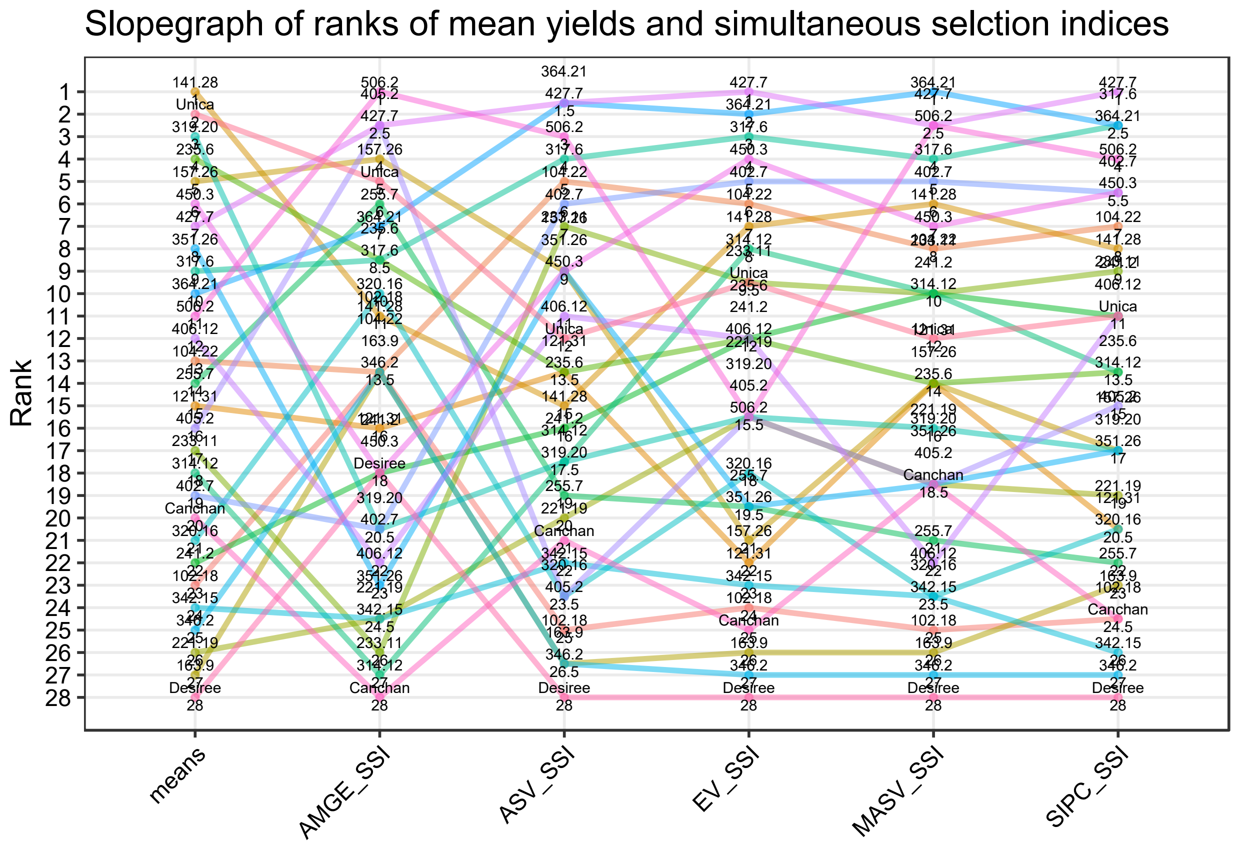

```
$`SP and SSI Correlogram`
```



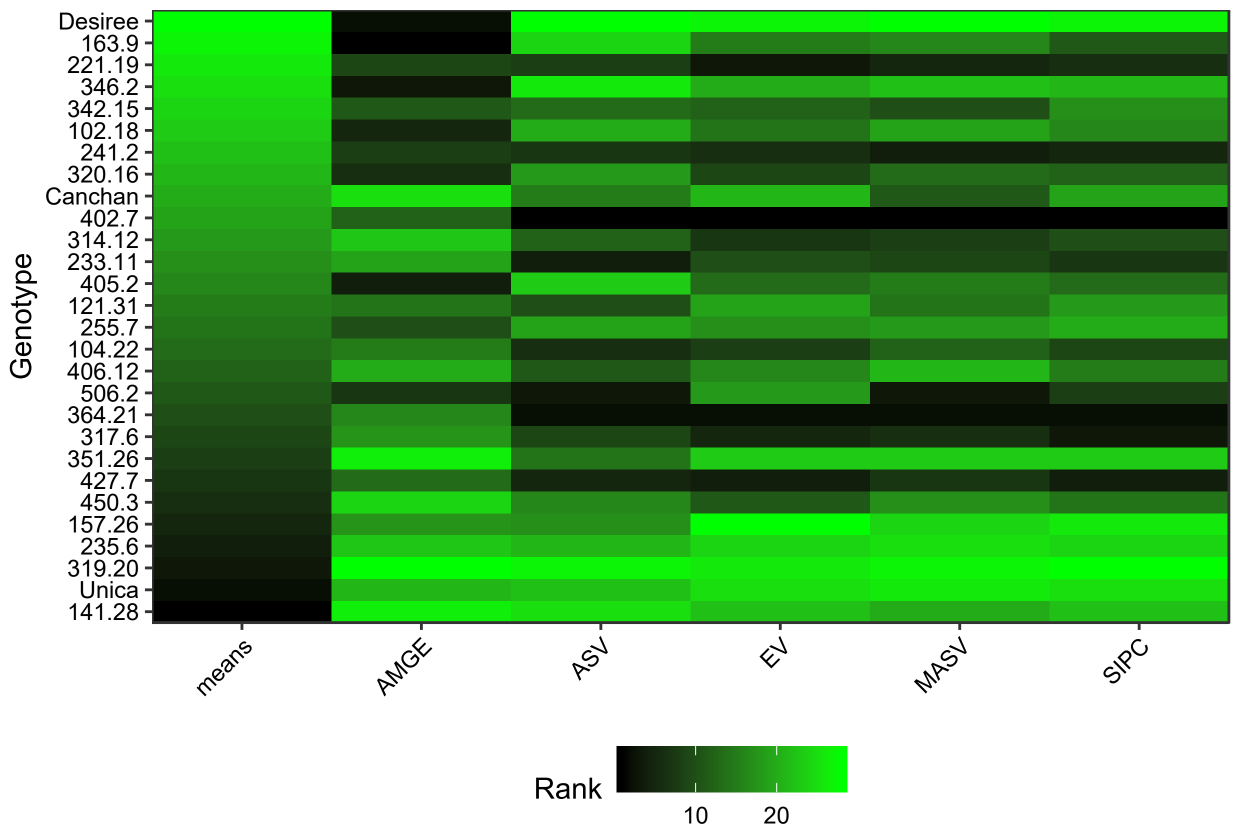

```
$`SP Slopegraph`
```



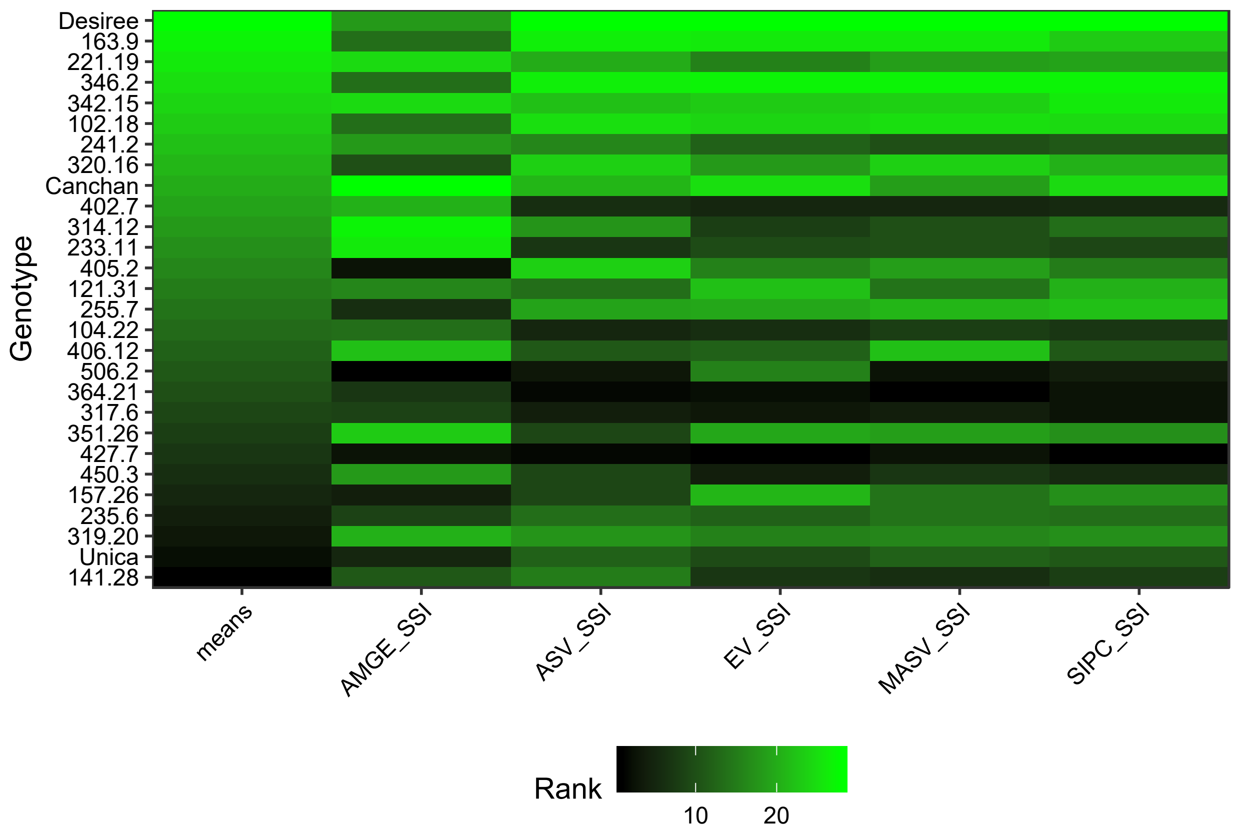

$`SSI Slopegraph`


Slopegraph of ranks of mean yields and simultaneous selction indices
Rank
means
AMGE_SSI
ASV_SSI
EV_SSI
MASV_SSI
SIPC_SSI

$`SP Heatmap`


Desiree
163.9
221.19
346.2
342.15
102.18
241.2
320.16
Canchan
402.7
314.12
233.11
405.2
121.31
255.7
104.22
406.12
506.2
364.21
317.6
351.26
427.7
450.3
157.26
235.6
319.20
Unica
141.28
Genotype
means
AMGE
ASV
EV
MASV
SIPC
Rank
10
20

```
$`SSI Heatmap`
```




## Citing ammistability

```
To cite the R package 'ammistability' in publications use:

  Ajay, B. C., Aravind, J., and Abdul Fiyaz, R. (2018).
  ammistability: Additive Main Effects and Multiplicative
  Interaction Model Stability Parameters. R package version 0.1.0,
  https://ajaygpb.github.io/ammistability/.

A BibTeX entry for LaTeX users is

  @Manual{,
    title = {ammistability: Additive Main Effects and Multiplicative Interaction Model Stability Parame
    author = {B. C. Ajay and J. Aravind and R. {Abdul Fiyaz}},
    year = {2018},
    note = {R package version 0.1.0},
    note = {https://ajaygpb.github.io/ammistability/},
  }

This free and open-source software implements academic research by
the authors and co-workers. If you use it, please support the
project by citing the package.
```

