Meta-analysis of the effect of DMI+QoI mixtures plus mancozeb on Asian soybean rust and yield return

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Contents

1 Import data **1**

2 Descritive analysis **1**
2.1 number of studies by fungicide 1
2.2 Variables for MA 2

3 modelo multivariado **3**

4 Yield return **3**

5 Percent yield return **7**

6 Control efficacy **12**

7 Plots **16**

1 Import data

2 Descritive analysis

2.1 number of studies by fungicide

```
check <- dat2 %>% group_by(study) %>% filter (AI == "AACHECK")
nrow(data.frame(table(check$study)))
```

```
## [1] 101
```

```
pico_cipr <- dat2 %>% group_by(study) %>% filter (AI == "PICO + CIPR")
nrow(data.frame(table(pico_cipr$study)))
```

```
## [1] 33
```

```
pico_cipr_manc <- dat2 %>% group_by(study) %>% filter (AI == "PICO + CIPR + MANC")
nrow(data.frame(table(pico_cipr_manc$study)))
```

```
## [1] 33
```

```
azox_benz <- dat2 %>% group_by(study) %>% filter (AI == "AZOX + BENZ")
nrow(data.frame(table(azox_benz$study)))
```

```
## [1] 52
```

```
azox_benz_manc <- dat2 %>% group_by(study) %>% filter (AI == "AZOX + BENZ + MANC")
nrow(data.frame(table(azox_benz_manc$study)))
```

```
## [1] 18
```

```
tflx_prot <- dat2 %>% group_by(study) %>% filter (AI == "TFLX + PROT")
nrow(data.frame(table(tflx_prot$study)))
```

```
## [1] 62
```

```
tflx_prot_manc <- dat2 %>% group_by(study) %>% filter (AI == "TFLX + PROT + MANC")
nrow(data.frame(table(tflx_prot_manc$study)))
```

```
## [1] 40
```

```
pico_tebu <- dat2 %>% group_by(study) %>% filter (AI == "PICO + TEBU")
nrow(data.frame(table(pico_tebu$study)))
```

```
## [1] 38
```

```
pico_tebu_manc <- dat2 %>% group_by(study) %>% filter (AI == "PICO + TEBU + MANC")
nrow(data.frame(table(pico_tebu_manc$study)))
```

```
## [1] 21
```

```
pira_epox <- dat2 %>% group_by(study) %>% filter (AI == "PIRA + EPOX")
nrow(data.frame(table(pira_epox$study)))
```

```
## [1] 22
```

```
pira_epox_manc <- dat2 %>% group_by(study) %>% filter (AI == "PIRA + EPOX + MANC")
nrow(data.frame(table(pira_epox_manc$study)))
```

```
## [1] 22
```

```
pira_flux <- dat2 %>% group_by(study) %>% filter (AI == "PIRA + FLUX")
nrow(data.frame(table(pira_flux$study)))
```

```
## [1] 47
```

```
pira_flux_manc <- dat2 %>% group_by(study) %>% filter (AI == "PIRA + FLUX + MANC")
nrow(data.frame(table(pira_flux_manc$study)))
```

```
## [1] 14
```

```
azox_cipr <- dat2 %>% group_by(study) %>% filter (AI == "AZOX + CIPR")
nrow(data.frame(table(azox_cipr$study)))
```

```
## [1] 52
```

```
azox_cipr_manc <- dat2 %>% group_by(study) %>% filter (AI == "AZOX + CIPR + MANC")
nrow(data.frame(table(azox_cipr_manc$study)))
```

```
## [1] 35
```

2.2 Variables for MA

```
# Calcula a variancia do ensaio (V)
dat2$V_sev <- ((dat2$cv_sev_r6/100)*dat2$mean_sev)^2
```

```r
dat2$V_yield <- ((dat2$cv_yield_kg/100)*dat2$mean_yield)^2


# Sampling variance for log of the mean (Paul et al., 2008) to use in multivariate model
dat2$L.var_yield <- with(dat2, V_yield / (4 * yield_kg^2))
dat2$L.var_sev <- with(dat2, V_sev / (4 * sev_r6^2))


# Calculate the D
dat2$D <-dat2$yield_kg - dat2$check_yield_kg

# Sampling variance for yield
dat2$var_D <- dat2$V_yield/4



# Multi treatment meta-analysis (response ratio)
# Preparing the variables: yi is the effect size and vi is the sampling variance
dat2$yi <- log(dat2$yield_kg)
dat2$vi <- dat2$L.var_yield
dat2$id <- 1:nrow(dat2)


dat2$yi_sev <- log(dat2$sev_r6)
dat2$vi_sev <- dat2$L.var_sev

# Multi treatment meta-analysis (D)

# Preparing the variables: yi is the effect size and vi is the sampling variance
dat2$yi2 <- dat2$yield_kg
dat2$vi2 <- dat2$var_D
```

