DASC 6510 Project Models

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Split-Split-Plot ANOVA

The experiment was conducted using three blocks to control for field variability. Treatments were randomized within each block following a split–split-plot design.

The structure of the experimental design was as follows:

- Main plot factor: Planting date (5 levels: July 16, August 1, August 16, September 1, September 16)
- Subplot factor: Rice genotype (3 varieties: Nehara, Bhasamanik, Bhasakalma)
- Sub-subplot factors: Plant spacing (6 in, 9 in, 12 in) and number of seedlings per hill (1, 2, and local method)

It was determined that a split-split-plot ANOVA model should be fitted to the data, as a standard ANOVA model might not be adequate. The *lmer* function from the *lme4* package will be used to fit the model.

```
# Loading the lme4 package
library(lmerTest)
```

```
## Loading required package: lme4
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'lmerTest'
```

```
## The following object is masked from 'package:lme4':
##
##     lmer
```

```
## The following object is masked from 'package:stats':
##
##     step
```

```
## Fitting the mixed-effects model ##
  # Fixed effects include all factors and their interactions.
  # Random effects capture the appropriate
    # error structures for each plot size.
splitSplitAnova_fit <- lmer(yield ~ date * variety * seed * spacing +
```

```
                            (1 | block) +
                            (1 | block:date) +
                            (1 | block:date:variety),
                          data = df)
anova(splitSplitAnova_fit)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                           Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## date                      426381  106595     4     8  78.4703 1.870e-06 ***
## variety                   326478  163239     2    20 120.1686 7.161e-12 ***
## seed                       65375   32687     2   240  24.0629 2.989e-10 ***
## spacing                   129705   64852     2   240  47.7413 < 2.2e-16 ***
## date:variety               54569    6821     8    20   5.0214 0.0016073 **
## date:seed                  19883    2485     8   240   1.8296 0.0722917 .
## variety:seed                4449    1112     4   240   0.8189 0.5141991
## date:spacing               42571    5321     8   240   3.9174 0.0002276 ***
## variety:spacing             5213    1303     4   240   0.9593 0.4305374
## seed:spacing                5574    1394     4   240   1.0259 0.3945266
## date:variety:seed          63885    3993    16   240   2.9393 0.0001857 ***
## date:variety:spacing       47251    2953    16   240   2.1740 0.0065104 **
## date:seed:spacing          23059    1441    16   240   1.0609 0.3937950
## variety:seed:spacing        9584    1198     8   240   0.8819 0.5323336
## date:variety:seed:spacing  30288     946    32   240   0.6968 0.8896726
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Updating the model formula to remove the highest-order
#   non-significant interaction term:
#     - date:variety:seed:spacing
splitSplitAnova2 <- update(splitSplitAnova_fit, .~.
                -date:variety:seed:spacing)
anova(splitSplitAnova2)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## date                  411169  102792     4     8  78.4702 1.870e-06 ***
## variety               314831  157416     2    20 120.1688 7.160e-12 ***
## seed                   65375   32687     2   272  24.9531 1.122e-10 ***
## spacing               129705   64852     2   272  49.5074 < 2.2e-16 ***
## date:variety           52623    6578     8    20   5.0214 0.0016073 **
## date:seed              19883    2485     8   272   1.8973 0.0604901 .
## variety:seed            4449    1112     4   272   0.8492 0.4951088
## date:spacing           42571    5321     8   272   4.0623 0.0001386 ***
## variety:spacing         5213    1303     4   272   0.9948 0.4107872
## seed:spacing            5574    1394     4   272   1.0638 0.3747701
## date:variety:seed      63885    3993    16   272   3.0480 9.771e-05 ***
## date:variety:spacing   47251    2953    16   272   2.2544 0.0043273 **
## date:seed:spacing      23059    1441    16   272   1.1002 0.3545443
## variety:seed:spacing    9584    1198     8   272   0.9145 0.5047689
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Updating the model formula to remove non-significant
#   3-way interaction terms:
#     - variety:seed:spacing
#     - date:seed:spacing
splitSplitAnova3 <- update(splitSplitAnova2, .~.