## Session Info

```r
sessionInfo()
```

```
R version 3.5.1 (2018-07-02)
Platform: x86_64-w64-mingw32/x64 (64-bit)
Running under: Windows 10 x64 (build 17134)

Matrix products: default

locale:
[1] LC_COLLATE=C                   LC_CTYPE=English_India.1252
[3] LC_MONETARY=English_India.1252 LC_NUMERIC=C
[5] LC_TIME=English_India.1252

attached base packages:
[1] stats     graphics  grDevices utils     datasets  methods   base

other attached packages:
[1] agricolae_1.2-8     ammistability_0.1.0

loaded via a namespace (and not attached):
 [1] Rcpp_0.12.18          lattice_0.20-35       deldir_0.1-15
 [4] gtools_3.8.1          assertthat_0.2.0      rprojroot_1.3-2
 [7] digest_0.6.15         mime_0.5              R6_2.2.2
[10] plyr_1.8.4            AlgDesign_1.1-7.3     backports_1.1.2
[13] ggcorrplot_0.1.1      evaluate_0.11         coda_0.19-1
[16] ggplot2_3.0.0         highr_0.7             pillar_1.3.0
[19] Rdpack_0.8-0          rlang_0.2.1           lazyeval_0.2.1
[22] spdep_0.7-7           rstudioapi_0.7.0-9001 gdata_2.18.0
[25] miniUI_0.1.1.1        gmodels_2.18.1        Matrix_1.2-14
[28] combinat_0.0-8        rmarkdown_1.10        labeling_0.3
[31] splines_3.5.1         pander_0.6.2          stringr_1.3.1
[34] questionr_0.6.3       munsell_0.5.0         shiny_1.1.0
[37] compiler_3.5.1        httpuv_1.4.5          pkgconfig_2.0.1
[40] htmltools_0.3.6       tidyselect_0.2.4      tibble_1.4.2
[43] expm_0.999-2          crayon_1.3.4          dplyr_0.7.6
[46] later_0.7.3           MASS_7.3-50           grid_3.5.1
[49] nlme_3.1-137          spData_0.2.9.0        xtable_1.8-2
[52] gtable_0.2.0          magrittr_1.5          scales_0.5.0
[55] bibtex_0.4.2          stringi_1.2.4         reshape2_1.4.3
[58] LearnBayes_2.15.1     promises_1.0.1        bindrcpp_0.2.2
[61] sp_1.3-1              boot_1.3-20           klaR_0.6-14
[64] tools_3.5.1           glue_1.3.0            purrr_0.2.5
[67] yaml_2.2.0            colorspace_1.3-2      cluster_2.0.7-1
[70] gbRd_0.4-11           knitr_1.20            bindr_0.1.1
```

## References

Annicchiarico, P. (1997). Joint regression vs AMMI analysis of genotype-environment interactions for cereals in Italy. *Euphytica* 94, 53–62. doi:10.1023/A:1002954824178.

Bajpai, P. K., and Prabhakaran, V. T. (2000). A new procedure of simultaneous selection for high yielding and stable crop genotypes. *Indian Journal of Genetics & Plant Breeding* 60, 141–146.

Farshadfar, E. (2008). Incorporation of AMMI stability value and grain yield in a single non-parametric index (GSI) in bread wheat. *Pakistan Journal of biological sciences* 11, 1791.

Farshadfar, E., Mahmodi, N., and Yaghotipoor, A. (2011). AMMI stability value and simultaneous estimation of yield and yield stability in bread wheat (*Triticum aestivum* L.). *Australian Journal of Crop Science* 5, 1837–1844.