3 modelo multivariado

4 Yield return

```r
ma_AI <- rma.mv(yi2, vi2, mods= ~ AI,  method="ML", struct="UN", random = list(~ AI | study), control =
```

```
## Warning in rma.mv(yi2, vi2, mods = ~AI, method = "ML", struct = "UN",
## random = list(~AI | : Rows with NAs omitted from model fitting.
```

```
## Warning in rma.mv(yi2, vi2, mods = ~AI, method = "ML", struct = "UN",
## random = list(~AI | : Some combinations of the levels of the inner factor
## never occurred. Corresponding 'rho' value(s) fixed to 0.
```

```r
summary(ma_AI)
```

```
##
## Multivariate Meta-Analysis Model (k = 678; method: ML)
##
##     logLik    Deviance         AIC         BIC        AICc
## -4843.5647   2256.4077   9953.1295  10554.1760  10018.6515
```

```
##
## Variance Components:
##
## outer factor: study (nlvls = 97)
## inner factor: AI    (nlvls = 15)
##
##                    estim       sqrt  k.lvl  fixed              level
## tau^2.1      927642.7492   963.1421     97     no            AACHECK
## tau^2.2      695858.9953   834.1816     57     no         AZOX + BENZ
## tau^2.3      719386.3224   848.1664     20     no  AZOX + BENZ + MANC
## tau^2.4      776838.7497   881.3846     65     no         AZOX + CIPR
## tau^2.5      728247.2054   853.3740     62     no  AZOX + CIPR + MANC
## tau^2.6      805476.9338   897.4837     41     no         PICO + CIPR
## tau^2.7      804110.3848   896.7220     41     no  PICO + CIPR + MANC
## tau^2.8      926525.7354   962.5621     45     no         PICO + TEBU
## tau^2.9      814697.1009   902.6057     29     no  PICO + TEBU + MANC
## tau^2.10    1007911.4930  1003.9480     24     no         PIRA + EPOX
## tau^2.11     837079.7109   914.9206     24     no  PIRA + EPOX + MANC
## tau^2.12    1068982.6839  1033.9162     46     no         PIRA + FLUX
## tau^2.13     876534.1031   936.2340     16     no  PIRA + FLUX + MANC
## tau^2.14     880622.6099   938.4149     63     no         TFLX + PROT
## tau^2.15     842610.0433   917.9379     48     no  TFLX + PROT + MANC
##
##                     rho.AACH  rho.AZ+B  rho.A+B+M  rho.AZ+C  rho.A+C+M
## AACHECK                    1    0.7297     0.6780    0.9410     0.9117
## AZOX + BENZ           0.7297         1     0.9684    0.7723     0.8524
## AZOX + BENZ + MANC    0.6780    0.9684          1    0.7499     0.8471
## AZOX + CIPR           0.9410    0.7723     0.7499         1     0.9774
## AZOX + CIPR + MANC    0.9117    0.8524     0.8471    0.9774          1
## PICO + CIPR           0.9323    0.8493     0.8344    0.9857     0.9825
## PICO + CIPR + MANC    0.9235    0.8921     0.8811    0.9577     0.9751
## PICO + TEBU           0.9169    0.8656     0.8466    0.9668     0.9762
## PICO + TEBU + MANC    0.8516    0.9442     0.9481    0.8952     0.9481
## PIRA + EPOX           0.9394    0.6947     0.0000    0.9918     0.9571
## PIRA + EPOX + MANC    0.9380    0.8286     0.0000    0.9883     0.9932
## PIRA + FLUX           0.8582    0.8624     0.8422    0.9619     0.9706
## PIRA + FLUX + MANC    0.9014    0.9149     0.9047    0.9337     0.9674
## TFLX + PROT           0.8689    0.9445     0.9396    0.9108     0.9595
## TFLX + PROT + MANC    0.8391    0.9586     0.9634    0.8726     0.9346
##                     rho.PI+C  rho.P+C+M  rho.PI+T  rho.P+T+M  rho.PI+E
## AACHECK               0.9323     0.9235    0.9169     0.8516    0.9394
## AZOX + BENZ           0.8493     0.8921    0.8656     0.9442    0.6947
## AZOX + BENZ + MANC    0.8344     0.8811    0.8466     0.9481    0.0000
## AZOX + CIPR           0.9857     0.9577    0.9668     0.8952    0.9918
## AZOX + CIPR + MANC    0.9825     0.9751    0.9762     0.9481    0.9571
## PICO + CIPR                1     0.9912    0.9920     0.9532    0.9600
## PICO + CIPR + MANC    0.9912          1    0.9935     0.9818    0.9227
## PICO + TEBU           0.9920     0.9935         1     0.9678    0.9387
## PICO + TEBU + MANC    0.9532     0.9818    0.9678          1    0.8444
## PIRA + EPOX           0.9600     0.9227    0.9387     0.8444         1
## PIRA + EPOX + MANC    0.9936     0.9841    0.9868     0.9457    0.9722
## PIRA + FLUX           0.9796     0.9688    0.9825     0.9441    0.9287
## PIRA + FLUX + MANC    0.9771     0.9957    0.9890     0.9926    0.8941
## TFLX + PROT           0.9597     0.9825    0.9660     0.9917    0.8592
```

```
## TFLX + PROT + MANC    0.9353     0.9692    0.9458     0.9942    0.8147
##                     rho.P+E+M  rho.PI+F  rho.P+F+M  rho.TF+P  rho.T+P+M
## AACHECK                0.9380    0.8582     0.9014    0.8689     0.8391
## AZOX + BENZ            0.8286    0.8624     0.9149    0.9445     0.9586
## AZOX + BENZ + MANC     0.0000    0.8422     0.9047    0.9396     0.9634
## AZOX + CIPR            0.9883    0.9619     0.9337    0.9108     0.8726
## AZOX + CIPR + MANC     0.9932    0.9706     0.9674    0.9595     0.9346
## PICO + CIPR            0.9936    0.9796     0.9771    0.9597     0.9353
## PICO + CIPR + MANC     0.9841    0.9688     0.9957    0.9825     0.9692
## PICO + TEBU            0.9868    0.9825     0.9890    0.9660     0.9458
## PICO + TEBU + MANC     0.9457    0.9441     0.9926    0.9917     0.9942
## PIRA + EPOX            0.9722    0.9287     0.8941    0.8592     0.8147
## PIRA + EPOX + MANC          1    0.9693     0.9720    0.9511     0.9259
## PIRA + FLUX            0.9693         1     0.9613    0.9515     0.9231
## PIRA + FLUX + MANC     0.9720    0.9613          1    0.9880     0.9808
## TFLX + PROT            0.9511    0.9515     0.9880         1     0.9947
## TFLX + PROT + MANC     