Analysis of Symptoms of Diseases for Soybean Crop

Analysis of Categorical Data Course Project - Phase I

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Contents

Introduction **3**

Data set source and description **3**

Preparing data **5**
Checking the levels for different predictors. 5
Converting the NAs present in categorical dataset with "Unknown" 6

Visulisations **7**
Bar plot for the Target variable 7
Predictors vs Target Plots 8

Results and Discussion **43**
1. For 2-4-d injury: 43
2. For Alternarialeaf-spot: 47
3. For Anthracnose: 51
4. For Bacterial Blight: 55
5. For Bacterial-Pustule: 59
6. For Brown spot: 63
7. For Brown stem rot: 67
8. For Charcoal rot: 71
9. For cyst-nematode: 75
10. For Diaporthe-pod-&-stem-blight 79
11. For diaprthe-stem-canker: 83
13. For frog-eye-leaf-spot: 91
14. For Herbicide injury: 95
15. For phyllosticta-leaf-spot: 99
16. For phytophthora-rot: 103
17. For powdery mildew: 107
18. For purple-seed-stain: 111
19. For: Rhizoctonia-root-rot: 115

Conclusion **119**

References **119**

Introduction

The dataset is sourced from openml.org. This dataset consists of 36 categorical variables out of which some are nominal and others are ordered. Target variable is class constituting of various disease names. There are 19 class types each of which is type of disease and the variables in the dataset are the conditions which lead to the mentioned disease. We will analyse the data and build a machine learning model to detect the disease type out of 19 possible disease types for the soybean crop.

Part one of the porject is to examine different variables and check the relationships they have in predicting the type of disease the crop might have.

Data set source and description

The data set used for this project was created by R.S. Michalski and R.L. Chilausky and is sourced from openml.org. The data set contains 683 instances and records the different 36 symptoms observed in the soybean crop such as plant height, seed, size, leaf spots, etc. which leads to the 19 different diseases. The list of variables is mentioned below.

- date: april,may,june,july,august,september,october,?.
- plant-stand: normal,lt-normal,?.
- precip: lt-norm,norm,gt-norm,?.
- temp: lt-norm,norm,gt-norm,?.
- hail: yes,no,?.
- crop-hist: diff-lst-year,same-lst-yr,same-lst-two-yrs, same-lst-sev-yrs,?.
- area-damaged: scattered,low-areas,upper-areas,whole-field,?.
- severity: minor,pot-severe,severe,?.
- seed-tmt: none,fungicide,other,?.
- germination: 90-100%,80-89%,lt-80%,?.
- plant-growth: norm,abnorm,?.
- leaves: norm,abnorm.
- leafspots-halo: absent,yellow-halos,no-yellow-halos,?.
- leafspots-marg: w-s-marg,no-w-s-marg,dna,?.
- leafspot-size: lt-1/8,gt-1/8,dna,?.
- leaf-shread: absent,present,?.
- leaf-malf: absent,present,?.
- leaf-mild: absent,upper-surf,lower-surf,?.
- stem: norm,abnorm,?.
- lodging: yes,no,?.
- stem-cankers: absent,below-soil,above-soil,above-sec-nde,?.
- canker-lesion: dna,brown,dk-brown-blk,tan,?.
- fruiting-bodies: absent,present,?.

- external decay: absent,firm-and-dry,watery,?.
- mycelium: absent,present,?.
- int-discolor: none,brown,black,?.
- sclerotia: absent,present,?.
- fruit-pods: norm,diseased,few-present,dna,?.
- fruit spots: absent,colored,brown-w/blk-specks,distort,dna,?.
- seed: norm,abnorm,?.
- mold-growth: absent,present,?.
- seed-discolor: absent,present,?.
- seed-size: norm,lt-norm,?.
- shriveling: absent,present,?.
- roots: norm,rotted,galls-cysts,?.
- 19 Classes: diaporthe-stem-canker, charcoal-rot, rhizoctonia-root-rot, phytophthora-rot, brown-stem-rot, powdery-mildew, downy-mildew, brown-spot, bacterial-blight, bacterial-pustule, purple-seed-stain, anthracnose, phyllosticta-leaf-spot, alternarialeaf-spot, frog-eye-leaf-spot, diaporthe-pod-&-stem-blight, cyst-nematode, 2-4-d-injury, herbicide-injury

Preparing data

Reading the data from the file containing the data set.The missing data represented in the form of "?" and " ?" has been replaced by the NAs.