                -variety:seed:spacing
                -date:seed:spacing)
anova(splitSplitAnova3)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## date                  412448  103112     4     8  78.4706 1.870e-06 ***
## variety               315808  157904     2    20 120.1688 7.160e-12 ***
## seed                   65375   32687     2   296  24.8759 1.033e-10 ***
## spacing               129705   64852     2   296  49.3542 < 2.2e-16 ***
## date:variety           52786    6598     8    20   5.0214 0.0016073 **
## date:seed              19883    2485     8   296   1.8914 0.0610042 .
## variety:seed            4449    1112     4   296   0.8465 0.4966250
## date:spacing           42571    5321     8   296   4.0497 0.0001375 ***
## variety:spacing         5213    1303     4   296   0.9917 0.4122963
## seed:spacing            5574    1394     4   296   1.0605 0.3762520
## date:variety:seed      63885    3993    16   296   3.0386 9.529e-05 ***
## date:variety:spacing   47251    2953    16   296   2.2474 0.0043292 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Updating the model formula to remove non-significant
#   2-way interaction terms (while preserving hierarchy):
#     - seed:spacing
splitSplitAnova4 <- update(splitSplitAnova3, .~.
                -seed:spacing)
anova(splitSplitAnova4)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## date                  412776  103194     4     8  78.4696 1.870e-06 ***
## variety               316064  158032     2    20 120.1690 7.160e-12 ***
## seed                   65375   32687     2   300  24.8559 1.027e-10 ***
## spacing               129705   64852     2   300  49.3144 < 2.2e-16 ***
## date:variety           52829    6604     8    20   5.0214 0.0016073 **
## date:seed              19883    2485     8   300   1.8899 0.0611809 .
## variety:seed            4449    1112     4   300   0.8459 0.4970313
## date:spacing           42571    5321     8   300   4.0464 0.0001379 ***
## variety:spacing         5213    1303     4   300   0.9909 0.4127064
## date:variety:seed      63885    3993    16   300   3.0362 9.542e-05 ***
## date:variety:spacing   47251    2953    16   300   2.2456 0.0043445 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The final reduced model includes the following terms:

- date

- variety
- seed
- spacing
- date:variety
- date:seed
- variety:seed
- date:spacing
- variety:spacing
- date:variety:seed
- date:variety:spacing

Note that the date:seed, variety:seed, and variety:spacing interactions were found to not be significant at $\alpha = 0.05$. However, these terms were included in the model to preserve hierarchy.

```
# The final reduced split-split-plot ANOVA model
splitSplitAnova_reduced <- splitSplitAnova4
anova(splitSplitAnova_reduced)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##                       Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
## date                  412776  103194     4     8  78.4696 1.870e-06 ***
## variety               316064  158032     2    20 120.1690 7.160e-12 ***
## seed                   65375   32687     2   300  24.8559 1.027e-10 ***
## spacing               129705   64852     2   300  49.3144 < 2.2e-16 ***
## date:variety           52829    6604     8    20   5.0214 0.0016073 **
## date:seed              19883    2485     8   300   1.8899 0.0611809 .
## variety:seed            4449    1112     4   300   0.8459 0.4970313
## date:spacing           42571    5321     8   300   4.0464 0.0001379 ***
## variety:spacing         5213    1303     4   300   0.9909 0.4127064
## date:variety:seed      63885    3993    16   300   3.0362 9.542e-05 ***
## date:variety:spacing   47251    2953    16   300   2.2456 0.0043445 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Standard ANOVA

A standard ANOVA model for a factorial experimental design with blocking will also be fitted to the data as an alternative strategy. In this case, the blocking factor will be treated as an independent nuisance factor.

A key assumption for this model is that there is no interaction between the blocks and the treatment factors.

```
# Fitting a standard factorial ANOVA model with blocking
factorialAnova_fit <- aov(yield ~ date * variety * seed * spacing + block, data=df)
summary(factorialAnova_fit)
```