0.9259    0.9231     0.9808    0.9947          1
##                      AACH  AZ+B  A+B+M  AZ+C  A+C+M  PI+C  P+C+M  PI+T
## AACHECK                 -    no     no    no     no    no     no    no
## AZOX + BENZ            51     -     no    no     no    no     no    no
## AZOX + BENZ + MANC     18    18      -    no     no    no     no    no
## AZOX + CIPR            49    14      1     -     no    no     no    no
## AZOX + CIPR + MANC     34    13      1    33      -    no     no    no
## PICO + CIPR            33    14      6    22     22     -     no    no
## PICO + CIPR + MANC     33    14      6    22     22    33      -    no
## PICO + TEBU            37    25      1    20     20    19     19     -
## PICO + TEBU + MANC     21     9      1    20     20    19     19    21
## PIRA + EPOX            22    11      0    18     18    13     13    11
## PIRA + EPOX + MANC     22    11      0    18     18    13     13    11
## PIRA + FLUX            46    35      6    20     16    13     13    28
## PIRA + FLUX + MANC     14     8      6     5      5     4      4     4
## TFLX + PROT            61    42     12    24     20    19     19    29
## TFLX + PROT + MANC     40    25     12    20     21    19     19    13
##                      P+T+M  PI+E  P+E+M  PI+F  P+F+M  TF+P  T+P+M
## AACHECK                 no    no     no    no     no    no     no
## AZOX + BENZ             no    no     no    no     no    no     no
## AZOX + BENZ + MANC      no   yes    yes    no     no    no     no
## AZOX + CIPR             no    no     no    no     no    no     no
## AZOX + CIPR + MANC      no    no     no    no     no    no     no
## PICO + CIPR             no    no     no    no     no    no     no
## PICO + CIPR + MANC      no    no     no    no     no    no     no
## PICO + TEBU             no    no     no    no     no    no     no
## PICO + TEBU + MANC       -    no     no    no     no    no     no
## PIRA + EPOX             11     -     no    no     no    no     no
## PIRA + EPOX + MANC      11    22      -    no     no    no     no
## PIRA + FLUX             13    17     17     -     no    no     no
## PIRA + FLUX + MANC       4     7      7    14      -    no     no
## TFLX + PROT             13    19     19    44     12     -     no
## TFLX + PROT + MANC      13    19     19    25     12    39      -
##
## Test for Residual Heterogeneity:
## QE(df = 663) = 79912.7745, p-val < .0001
##
## Test of Moderators (coefficient(s) 2,3,4,5,6,7,8,9,10,11,12,13,14,15):
```

```
## QM(df = 14) = 396.2752, p-val < .0001
##
## Model Results:
##
##                        estimate       se     zval    pval      ci.lb
## intrcpt               2174.4724  98.4021  22.0978  <.0001  1981.6078
## AIAZOX + BENZ         1028.9897  76.4388  13.4616  <.0001   879.1725
## AIAZOX + BENZ + MANC  1161.6984  87.6290  13.2570  <.0001   989.9486
## AIAZOX + CIPR          447.9271  39.9789  11.2041  <.0001   369.5698
## AIAZOX + CIPR + MANC   630.1411  49.1441  12.8223  <.0001   533.8203
## AIPICO + CIPR          539.6382  42.5143  12.6931  <.0001   456.3117
## AIPICO + CIPR + MANC   723.2180  44.5000  16.2521  <.0001   635.9995
## AIPICO + TEBU          637.4720  47.3087  13.4747  <.0001   544.7487
## AIPICO + TEBU + MANC   735.6066  60.8706  12.0848  <.0001   616.3023
## AIPIRA + EPOX          359.8802  49.0524   7.3366  <.0001   263.7392
## AIPIRA + EPOX + MANC   559.6787  44.1628  12.6731  <.0001   473.1213
## AIPIRA + FLUX          810.2621  61.9865  13.0716  <.0001   688.7708
## AIPIRA + FLUX + MANC   900.5441  56.7828  15.8595  <.0001   789.2519
## AITFLX + PROT          844.0221  55.0709  15.3261  <.0001   736.0851
## AITFLX + PROT + MANC   929.1345  61.0166  15.2276  <.0001   809.5442
##                          ci.ub
## intrcpt               2367.3369  ***
## AIAZOX + BENZ         1178.8069  ***
## AIAZOX + BENZ + MANC  1333.4481  ***
## AIAZOX + CIPR          526.2843  ***
## AIAZOX + CIPR + MANC   726.4618  ***
## AIPICO + CIPR          622.9646  ***
## AIPICO + CIPR + MANC   810.4364  ***
## AIPICO + TEBU          730.1953  ***
## AIPICO + TEBU + MANC   854.9109  ***
## AIPIRA + EPOX          456.0211  ***
## AIPIRA + EPOX + MANC   646.2362  ***
## AIPIRA + FLUX          931.7534  ***
## AIPIRA + FLUX + MANC  1011.8363  ***
## AITFLX + PROT          951.9590  ***
## AITFLX + PROT + MANC  1048.7249  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(ma_AI, L=rbind(c(0,-1,1,0,0,0,0,0,0,0,0,0,0,0,0),
                     c(0,0,0,-1,1,0,0,0,0,0,0,0,0,0,0),
                     c(0,0,0,0,0,-1,1,0,0,0,0,0,0,0,0),
                     c(0,0,0,0,0,0,0,-1,1,0,0,0,0,0,0),
                     c(0,0,0,0,0,0,0,0,0,-1,1,0,0,0,0),
                     c(0,0,0,0,0,0,0,0,0,0,0,-1,1,0,0),
                     c(0,0,0,0,0,0,0,0,0,0,0,0,0,-1,1)))
```

```
##
## Hypotheses:
## 1: -AIAZOX + BENZ + AIAZOX + BENZ + MANC = 0
## 2: -AIAZOX + CIPR + AIAZOX + CIPR + MANC = 0
## 3: -AIPICO + CIPR + AIPICO + CIPR + MANC = 0
## 4: -AIPICO + TEBU + AIPICO + TEBU + MANC = 0
## 5: -AIPIRA + EPOX + AIPIRA + EPOX + MANC = 0
```

```
## 6: -AIPIRA + FLUX + AIPIRA + FLUX + MANC = 0
## 7: -AITFLX + PROT + AITFLX + PROT + MANC = 0
##
## Results:
##    estimate      se   zval   pval
## 1: 132.7086 47.1140 2.8168 0.0049
## 2: 182.2140 32.3418 5.6340 <.0001
## 3: 183.5798 24.7914 7.4050 <.0001
## 4:  98.1346 38.4364 2.5532 0.0107
## 5: 199.7986 39.2998 5.0840 <.0001
## 6:  90.2821 49.4045 1.8274 0.0676
## 7:  85.1125 23.0807 3.6876 0.0002
##
## Omnibus Test of Hypotheses:
## QM(df = 7) = 80.5360, p-val < .0001
```