Gauch, H. G. (1988). Model selection and validation for yield trials with interaction. *Biometrics* 44, 705–715. doi:10.2307/2531585.

Gauch, H. G. (1992). *Statistical Analysis of Regional Yield Trials: AMMI Analysis of Factorial Designs*. Amsterdam ; New York: Elsevier.

Jambhulkar, N. N., Bose, L. K., Pande, K., and Singh, O. N. (2015). Genotype by environment interaction and stability analysis in rice genotypes. *Ecology, Environment and Conservation* 21, 1427–1430. Available at: http://www.envirobiotechjournals.com/article_abstract.php?aid=6346&iid=200&jid=3.

Jambhulkar, N. N., Bose, L. K., and Singh, O. N. (2014). "AMMI stability index for stability analysis," in *CRRI Newsletter, January-March 2014*, ed. T. Mohapatra (Cuttack, Orissa: Central Rice Research Institute), 15. Available at: http://www.crri.nic.in/CRRI_newsletter/crnl_jan_mar_14_web.pdf.

Jambhulkar, N. N., Rath, N. C., Bose, L. K., Subudhi, H., Biswajit, M., Lipi, D., et al. (2017). Stability analysis for grain yield in rice in demonstrations conducted during rabi season in India. *Oryza* 54, 236–240. doi:10.5958/2249-5266.2017.00030.3.

Purchase, J. L. (1997). Parametric Analysis to Describe Genotype × Environment Interaction and Yield Stability in Winter Wheat. Available at: http://scholar.ufs.ac.za:8080/xmlui/handle/11660/1966.

Purchase, J. L., Hatting, H., and Deventer, C. S. van (1999). "The use of the AMMI model and AMMI stability value to describe genotype x environment interaction and yield stability in winter wheat (*Triticum aestivum* L.)," in *Proceedings of the Tenth Regional Wheat Workshop for Eastern, Central and Southern Africa, 14-18 September 1998* (South Africa: University of Stellenbosch).

Purchase, J. L., Hatting, H., and Deventer, C. S. van (2000). Genotype × environment interaction of winter wheat (*Triticum aestivum* L.) In South Africa: II. Stability analysis of yield performance. *South African Journal of Plant and Soil* 17, 101–107. doi:10.1080/02571862.2000.10634878.

Raju, B. M. K. (2002). A study on AMMI model and its biplots. *Journal of the Indian Society of Agricultural Statistics* 55, 297–322.

Rao, A. R., and Prabhakaran, V. T. (2005). Use of AMMI in simultaneous selection of genotypes for yield and stability. *Journal of the Indian Society of Agricultural Statistics* 59, 76–82.

Sneller, C. H., Kilgore-Norquest, L., and Dombek, D. (1997). Repeatability of yield stability statistics in soybean. *Crop Science* 37, 383–390. doi:10.2135/cropsci1997.0011183X003700020013x.

Wricke, G. (1962). On a method of understanding the biological diversity in field research. *Zeitschrift für Pflanzenzüchtung* 47, 92–146.

Zali, H., Farshadfar, E., Sabaghpour, S. H., and Karimizadeh, R. (2012). Evaluation of genotype × environment interaction in chickpea using measures of stability from AMMI model. *Annals of Biological Research* 3, 3126–3136. Available at: http://eprints.icrisat.ac.in/id/eprint/7173.

Zhang, Z., Lu, C., and Xiang, Z. (1998). Analysis of variety stability based on AMMI model. *Acta Agronomica Sinica* 24, 304–309. Available at: http://zwxb.chinacrops.org/EN/Y1998/V24/I03/304.

Zobel, R. W. (1994). "Stress resistance and root systems," in *Proceedings of the Workshop on Adaptation of Plants to Soil Stress. 1-4 August, 1993. INTSORMIL Publication 94-2* (Institute of Agriculture; Natural Resources, University of Nebraska-Lincoln), 80–99.