```
##                              Df  Sum Sq Mean Sq F value   Pr(>F)
## date                          4 9559048 2389762 931.473  < 2e-16 ***
## variety                       2 1417021  708510 276.161  < 2e-16 ***
## seed                          2   65375   32687  12.741 5.18e-06 ***
## spacing                       2  129705   64852  25.278 8.77e-11 ***
## block                         2  288096  144048  56.147  < 2e-16 ***
## date:variety                  8  236848   29606  11.540 4.47e-14 ***
## date:seed                     8   19883    2485   0.969   0.4608
## variety:seed                  4    4449    1112   0.434   0.7843
## date:spacing                  8   42571    5321   2.074   0.0386 *
## variety:spacing               4    5213    1303   0.508   0.7299
## seed:spacing                  4    5574    1394   0.543   0.7042
## date:variety:seed            16   63885    3993   1.556   0.0806 .
## date:variety:spacing         16   47251    2953   1.151   0.3082
## date:seed:spacing            16   23059    1441   0.562   0.9105
## variety:seed:spacing          8    9584    1198   0.467   0.8789
## date:variety:seed:spacing    32   30288     946   0.369   0.9994
## Residuals                   268  687574    2566
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Updating the model formula to remove the highest-order
#   non-significant interaction term:
#     - date:variety:seed:spacing
factorialAnova2 <- update(factorialAnova_fit, .~.
                -date:variety:seed:spacing)
summary(factorialAnova2)
```

```
##                          Df  Sum Sq Mean Sq F value   Pr(>F)
## date                      4 9559048 2389762 998.701  < 2e-16 ***
## variety                   2 1417021  708510 296.092  < 2e-16 ***
## seed                      2   65375   32687  13.660 2.10e-06 ***
## spacing                   2  129705   64852  27.102 1.51e-11 ***
## block                     2  288096  144048  60.199  < 2e-16 ***
## date:variety              8  236848   29606  12.373 2.53e-15 ***
## date:seed                 8   19883    2485   1.039   0.4068
## variety:seed              4    4449    1112   0.465   0.7615
## date:spacing              8   42571    5321   2.224   0.0257 *
## variety:spacing           4    5213    1303   0.545   0.7031
## seed:spacing              4    5574    1394   0.582   0.6756
## date:variety:seed        16   63885    3993   1.669   0.0517 .
## date:variety:spacing     16   47251    2953   1.234   0.2404
## date:seed:spacing        16   23059    1441   0.602   0.8816
## variety:seed:spacing      8    9584    1198   0.501   0.8555
## Residuals               300  717861    2393
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Updating the model formula to remove all non-significant
#   3-way interaction terms:
#     - variety:seed:spacing
#     - date:seed:spacing
#     - date:variety:spacing
```

```r
factorialAnova3 <- update(factorialAnova2, .~.
                 -variety:seed:spacing
                 -date:seed:spacing
                 -date:variety:spacing)
summary(factorialAnova3)
```

```
##                     Df  Sum Sq Mean Sq  F value   Pr(>F)
## date                 4 9559048 2389762 1018.507  < 2e-16 ***
## variety              2 1417021  708510  301.964  < 2e-16 ***
## seed                 2   65375   32687   13.931 1.53e-06 ***
## spacing              2  129705   64852   27.640 7.54e-12 ***
## block                2  288096  144048   61.393  < 2e-16 ***
## date:variety         8  236848   29606   12.618 6.91e-16 ***
## date:seed            8   19883    2485    1.059   0.3914
## variety:seed         4    4449    1112    0.474   0.7548
## date:spacing         8   42571    5321    2.268   0.0225 *
## variety:spacing      4    5213    1303    0.555   0.6952
## seed:spacing         4    5574    1394    0.594   0.6673
## date:variety:seed   16   63885    3993    1.702   0.0446 *
## Residuals          340  797755    2346
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Updating the model formula to remove all non-significant
#   2-way interaction terms (while preserving hierarchy):
#     - seed:spacing
#     - variety:spacing
factorialAnova4 <- update(factorialAnova3, .~.
                 -seed:spacing
                 -variety:spacing)
summary(factorialAnova4)
```

```
##                     Df  Sum Sq Mean Sq  F value   Pr(>F)
## date                 4 9559048 2389762 1028.564  < 2e-16 ***
## variety              2 1417021  708510  304.946  < 2e-16 ***
## seed                 2   65375   32687   14.069 1.33e-06 ***
## spacing              2  129705   64852   27.913 5.72e-12 ***
## block                2  288096  144048   61.999  < 2e-16 ***
## date:variety         8  236848   29606   12.743 4.32e-16 ***
## date:seed            8   19883    2485    1.070   0.3838
## variety:seed         4    4449    1112    0.479   0.7513
## date:spacing         8   42571    5321    2.290   0.0212 *
## date:variety:seed   16   63885    3993    1.719   0.0416 *
## Residuals          348  808542    2323
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The final reduced model includes the following terms:

- date
- variety

- seed
- spacing
- date:variety
- date:seed
- variety:seed
- date:spacing
- date:variety:seed

Note that the date:seed and variety:seed interactions were found to not be significant at $\alpha = 0.05$. However, these terms were included in the model to preserve hierarchy.