5 Percent yield return

```
ma_AI_perc_yield <- rma.mv(yi, vi, mods= ~ AI,  method="ML", struct="UN", random = list(~ AI | study), c
```

```
## Warning in rma.mv(yi, vi, mods = ~AI, method = "ML", struct = "UN", random
## = list(~AI | : Rows with NAs omitted from model fitting.
```

```
## Warning in rma.mv(yi, vi, mods = ~AI, method = "ML", struct = "UN", random
## = list(~AI | : Some combinations of the levels of the inner factor never
## occurred. Corresponding 'rho' value(s) fixed to 0.
```

```
summary(ma_AI_perc_yield)
```

```
##
## Multivariate Meta-Analysis Model (k = 678; method: ML)
##
##    logLik   Deviance        AIC        BIC       AICc
##  349.4856  2495.7008  -432.9712   168.0754  -367.4491
##
## Variance Components:
##
## outer factor: study (nlvls = 97)
## inner factor: AI    (nlvls = 15)
##
##              estim    sqrt  k.lvl  fixed               level
## tau^2.1     3.3044  1.8178     97     no             AACHECK
## tau^2.2     0.2010  0.4483     57     no         AZOX + BENZ
## tau^2.3     0.0892  0.2987     20     no  AZOX + BENZ + MANC
## tau^2.4     1.9891  1.4103     65     no         AZOX + CIPR
## tau^2.5     1.2411  1.1141     62     no  AZOX + CIPR + MANC
## tau^2.6     1.4705  1.2126     41     no         PICO + CIPR
## tau^2.7     1.0307  1.0153     41     no  PICO + CIPR + MANC
## tau^2.8     1.5544  1.2467     45     no         PICO + TEBU
## tau^2.9     0.7252  0.8516     29     no  PICO + TEBU + MANC
## tau^2.10    4.0181  2.0045     24     no         PIRA + EPOX
## tau^2.11    1.7243  1.3131     24     no  PIRA + EPOX + MANC
## tau^2.12    1.7397  1.3190     46     no         PIRA + FLUX
```

```
## tau^2.13    0.6942  0.8332     16     no  PIRA + FLUX + MANC
## tau^2.14    0.7028  0.8383     63     no         TFLX + PROT
## tau^2.15    0.4489  0.6700     48     no  TFLX + PROT + MANC
##
##                     rho.AACH  rho.AZ+B  rho.A+B+M  rho.AZ+C  rho.A+C+M
## AACHECK                    1    0.8545    -0.0929    0.9957     0.9905
## AZOX + BENZ           0.8545         1     0.4210    0.8703     0.8954
## AZOX + BENZ + MANC   -0.0929    0.4210          1   -0.0619    -0.0090
## AZOX + CIPR           0.9957    0.8703    -0.0619         1     0.9974
## AZOX + CIPR + MANC    0.9905    0.8954    -0.0090    0.9974          1
## PICO + CIPR           0.9924    0.8976    -0.0009    0.9978     0.9987
## PICO + CIPR + MANC    0.9881    0.9154     0.0420    0.9929     0.9968
## PICO + TEBU           0.9907    0.9007     0.0020    0.9964     0.9984
## PICO + TEBU + MANC    0.9670    0.9495     0.1422    0.9755     0.9864
## PIRA + EPOX           0.9963    0.8487     0.0000    0.9990     0.9942
## PIRA + EPOX + MANC    0.9934    0.8894     0.0000    0.9985     0.9994
## PIRA + FLUX           0.9881    0.8978    -0.0043    0.9970     0.9985
## PIRA + FLUX + MANC    0.9759    0.9376     0.1036    0.9824     0.9896
## TFLX + PROT           0.9688    0.9493     0.1400    0.9775     0.9880
## TFLX + PROT + MANC    0.9449    0.9700     0.2272    0.9536     0.9688
##                     rho.PI+C  rho.P+C+M  rho.PI+T  rho.P+T+M  rho.PI+E
## AACHECK               0.9924     0.9881    0.9907     0.9670    0.9963
## AZOX + BENZ           0.8976     0.9154    0.9007     0.9495    0.8487
## AZOX + BENZ + MANC   -0.0009     0.0420    0.0020     0.1422    0.0000
## AZOX + CIPR           0.9978     0.9929    0.9964     0.9755    0.9990
## AZOX + CIPR + MANC    0.9987     0.9968    0.9984     0.9864    0.9942
## PICO + CIPR                1     0.9985    0.9994     0.9876    0.9941
## PICO + CIPR + MANC    0.9985          1    0.9987     0.9941    0.9875
## PICO + TEBU           0.9994     0.9987         1     0.9890    0.9928
## PICO + TEBU + MANC    0.9876     0.9941    0.9890          1    0.9660
## PIRA + EPOX           0.9941     0.9875    0.9928     0.9660         1
## PIRA + EPOX + MANC    0.9995     0.9973    0.9990     0.9852    0.9959
## PIRA + FLUX           0.9985     0.9961    0.9987     0.9853    0.9934
## PIRA + FLUX + MANC    0.9923     0.9970    0.9938     0.9976    0.9744
## TFLX + PROT           0.9888     0.9945    0.9893     0.9994    0.9679
## TFLX + PROT + MANC    0.9710     0.9816    0.9722     0.9956    0.9403
##                     rho.P+E+M  rho.PI+F  rho.P+F+M  rho.TF+P  rho.T+P+M
## AACHECK                0.9934    0.9881     0.9759    0.9688     0.9449
## AZOX + BENZ            0.8894    0.8978     0.9376    0.9493     0.9700
## AZOX + BENZ + MANC     0.0000   -0.0043     0.1036    0.1400     0.2272
## AZOX + CIPR            0.9985    0.9970     0.9824    0.9775     0.9536
## AZOX + CIPR + MANC     0.9994    0.9985     0.9896    0.9880     0.9688
## PICO + CIPR            0.9995    0.9985     0.9923    0.9888     0.9710
## PICO + CIPR + MANC     0.9973    0.9961     0.9970    0.9945     0.9816
## PICO + TEBU            0.9990    0.9987     0.9938    0.9893     0.9722
## PICO + TEBU + MANC     0.9852    0.9853     0.9976    0.9994     0.9956
## PIRA + EPOX            0.9959    0.9934     0.9744    0.9679     0.9403
## PIRA + EPOX + MANC          1    0.9982     0.9898    0.9863     0.9667
## PIRA + FLUX            0.9982         1     0.9906    0.9868     0.9674
## PIRA + FLUX + MANC     0.9898    0.9906          1    0.9971     0.9903
## TFLX + PROT            0.9863    0.9868     0.9971         1     0.9954
## TFLX + PROT + MANC     0.9667    0.9674     0.9903    0.9954          1
##                     AACH  AZ+B  A+B+M  AZ+C  A+C+M  PI+C  P+C+M  PI+T
## AACHECK                -    no     no    no     no    no     no    no
```

```
## AZOX + BENZ           51     -     no    no     no    no     no    no
## AZOX + BENZ + MANC    18    18      -    no     no    no     no    no
## AZOX + CIPR           49    14      1     -     no    no     no    no
## AZOX + CIPR + MANC    34    13      1    33      -    no     no    no
## PICO + CIPR           33    14      6    22     22     -     no    no
## PICO + CIPR + MANC    33    14      6    22     22    33      -    no
## PICO + TEBU           37    25      1    20     20    19     19     -
## PICO + TEBU + MANC    21     9      1    20     20    19     19    21
## PIRA + EPOX           22    11      0    18     18    13     13    11
## PIRA + EPOX + MANC    22    11      0    18     18    13     13    11
## PIRA + FLUX           46    35      6    20     16    13     13    28
## PIRA + FLUX + MANC    14     8      6     5      5     4      4     4
## TFLX + PROT           61    42     12    24     20    19     19    29
## TFLX + PROT + MANC    40    25     12    20     21    19     19    13
##                     P+T+M  PI+E  P+E+M  PI+F  P+F+M  TF+P  T+P+M
## AACHECK               no    no     no    no     no    no     no
## AZOX + BENZ           no    no     no    no     no    no     no
## AZOX + BENZ + MANC    no   yes    yes    no     no    no     no
## AZOX + CIPR           no    no     no    no     no    no     no
## AZOX + CIPR + MANC    no    no     no    no     no    no     no
## PICO + CIPR           no    no     no    no     no    no     no
## PICO + CIPR + MANC    no    no     no    no     no    no     