Checking the levels for different predictors.

```
for (n in names(soybean))
  if (is.factor(soybean[[n]])) {
    print(n)
    print(levels(soybean[[n]]))
  }
```

```
## [1] "date"
## [1] "april"     "august"    "july"      "june"      "may"       "october"
## [7] "september"
## [1] "plant.stand"
## [1] " lt-normal" " normal"
## [1] "precip"
## [1] " gt-norm" " lt-norm" " norm"
## [1] "temp"
## [1] " gt-norm" " lt-norm" " norm"
## [1] "hail"
## [1] " no"  " yes"
## [1] "crop.hist"
## [1] " diff-lst-year"    " same-lst-sev-yrs" " same-lst-two-yrs"
## [4] " same-lst-yr"
## [1] "area.damaged"
## [1] " low-areas"   " scattered"   " upper-areas" " whole-field"
## [1] "severity"
## [1] " minor"      " pot-severe" " severe"
## [1] "seed.tmt"
## [1] " fungicide" " none"      " other"
## [1] "germination"
## [1] " 80-89"  " 90-100" " lt-80"
## [1] "plant.growth"
## [1] " abnorm" " norm"
## [1] "leaves"
## [1] " abnorm" " norm"
## [1] "leafspots.halo"
## [1] " absent"          " no-yellow-halos" " yellow-halos"
## [1] "leafspots.marg"
## [1] " dna"         " no-w-s-marg" " w-s-marg"
## [1] "leafspot.size"
## [1] " dna"    " gt-1/8" " lt-1/8"
## [1] "leaf.shread"
## [1] " absent"  " present"
## [1] "leaf.malf"
## [1] " absent"  " present"
## [1] "leaf.mild"
## [1] " absent"     " lower-surf" " upper-surf"
## [1] "stem"
## [1] " abnorm" " norm"
```

```
## [1] "lodging"
## [1] " no"  " yes"
## [1] "stem.cankers"
## [1] " above-sec-nde" " above-soil"    " absent"        " below-soil"
## [1] "canker.lesion"
## [1] " brown"        " dk-brown-blk" " dna"          " tan"
## [1] "fruiting.bodies"
## [1] " absent"  " present"
## [1] "external.decay"
## [1] " absent"       " firm-and-dry" " watery"
## [1] "mycelium"
## [1] " absent"  " present"
## [1] "int.discolor"
## [1] " black" " brown" " none"
## [1] "sclerotia"
## [1] " absent"  " present"
## [1] "fruit.pods"
## [1] " diseased"    " dna"         " few-present" " norm"
## [1] "fruit.spots"
## [1] " absent"             " brown-w/blk-specks" " colored"
## [4] " dna"
## [1] "seed"
## [1] " abnorm" " norm"
## [1] "mold.growth"
## [1] " absent"  " present"
## [1] "seed.discolor"
## [1] " absent"  " present"
## [1] "seed.size"
## [1] " lt-norm" " norm"
## [1] "shriveling"
## [1] " absent"  " present"
## [1] "roots"
## [1] " galls-cysts" " norm"        " rotted"
## [1] "class"
##  [1] " 2-4-d-injury"               " alternarialeaf-spot"
##  [3] " anthracnose"                " bacterial-blight"
##  [5] " bacterial-pustule"          " brown-spot"
##  [7] " brown-stem-rot"             " charcoal-rot"
##  [9] " cyst-nematode"              " diaporthe-pod-&-stem-blight"
## [11] " diaporthe-stem-canker"      " downy-mildew"
## [13] " frog-eye-leaf-spot"         " herbicide-injury"
## [15] " phyllosticta-leaf-spot"     " phytophthora-rot"
## [17] " powdery-mildew"             " purple-seed-stain"
## [19] " rhizoctonia-root-rot"
```

Converting the NAs present in categorical dataset with "Unknown"