```
# The final reduced factorial ANOVA model with blocking
factorialAnova_reduced <- factorialAnova4
summary(factorialAnova_reduced)
```

```
##                     Df  Sum Sq Mean Sq  F value   Pr(>F)
## date                 4 9559048 2389762 1028.564  < 2e-16 ***
## variety              2 1417021  708510  304.946  < 2e-16 ***
## seed                 2   65375   32687   14.069 1.33e-06 ***
## spacing              2  129705   64852   27.913 5.72e-12 ***
## block                2  288096  144048   61.999  < 2e-16 ***
## date:variety         8  236848   29606   12.743 4.32e-16 ***
## date:seed            8   19883    2485    1.070   0.3838
## variety:seed         4    4449    1112    0.479   0.7513
## date:spacing         8   42571    5321    2.290   0.0212 *
## date:variety:seed   16   63885    3993    1.719   0.0416 *
## Residuals          348  808542    2323
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Split-Split-Plot regression model with coefficients

```
# Regression model (split-split-plot ANOVA) with coefficients
summary(splitSplitAnova_reduced)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: yield ~ date + variety + seed + spacing + (1 | block) + (1 |
##     block:date) + (1 | block:date:variety) + date:variety + date:seed +
##     variety:seed + date:spacing + variety:spacing + date:variety:seed +
##     date:variety:spacing
##    Data: df
##
## REML criterion at convergence: 3519.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -4.9659 -0.4270 -0.0118  0.3546  3.8656
##
## Random effects:
##  Groups              Name        Variance Std.Dev.
##  block:date:variety (Intercept)  509.0   22.56
##  block:date         (Intercept)  909.6   30.16
##  block              (Intercept)  841.4   29.01
##  Residual                       1315.1   36.26
## Number of obs: 405, groups:  block:date:variety, 45; block:date, 15; block, 3
##
## Fixed effects:
##                                    Estimate Std. Error        df t value
## (Intercept)                         484.3148    31.5732   13.1192  15.339
## dateA16                             -49.3889    37.8520   27.2163  -1.305
## dateJ16                             -26.9444    37.8520   27.2163  -0.712
## dateS01                             -64.3519    37.8520   27.2163  -1.700
## dateS16                            -483.7222    37.8520   27.2163 -12.779
## varietyBhasamanik                    61.6667    28.7470   67.9995   2.145
## varietyNehara                      -106.6667    28.7470   67.9995  -3.711
## seed2                                 0.2778    17.0950  300.0000   0.016
## seedlocal                            25.6111    17.0950  300.0000   1.498
## spacing9                             19.2222    17.0950  300.0000   1.124
## spacing12                           -10.5000    17.0950  300.0000  -0.614
## dateA16:varietyBhasamanik             7.4444    40.6544   67.9995   0.183
## dateJ16:varietyBhasamanik           -33.2222    40.6544   67.9995  -0.817
## dateS01:varietyBhasamanik           -37.5185    40.6544   67.9995  -0.923
## dateS16:varietyBhasamanik           100.7963    40.6544   67.9995   2.479
## dateA16:varietyNehara                45.5556    40.6544   67.9995   1.121
## dateJ16:varietyNehara                44.6481    40.6544   67.9995   1.098
## dateS01:varietyNehara               -46.8704    40.6544   67.9995  -1.153
## dateS16:varietyNehara               111.8889    40.6544   67.9995   2.752
## dateA16:seed2                        58.7778    24.1760  300.0000   2.431
## dateJ16:seed2                        32.5000    24.1760  300.0000   1.344
## dateS01:seed2                         8.6111    24.1760  300.0000   0.356
## dateS16:seed2                        -0.6111    24.1760  300.0000  -0.025
## dateA16:seedlocal                    40.5556    24.1760  300.0000   1.678
## dateJ16:seedlocal                    -1.3333    