no
## PICO + TEBU           no    no     no    no     no    no     no
## PICO + TEBU + MANC     -    no     no    no     no    no     no
## PIRA + EPOX           11     -     no    no     no    no     no
## PIRA + EPOX + MANC    11    22      -    no     no    no     no
## PIRA + FLUX           13    17     17     -     no    no     no
## PIRA + FLUX + MANC     4     7      7    14      -    no     no
## TFLX + PROT           13    19     19    44     12     -     no
## TFLX + PROT + MANC    13    19     19    25     12    39      -
##
## Test for Residual Heterogeneity:
## QE(df = 663) = 62226.6639, p-val < .0001
##
## Test of Moderators (coefficient(s) 2,3,4,5,6,7,8,9,10,11,12,13,14,15):
## QM(df = 14) = 200.4007, p-val < .0001
##
## Model Results:
##
##                     estimate      se     zval    pval   ci.lb   ci.ub
## intrcpt               7.5676  0.1847  40.9792  <.0001  7.2056  7.9295
## AIAZOX + BENZ         0.4635  0.1482   3.1276  0.0018  0.1730  0.7539
## AIAZOX + BENZ + MANC  0.5340  0.1911   2.7947  0.0052  0.1595  0.9085
## AIAZOX + CIPR         0.2341  0.0451   5.1888  <.0001  0.1457  0.3225
## AIAZOX + CIPR + MANC  0.3146  0.0750   4.1940  <.0001  0.1676  0.4617
## AIPICO + CIPR         0.2691  0.0650   4.1397  <.0001  0.1417  0.3965
## AIPICO + CIPR + MANC  0.3441  0.0849   4.0554  <.0001  0.1778  0.5104
## AIPICO + TEBU         0.2934  0.0625   4.6904  <.0001  0.1708  0.4159
## AIPICO + TEBU + MANC  0.3496  0.1042   3.3550  0.0008  0.1454  0.5538
## AIPIRA + EPOX         0.1606  0.0298   5.3863  <.0001  0.1022  0.2190
## AIPIRA + EPOX + MANC  0.2729  0.0556   4.9085  <.0001  0.1640  0.3819
## AIPIRA + FLUX         0.3601  0.0573   6.2841  <.0001  0.2478  0.4725
## AIPIRA + FLUX + MANC  0.4173  0.1051   3.9707  <.0001  0.2113  0.6233
## AITFLX + PROT         0.3827  0.1048   3.6523  0.0003  0.1773  0.5881
```

```
## AITFLX + PROT + MANC    0.4176  0.1229   3.3970  0.0007  0.1766  0.6585
##
## intrcpt               ***
## AIAZOX + BENZ         **
## AIAZOX + BENZ + MANC  **
## AIAZOX + CIPR         ***
## AIAZOX + CIPR + MANC  ***
## AIPICO + CIPR         ***
## AIPICO + CIPR + MANC  ***
## AIPICO + TEBU         ***
## AIPICO + TEBU + MANC  ***
## AIPIRA + EPOX         ***
## AIPIRA + EPOX + MANC  ***
## AIPIRA + FLUX         ***
## AIPIRA + FLUX + MANC  ***
## AITFLX + PROT         ***
## AITFLX + PROT + MANC  ***
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(ma_AI_perc_yield, L=rbind(c(0,-1,1,0,0,0,0,0,0,0,0,0,0,0),
                        c(0,0,0,-1,1,0,0,0,0,0,0,0,0,0),
                        c(0,0,0,0,0,-1,1,0,0,0,0,0,0,0),
                        c(0,0,0,0,0,0,0,-1,1,0,0,0,0,0),
                        c(0,0,0,0,0,0,0,0,0,-1,1,0,0,0),
                        c(0,0,0,0,0,0,0,0,0,0,0,-1,1,0,0),
                        c(0,0,0,0,0,0,0,0,0,0,0,0,0,-1,1)))
```

```
##
## Hypotheses:
## 1: -AIAZOX + BENZ + AIAZOX + BENZ + MANC = 0
## 2: -AIAZOX + CIPR + AIAZOX + CIPR + MANC = 0
## 3: -AIPICO + CIPR + AIPICO + CIPR + MANC = 0
## 4: -AIPICO + TEBU + AIPICO + TEBU + MANC = 0
## 5: -AIPIRA + EPOX + AIPIRA + EPOX + MANC = 0
## 6: -AIPIRA + FLUX + AIPIRA + FLUX + MANC = 0
## 7: -AITFLX + PROT + AITFLX + PROT + MANC = 0
##
## Results:
##    estimate     se   zval   pval
## 1:   0.0705 0.0463 1.5239 0.1275
## 2:   0.0805 0.0333 2.4197 0.0155
## 3:   0.0750 0.0226 3.3181 0.0009
## 4:   0.0562 0.0446 1.2599 0.2077
## 5:   0.1124 0.0732 1.5358 0.1246
## 6:   0.0572 0.0542 1.0552 0.2914
## 7:   0.0348 0.0201 1.7337 0.0830
##
## Omnibus Test of Hypotheses:
## QM(df = 7) = 33.8153, p-val < .0001
```

```
data.frame(round((exp(ma_AI_perc_yield$b)-1)*100, 4),
           round((exp(ma_AI_perc_yield$ci.lb)-1)*100, 4),
           round((exp(ma_AI_perc_yield$ci.ub)-1)*100, 4))
```

```
##                       round..exp.ma_AI_perc_yield.b....1....100..4.
## intrcpt                                                193347.0968
## AIAZOX + BENZ                                              58.9583
## AIAZOX + BENZ + MANC                                       70.5731
## AIAZOX + CIPR                                              26.3790
## AIAZOX + CIPR + MANC                                       36.9768
## AIPICO + CIPR                                              30.8794
## AIPICO + CIPR + MANC                                       41.0752
## AIPICO + TEBU                                              34.0925
## AIPICO + TEBU + MANC                                       41.8472
## AIPIRA + EPOX                                              17.4196
## AIPIRA + EPOX + MANC                                       31.3834
## AIPIRA + FLUX                                              43.3541
## AIPIRA + FLUX + MANC                                       51.7913
## AITFLX + PROT                                              46.6303
## AITFLX + PROT + MANC                                       51.8275
##                       round..exp.ma_AI_perc_yield.ci.lb....1....100..4.
## intrcpt                                                134601.2954
## AIAZOX + BENZ                                              18.8898
## AIAZOX + BENZ + MANC                                       17.2917
## AIAZOX + CIPR                                              15.6830
## AIAZOX + CIPR + MANC                                       18.2466
## AIPICO + CIPR                                              15.2228
## AIPICO + CIPR + MANC                                       19.4596
## AIPICO + TEBU                                              18.6224
## AIPICO + TEBU + MANC                                       15.6452
## AIPIRA + EPOX                                              10.7550
## AIPIRA + EPOX + MANC                                       17.8167
## AIPIRA + FLUX                                              28.1230
## AIPIRA + FLUX + MANC                                       23.5329
## AITFLX + PROT                                              19.4048
## AITFLX + PROT + MANC                                       19.3208
##                       round..exp.ma_AI_perc_yield.ci.ub....1....100..4.
## intrcpt                                                277713.0613
## AIAZOX + BENZ                                             112.5308
## AIAZOX + BENZ + MANC                                      148.0584
## AIAZOX + CIPR                                              38.0640
## AIAZOX + CIPR + MANC                                       58.6737
## AIPICO + CIPR                                              48.6633
## AIPICO + CIPR + MANC                                       66.6020
## AIPICO + TEBU                                              51.5802
## AIPICO + TEBU + MANC                                       73.9859
## AIPIRA + EPOX                                              24.4852
## AIPIRA + EPOX + MANC                                       46.5122
## AIPIRA + FLUX                                              60.3958
## AIPIRA + FLUX + MANC                                       86.5138
## AITFLX + PROT                                              80.0635
## AITFLX + PROT + MANC                                       93.1901
```