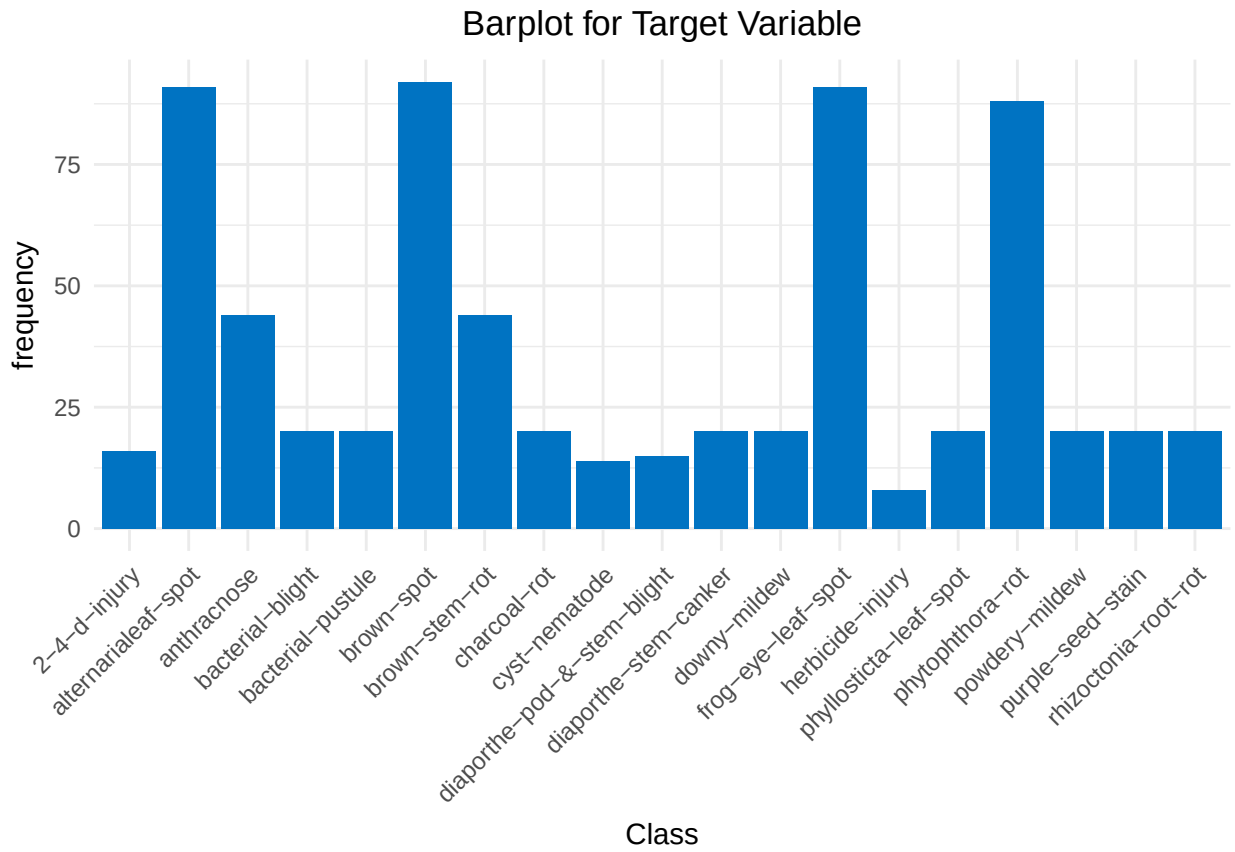
```
for (i in 1:ncol(soybean)) {
  soybean[,i] <- as.character(soybean[,i])
  soybean[which(is.na(soybean[,i])==TRUE),i] <- "Unknown"
  soybean[,i] <- as.factor(soybean[,i])
}
```

Visulisations

Bar plot for the Target variable

All the predictor types have got significance in detecting disease type, so no attribute type is considered as an outlier even if less common.Because a particular symptom might be present in only one disease and this makes it even more important observation.But we can check for the most common disease types out of all the given possibilities. The following graph represents this.