24.1760  300.0000  -0.055
## dateS01:seedlocal                    15.7778    24.1760  300.0000   0.653
## dateS16:seedlocal                   -25.8889    24.1760  300.0000  -1.071
## varietyBhasamanik:seed2               1.4444    24.1760  300.0000   0.060
## varietyNehara:seed2                  51.3333    24.1760  300.0000   2.123
## varietyBhasamanik:seedlocal         -17.9444    24.1760  300.0000  -0.742
## varietyNehara:seedlocal             -22.1667    24.1760  300.0000  -0.917
## dateA16:spacing9                    -27.5556    24.1760  300.0000  -1.140
## dateJ16:spacing9                    -39.7222    24.1760  300.0000  -1.643
## dateS01:spacing9                    -57.7222    24.1760  300.0000  -2.388
## dateS16:spacing9                    -19.5000    24.1760  300.0000  -0.807
## dateA16:spacing12                   -30.2778    24.1760  300.0000  -1.252
## dateJ16:spacing12                   -32.2778    24.1760  300.0000  -1.335
## dateS01:spacing12                   -92.0556    24.1760  300.0000  -3.808
## dateS16:spacing12                    10.8333    24.1760  300.0000   0.448
## varietyBhasamanik:spacing9          -27.3333    24.1760  300.0000  -1.131
## varietyNehara:spacing9               -9.0556    24.1760  300.0000  -0.375
## varietyBhasamanik:spacing12          -5.1667    24.1760  300.0000  -0.214
```

```
## varietyNehara:spacing12               3.0556    24.1760  300.0000   0.126
## dateA16:varietyBhasamanik:seed2     -52.5000    34.1901  300.0000  -1.536
## dateJ16:varietyBhasamanik:seed2     -18.1667    34.1901  300.0000  -0.531
## dateS01:varietyBhasamanik:seed2      15.7778    34.1901  300.0000   0.461
## dateS16:varietyBhasamanik:seed2      68.0000    34.1901  300.0000   1.989
## dateA16:varietyNehara:seed2         -95.5556    34.1901  300.0000  -2.795
## dateJ16:varietyNehara:seed2        -109.8889    34.1901  300.0000  -3.214
## dateS01:varietyNehara:seed2         -32.4444    34.1901  300.0000  -0.949
## dateS16:varietyNehara:seed2         -48.3889    34.1901  300.0000  -1.415
## dateA16:varietyBhasamanik:seedlocal -28.0000    34.1901  300.0000  -0.819
## dateJ16:varietyBhasamanik:seedlocal  10.8333    34.1901  300.0000   0.317
## dateS01:varietyBhasamanik:seedlocal  25.7778    34.1901  300.0000   0.754
## dateS16:varietyBhasamanik:seedlocal 125.6111    34.1901  300.0000   3.674
## dateA16:varietyNehara:seedlocal     -17.7778    34.1901  300.0000  -0.520
## dateJ16:varietyNehara:seedlocal      -2.0556    34.1901  300.0000  -0.060
## dateS01:varietyNehara:seedlocal      50.2222    34.1901  300.0000   1.469
## dateS16:varietyNehara:seedlocal      25.7222    34.1901  300.0000   0.752
## dateA16:varietyBhasamanik:spacing9   22.8333    34.1901  300.0000   0.668
## dateJ16:varietyBhasamanik:spacing9   31.7222    34.1901  300.0000   0.928
## dateS01:varietyBhasamanik:spacing9   33.4444    34.1901  300.0000   0.978
## dateS16:varietyBhasamanik:spacing9  -42.8889    34.1901  300.0000  -1.254
## dateA16:varietyNehara:spacing9      -22.8333    34.1901  300.0000  -0.668
## dateJ16:varietyNehara:spacing9       18.8889    34.1901  300.0000   0.552
## dateS01:varietyNehara:spacing9       29.1667    34.1901  300.0000   0.853
## dateS16:varietyNehara:spacing9        7.2222    34.1901  300.0000   0.211
## dateA16:varietyBhasamanik:spacing12  14.5000    34.1901  300.0000   0.424
## dateJ16:varietyBhasamanik:spacing12  -2.5556    34.1901  300.0000  -0.075
## dateS01:varietyBhasamanik:spacing12  51.6111    34.1901  300.0000   1.510
## dateS16:varietyBhasamanik:spacing12 -106.6667    34.1901  300.0000  -3.120
## dateA16:varietyNehara:spacing12     -12.6667    34.1901  300.0000  -0.370
## dateJ16:varietyNehara:spacing12       8.5000    34.1901  300.0000   0.249
## dateS01:varietyNehara:spacing12       2.4444    34.1901  300.0000   0.071
## dateS16:varietyNehara:spacing12      -7.3889    34.1901  