6 Control efficacy

```
ma_AI_sev <- rma.mv(yi_sev, vi_sev, mods= ~ AI,  method="ML", struct="UN", random = list(~ AI | study),
```

```
## Warning in rma.mv(yi_sev, vi_sev, mods = ~AI, method = "ML", struct =
## "UN", : Rows with NAs omitted from model fitting.
```

```
## Warning in rma.mv(yi_sev, vi_sev, mods = ~AI, method = "ML", struct =
## "UN", : Some combinations of the levels of the inner factor never occurred.
## Corresponding 'rho' value(s) fixed to 0.
```

```
summary(ma_AI_sev)
```

```
##
## Multivariate Meta-Analysis Model (k = 572; method: ML)
##
##    logLik   Deviance        AIC        BIC       AICc
## -909.9144  4183.7659  2081.8289  2651.5661  2160.4289
##
## Variance Components:
##
## outer factor: study (nlvls = 80)
## inner factor: AI    (nlvls = 15)
##
##               estim    sqrt  k.lvl  fixed              level
## tau^2.1      0.6845  0.8273     80     no           AACHECK
## tau^2.2      4.0865  2.0215     51     no         AZOX + BENZ
## tau^2.3      6.8497  2.6172     19     no  AZOX + BENZ + MANC
## tau^2.4      4.3139  2.0770     55     no         AZOX + CIPR
## tau^2.5      5.3851  2.3206     58     no  AZOX + CIPR + MANC
## tau^2.6      7.2276  2.6884     36     no         PICO + CIPR
## tau^2.7     10.5807  3.2528     36     no  PICO + CIPR + MANC
## tau^2.8     23.3096  4.8280     40     no         PICO + TEBU
## tau^2.9     28.7561  5.3625     26     no  PICO + TEBU + MANC
## tau^2.10     1.3976  1.1822     17     no         PIRA + EPOX
## tau^2.11     2.8645  1.6925     17     no  PIRA + EPOX + MANC
## tau^2.12    39.1953  6.2606     37     no         PIRA + FLUX
## tau^2.13     9.5321  3.0874     10     no  PIRA + FLUX + MANC
## tau^2.14    27.9314  5.2850     51     no         TFLX + PROT
## tau^2.15    37.9009  6.1564     39     no  TFLX + PROT + MANC
##
##                     rho.AACH  rho.AZ+B  rho.A+B+M  rho.AZ+C  rho.A+C+M
## AACHECK                    1    0.6143     0.6637    0.7254     0.6846
## AZOX + BENZ           0.6143         1     0.9949    0.9529     0.9715
## AZOX + BENZ + MANC    0.6637    0.9949          1    0.0000     0.0000
## AZOX + CIPR           0.7254    0.9529     0.0000         1     0.9942
## AZOX + CIPR + MANC    0.6846    0.9715     0.0000    0.9942          1
## PICO + CIPR           0.6033    0.9609     0.9753    0.9806     0.9878
## PICO + CIPR + MANC    0.5802    0.9632     0.9718    0.9719     0.9864
## PICO + TEBU           0.4514    0.9119     0.9147    0.9155     0.9402
## PICO + TEBU + MANC    0.4412    0.9110     0.9121    0.9106     0.9365
## PIRA + EPOX           0.9180    0.7039     0.0000    0.7674     0.7277
## PIRA + EPOX + MANC    0.7920    0.9559     0.0000    0.9574     0.9580
## PIRA + FLUX           0.4069    0.8845     0.8851    0.8903     0.9168
## PIRA + FLUX + MANC    0.6159    0.9485     0.9607    0.9726     0.9843
```

```
## TFLX + PROT           0.4271    0.9050     0.9058    0.9074     0.9324
## TFLX + PROT + MANC    0.4114    0.8994     0.8991    0.8976     0.9240
##                     rho.PI+C  rho.P+C+M  rho.PI+T  rho.P+T+M  rho.PI+E
## AACHECK               0.6033    0.5802     0.4514    0.4412     0.9180
## AZOX + BENZ           0.9609    0.9632     0.9119    0.9110     0.7039
## AZOX + BENZ + MANC    0.9753    0.9718     0.9147    0.9121     0.0000
## AZOX + CIPR           0.9806    0.9719     0.9155    0.9106     0.7674
## AZOX + CIPR + MANC    0.9878    0.9864     0.9402    0.9365     0.7277
## PICO + CIPR                1    0.9969     0.9678    0.9644     0.6624
## PICO + CIPR + MANC    0.9969         1     0.9802    0.9779     0.6283
## PICO + TEBU           0.9678    0.9802          1    0.9996     0.4680
## PICO + TEBU + MANC    0.9644    0.9779     0.9996         1     0.4578
## PIRA + EPOX           0.6624    0.6283     0.4680    0.4578          1
## PIRA + EPOX + MANC    0.9265    0.9187     0.8306    0.8243     0.8613
## PIRA + FLUX           0.9470    0.9630     0.9959    0.9973     0.4102
## PIRA + FLUX + MANC    0.9901    0.9949     0.9772    0.9754     0.6361
## TFLX + PROT           0.9595    0.9729     0.9976    0.9985     0.4399
## TFLX + PROT + MANC    0.9545    0.9688     0.9968    0.9984     0.4245
##                     rho.P+E+M  rho.PI+F  rho.P+F+M  rho.TF+P  rho.T+P+M
## AACHECK               0.7920    0.4069     0.6159    0.4271     0.4114
## AZOX + BENZ           0.9559    0.8845     0.9485    0.9050     0.8994
## AZOX + BENZ + MANC    0.0000    0.8851     0.9607    0.9058     0.8991
## AZOX + CIPR           0.9574    0.8903     0.9726    0.9074     0.8976
## AZOX + CIPR + MANC    0.9580    0.9168     0.9843    0.9324     0.9240
## PICO + CIPR           0.9265    0.9470     0.9901    0.9595     0.9545
## PICO + CIPR + MANC    0.9187    0.9630     0.9949    0.9729     0.9688
## PICO + TEBU           0.8306    0.9959     0.9772    0.9976     0.9968
## PICO + TEBU + MANC    0.8243    0.9973     0.9754    0.9985     0.9984
## PIRA + EPOX           0.8613    0.4102     0.6361    0.4399     0.4245
## PIRA + EPOX + MANC         1    0.7892     0.9169    0.8099     0.7997
## PIRA + FLUX           0.7892         1     0.9642    0.9979     0.9984
## PIRA + FLUX + MANC    0.9169    0.9642          1    0.9699     0.9661
## TFLX + PROT           0.8099    0.9979     0.9699         1     0.9993
## TFLX + PROT + MANC    0.7997    0.9984     0.9661    0.9993          1
##                     AACH  AZ+B  A+B+M  AZ+C  A+C+M  PI+C  P+C+M  PI+T
## AACHECK                -    no     no    no     no    no     no    no
## AZOX + BENZ           45     -     no    no     no    no     no    no
## AZOX + BENZ + MANC    17    17      -   yes    yes    no     no    no
## AZOX + CIPR           41    12      0     -     no    no     no    no
## AZOX + CIPR + MANC    31    12      0    30      -    no     no    no
## PICO + CIPR           29    14      6    20     20     -     no    no
## PICO + CIPR + MANC    29    14      6    20     20    29      -    no
## PICO + TEBU           33    23      1    18     18    17     17     -
## PICO + TEBU + MANC    19     9      1    18     18    17     17    19
## PIRA + EPOX           16     9      0    16     16    12     12    10
## PIRA + EPOX + MANC    16     9      0    16     16    12     12    10
## PIRA + FLUX           37    29      5    17     14    12     12    25
## PIRA + FLUX + MANC     8     5      5     3      3     3      3     3
## TFLX + PROT           50    36     11    20     17    16     16    26
## TFLX + PROT + MANC    32    22     11    17     18    16     16    12
##                     P+T+M  PI+E  P+E+M  PI+F  P+F+M  TF+P  T+P+M
## AACHECK                no    no     no    no     no    no     no
## AZOX + BENZ            no    no     no    no     no    no     no
## AZOX + BENZ + MANC     no   yes    yes    no     no    no     no
```