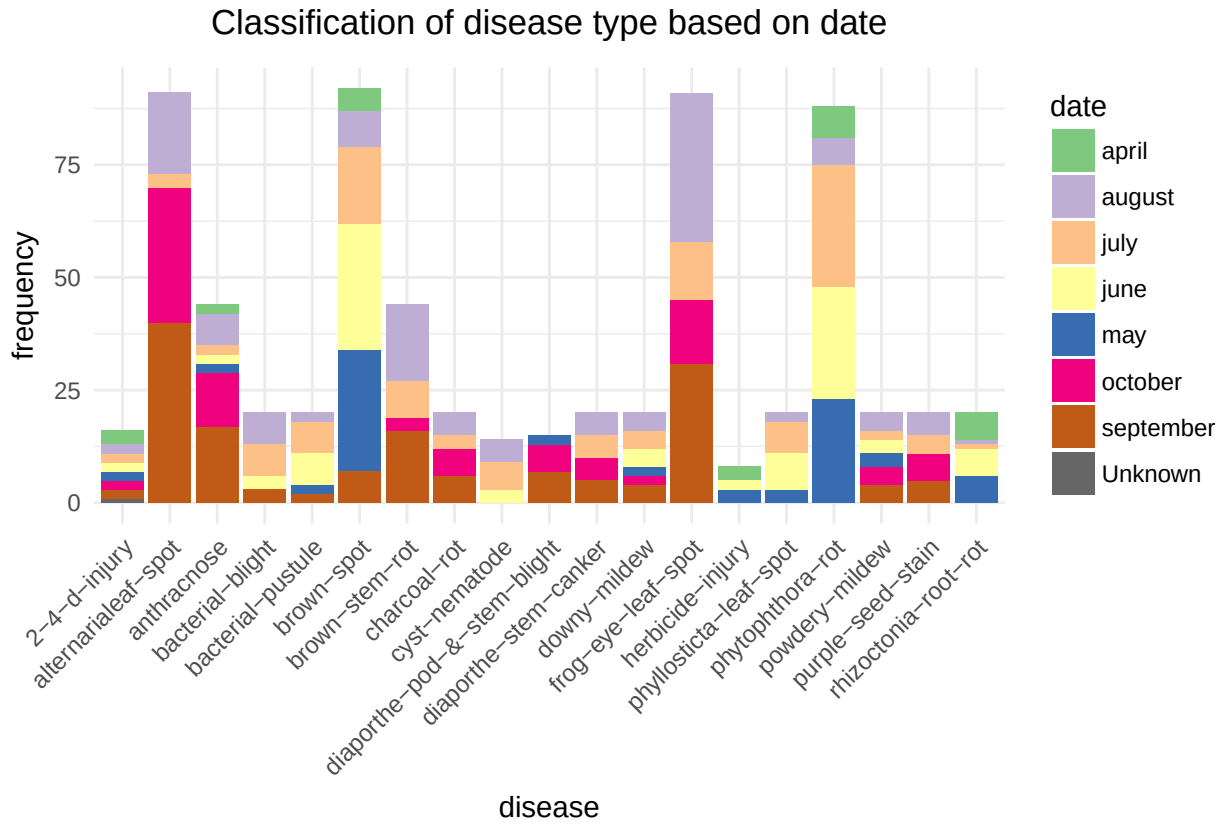
```
#soybean <- within(soybean,
#                   class <- factor(class,
#                                   levels = names(sort(table(class), decreasing = TRUE))))

y <- ggplot(data=soybean, aes(soybean$class)) +
      geom_bar(fill="#0073C2FF")+
      theme_minimal() +
      theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
      scale_fill_discrete(name= names(soybean[n]))+
      theme(plot.title = element_text(hjust=0.5))+
      labs(y = "frequency",
      x = "Class")+
      ggtitle("Barplot for Target Variable")
      print(y)
```