300.0000  -0.216
##                                    Pr(>|t|)
## (Intercept)                        9.26e-10 ***
## dateA16                            0.202890
## dateJ16                            0.482624
## dateS01                            0.100516
## dateS16                            5.14e-13 ***
## varietyBhasamanik                  0.035516 *
## varietyNehara                      0.000419 ***
## seed2                              0.987047
## seedlocal                          0.135143
## spacing9                           0.261728
## spacing12                          0.539540
## dateA16:varietyBhasamanik          0.855252
## dateJ16:varietyBhasamanik          0.416676
## dateS01:varietyBhasamanik          0.359341
## dateS16:varietyBhasamanik          0.015646 *
## dateA16:varietyNehara              0.266419
## dateJ16:varietyNehara              0.275975
## dateS01:varietyNehara              0.252989
## dateS16:varietyNehara              0.007583 **
## dateA16:seed2                      0.015633 *
```

```
## dateJ16:seed2                        0.179865
## dateS01:seed2                        0.721953
## dateS16:seed2                        0.979850
## dateA16:seedlocal                    0.094484 .
## dateJ16:seedlocal                    0.956055
## dateS01:seedlocal                    0.514501
## dateS16:seedlocal                    0.285098
## varietyBhasamanik:seed2              0.952397
## varietyNehara:seed2                  0.034546 *
## varietyBhasamanik:seedlocal          0.458522
## varietyNehara:seedlocal              0.359939
## dateA16:spacing9                     0.255284
## dateJ16:spacing9                     0.101422
## dateS01:spacing9                     0.017579 *
## dateS16:spacing9                     0.420545
## dateA16:spacing12                    0.211404
## dateJ16:spacing12                    0.182851
## dateS01:spacing12                    0.000170 ***
## dateS16:spacing12                    0.654403
## varietyBhasamanik:spacing9           0.259128
## varietyNehara:spacing9               0.708247
## varietyBhasamanik:spacing12          0.830918
## varietyNehara:spacing12              0.899510
## dateA16:varietyBhasamanik:seed2      0.125707
## dateJ16:varietyBhasamanik:seed2      0.595574
## dateS01:varietyBhasamanik:seed2      0.644794
## dateS16:varietyBhasamanik:seed2      0.047622 *
## dateA16:varietyNehara:seed2          0.005527 **
## dateJ16:varietyNehara:seed2          0.001451 **
## dateS01:varietyNehara:seed2          0.343413
## dateS16:varietyNehara:seed2          0.158020
## dateA16:varietyBhasamanik:seedlocal 0.413464
## dateJ16:varietyBhasamanik:seedlocal 0.751573
## dateS01:varietyBhasamanik:seedlocal 0.451467
## dateS16:varietyBhasamanik:seedlocal 0.000283 ***
## dateA16:varietyNehara:seedlocal      0.603469
## dateJ16:varietyNehara:seedlocal      0.952099
## dateS01:varietyNehara:seedlocal      0.142904
## dateS16:varietyNehara:seedlocal      0.452442
## dateA16:varietyBhasamanik:spacing9   0.504752
## dateJ16:varietyBhasamanik:spacing9   0.354247
## dateS01:varietyBhasamanik:spacing9   0.328768
## dateS16:varietyBhasamanik:spacing9   0.210664
## dateA16:varietyNehara:spacing9       0.504752
## dateJ16:varietyNehara:spacing9       0.581040
## dateS01:varietyNehara:spacing9       0.394299
## dateS16:varietyNehara:spacing9       0.832845
## dateA16:varietyBhasamanik:spacing12 0.671797
## dateJ16:varietyBhasamanik:spacing12 0.940467
## dateS01:varietyBhasamanik:spacing12 0.132214
## dateS16:varietyBhasamanik:spacing12 0.001986 **
## dateA16:varietyNehara:spacing12      0.711288
## dateJ16:varietyNehara:spacing12      0.803832
## dateS01:varietyNehara:spacing12      0.943051
```

```
## dateS16:varietyNehara:spacing12     0.829047
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 75 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it
```