```
## AZOX + CIPR            no    no     no    no     no    no     no
## AZOX + CIPR + MANC     no    no     no    no     no    no     no
## PICO + CIPR            no    no     no    no     no    no     no
## PICO + CIPR + MANC     no    no     no    no     no    no     no
## PICO + TEBU            no    no     no    no     no    no     no
## PICO + TEBU + MANC      -    no     no    no     no    no     no
## PIRA + EPOX            10     -     no    no     no    no     no
## PIRA + EPOX + MANC     10    16      -    no     no    no     no
## PIRA + FLUX            12    12     12     -     no    no     no
## PIRA + FLUX + MANC      3     2      2     8      -    no     no
## TFLX + PROT            12    15     15    37      8     -     no
## TFLX + PROT + MANC     12    15     15    21      8    31      -
##
## Test for Residual Heterogeneity:
## QE(df = 557) = 417789.8730, p-val < .0001
##
## Test of Moderators (coefficient(s) 2,3,4,5,6,7,8,9,10,11,12,13,14,15):
## QM(df = 14) = 1102.0419, p-val < .0001
##
## Model Results:
##
##                       estimate      se     zval    pval    ci.lb    ci.ub
## intrcpt                 4.0698  0.0925  43.9784  <.0001   3.8885   4.2512
## AIAZOX + BENZ          -1.6630  0.1917  -8.6759  <.0001  -2.0387  -1.2873
## AIAZOX + BENZ + MANC   -2.1783  0.2485  -8.7664  <.0001  -2.6654  -1.6913
## AIAZOX + CIPR          -0.8674  0.1809  -4.7939  <.0001  -1.2221  -0.5128
## AIAZOX + CIPR + MANC   -1.1684  0.2113  -5.5292  <.0001  -1.5826  -0.7542
## AIPICO + CIPR          -0.9649  0.2602  -3.7081  0.0002  -1.4749  -0.4549
## AIPICO + CIPR + MANC   -1.3353  0.3239  -4.1224  <.0001  -1.9702  -0.7005
## AIPICO + TEBU          -1.1765  0.5154  -2.2826  0.0225  -2.1866  -0.1663
## AIPICO + TEBU + MANC   -1.4531  0.5763  -2.5215  0.0117  -2.5825  -0.3236
## AIPIRA + EPOX          -0.5333  0.0737  -7.2321  <.0001  -0.6779  -0.3888
## AIPIRA + EPOX + MANC   -0.9069  0.1360  -6.6700  <.0001  -1.1733  -0.6404
## AIPIRA + FLUX          -1.3012  0.6831  -1.9047  0.0568  -2.6401   0.0377
## AIPIRA + FLUX + MANC   -1.3492  0.3031  -4.4512  <.0001  -1.9434  -0.7551
## AITFLX + PROT          -1.4601  0.5687  -2.5672  0.0103  -2.5748  -0.3454
## AITFLX + PROT + MANC   -1.7335  0.6698  -2.5882  0.0096  -3.0463  -0.4208
##
## intrcpt                ***
## AIAZOX + BENZ          ***
## AIAZOX + BENZ + MANC   ***
## AIAZOX + CIPR          ***
## AIAZOX + CIPR + MANC   ***
## AIPICO + CIPR          ***
## AIPICO + CIPR + MANC   ***
## AIPICO + TEBU            *
## AIPICO + TEBU + MANC     *
## AIPIRA + EPOX          ***
## AIPIRA + EPOX + MANC   ***
## AIPIRA + FLUX            .
## AIPIRA + FLUX + MANC   ***
## AITFLX + PROT            *
## AITFLX + PROT + MANC    **
##
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(ma_AI_sev, L=rbind(c(0,-1,1,0,0,0,0,0,0,0,0,0,0,0,0),
                         c(0,0,0,-1,1,0,0,0,0,0,0,0,0,0,0),
                         c(0,0,0,0,0,-1,1,0,0,0,0,0,0,0,0),
                         c(0,0,0,0,0,0,0,-1,1,0,0,0,0,0,0),
                         c(0,0,0,0,0,0,0,0,0,-1,1,0,0,0,0),
                         c(0,0,0,0,0,0,0,0,0,0,0,-1,1,0,0),
                         c(0,0,0,0,0,0,0,0,0,0,0,0,0,-1,1)))
```

```
##
## Hypotheses:
## 1: -AIAZOX + BENZ + AIAZOX + BENZ + MANC = 0
## 2: -AIAZOX + CIPR + AIAZOX + CIPR + MANC = 0
## 3: -AIPICO + CIPR + AIPICO + CIPR + MANC = 0
## 4: -AIPICO + TEBU + AIPICO + TEBU + MANC = 0
## 5: -AIPIRA + EPOX + AIPIRA + EPOX + MANC = 0
## 6: -AIPIRA + FLUX + AIPIRA + FLUX + MANC = 0
## 7: -AITFLX + PROT + AITFLX + PROT + MANC = 0
##
## Results:
##    estimate     se    zval   pval
## 1:  -0.5153 0.0750 -6.8671 <.0001
## 2:  -0.3010 0.0445 -6.7651 <.0001
## 3:  -0.3704 0.0722 -5.1293 <.0001
## 4:  -0.2766 0.0663 -4.1731 <.0001
## 5:  -0.3735 0.1096 -3.4074 0.0007
## 6:  -0.0481 0.3915 -0.1227 0.9023
## 7:  -0.2735 0.1063 -2.5717 0.0101
##
## Omnibus Test of Hypotheses:
## QM(df = 7) = 202.6480, p-val < .0001
```

```
data.frame(round(1-(exp(ma_AI_sev$b))*100, 4),
           round(1-(exp(ma_AI_sev$ci.lb))*100, 4),
           round(1-(exp(ma_AI_sev$ci.ub))*100, 4))
```

```
##                       round.1....exp.ma_AI_sev.b.....100..4.
## intrcpt                                            -5853.7177
## AIAZOX + BENZ                                        -17.9569
## AIAZOX + BENZ + MANC                                 -10.3229
## AIAZOX + CIPR                                        -41.0028
## AIAZOX + CIPR + MANC                                 -30.0864
## AIPICO + CIPR                                        -37.1012
## AIPICO + CIPR + MANC                                 -25.3077
## AIPICO + TEBU                                        -29.8370
## AIPICO + TEBU + MANC                                 -22.3854
## AIPIRA + EPOX                                        -57.6645
## AIPIRA + EPOX + MANC                                 -39.3790
## AIPIRA + FLUX                                        -26.2208
## AIPIRA + FLUX + MANC                                 -24.9436
## AITFLX + PROT                                        -22.2220
## AITFLX + PROT + MANC                                 -16.6657
##                       round.1....exp.ma_AI_sev.ci.lb.....100..4.
```

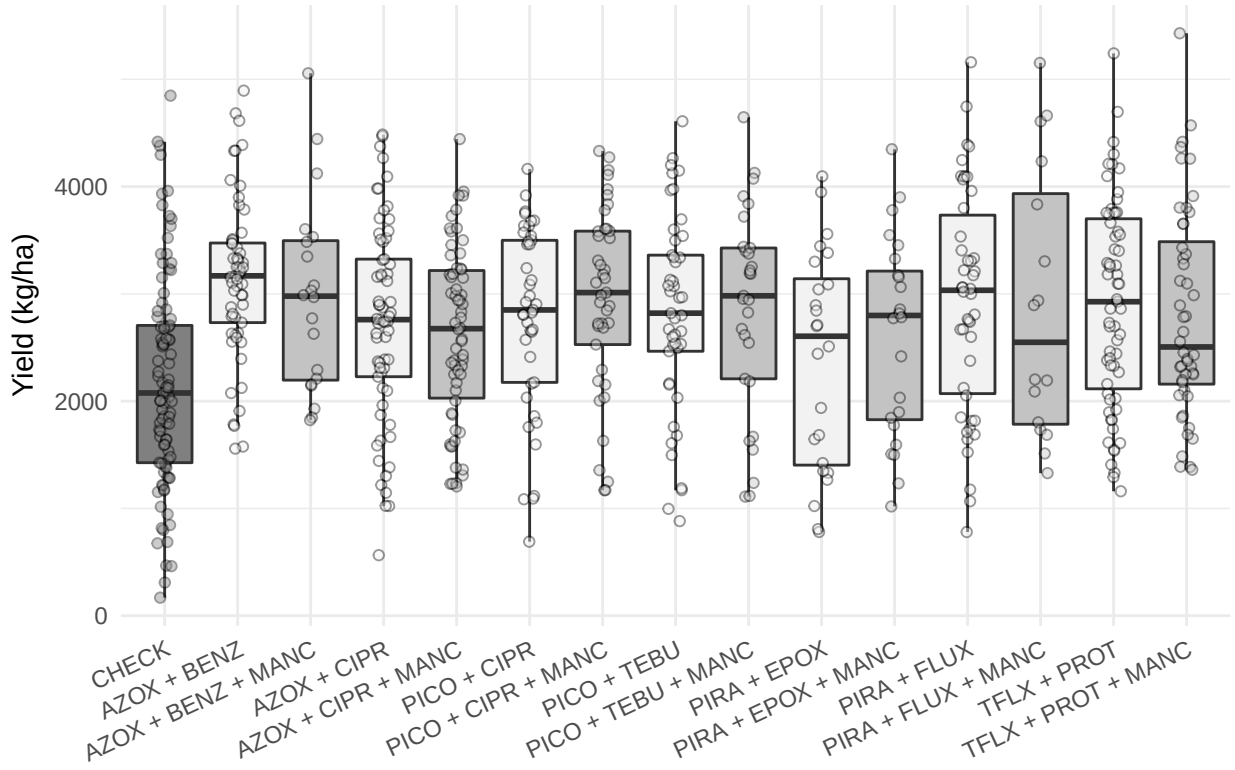
```
## intrcpt                                                -4882.5351
## AIAZOX + BENZ                                            -12.0199
## AIAZOX + BENZ + MANC                                      -5.9574
## AIAZOX + CIPR                                            -28.4617
## AIAZOX + CIPR + MANC                                     -19.5446
## AIPICO + CIPR                                            -21.8792
## AIPICO + CIPR + MANC                                     -12.9434
## AIPICO + TEBU                                            -10.2296
## AIPICO + TEBU + MANC                                      -6.5582
## AIPIRA + EPOX                                            -49.7696
## AIPIRA + EPOX + MANC                                     -29.9332
## AIPIRA + FLUX                                             -6.1353
## AIPIRA + FLUX + MANC                                     -13.3223
## AITFLX + PROT                                             -6.6171
## AITFLX + PROT + MANC                                      -3.7534
##                       round.1....exp.ma_AI_sev.ci.ub.....100..4.
## intrcpt                                                -7018.0383
## AIAZOX + BENZ                                            -26.6011
## AIAZOX + BENZ + MANC                                     -17.4277
## AIAZOX + CIPR                                            -58.8822
## AIAZOX + CIPR + MANC                                     -46.0373
## AIPICO + CIPR                                            -62.4510
## AIPICO + CIPR + MANC                                     -48.6361
## AIPICO + TEBU                                            -83.6796
## AIPICO + TEBU + MANC                                     -71.3552
## AIPIRA + EPOX                                            -66.7872
## AIPIRA + EPOX + MANC                                     -51.7092
## AIPIRA + FLUX                                           -102.8463
## AIPIRA + FLUX + MANC                                     -45.9946
## AITFLX + PROT                                            -69.7961
## AITFLX + PROT + MANC                                     -64.6542
```

7 Plots

```
# yield by fungicide

dat2$AI <- revalue(dat2$AI, c("AACHECK" = "_CHECK"))

dat2 %>% filter(yield_kg != "NA") %>% ggplot(aes(AI, yield_kg, fill = manc))+
geom_boxplot(outlier.size = NA)+
  theme_minimal()+
geom_jitter(width = 0.1, height = 0.1, shape = 21, alpha=0.4)+
theme(axis.text.x = element_text(angle = 25, hjust = 1))+
scale_fill_grey(start = 0.5, end = 0.95)+
  scale_x_discrete(labels = c("_CHECK" = "CHECK"))+
  theme(legend.position = "none")+
  labs(title ="", x = "", y = "Yield (kg/ha)")+
  ggsave("figs/yield_AI.png", width=7, height=4)
```


Yield (kg/ha)
4000
2000
0
CHECK
AZOX + BENZ
AZOX + BENZ + MANC
AZOX + CIPR
AZOX + CIPR + MANC
PICO + CIPR
PICO + CIPR + MANC
PICO + TEBU
PICO + TEBU + MANC
PIRA + EPOX
PIRA + EPOX + MANC
PIRA + FLUX
PIRA + FLUX + MANC
TFLX + PROT
TFLX + PROT + MANC