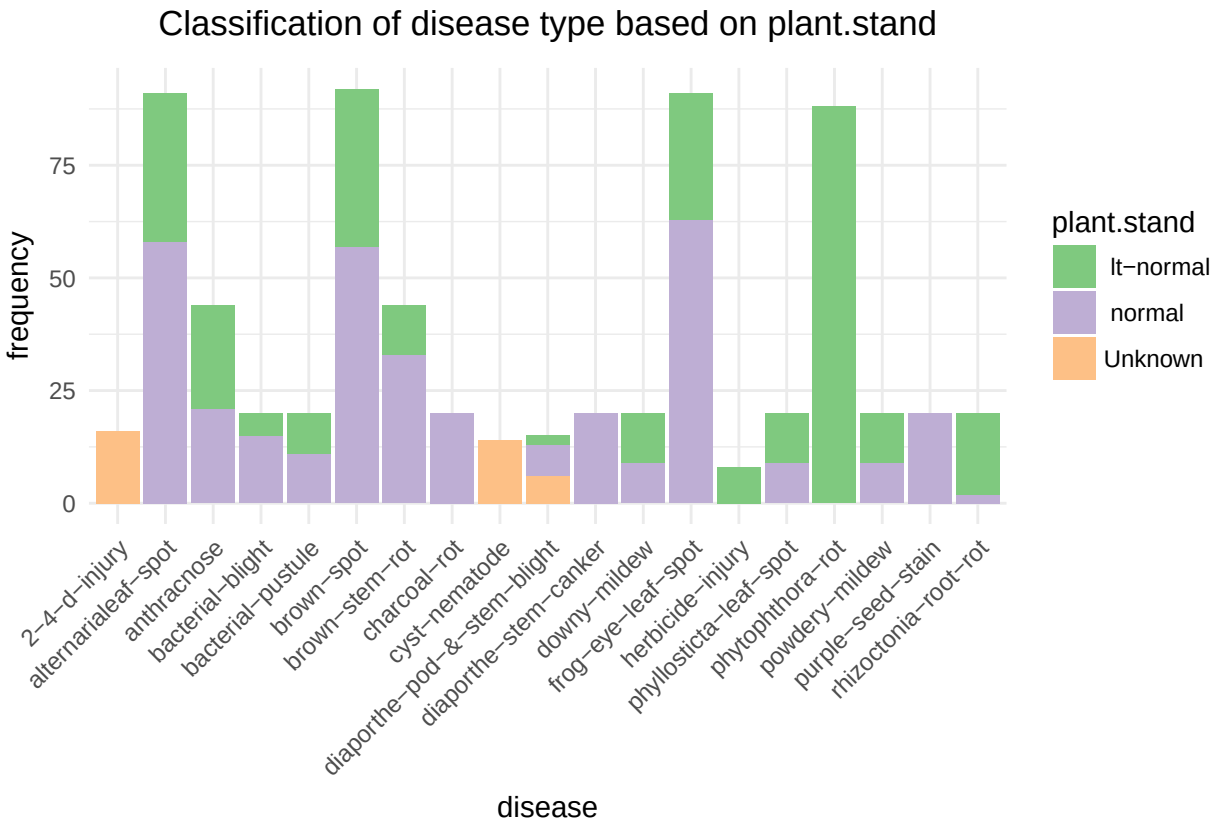


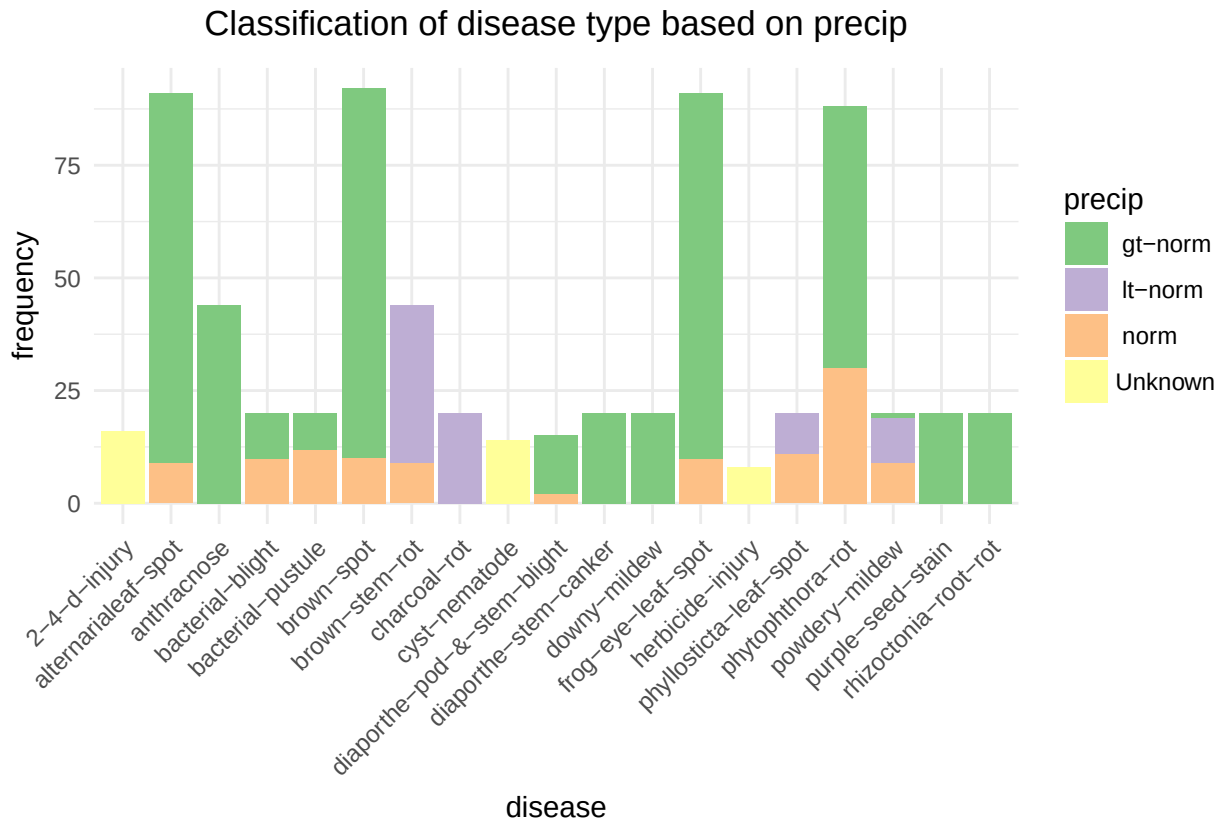
It is observed that brown-spot, alternarial-leafspot, frog-eye-leaf-spot and phytophthora-rot are the top four disease types.Anthracnose and brown-stem-rot are also common occurrences. Herbicide injury is found to be the least common disease type in comparison to other 18.

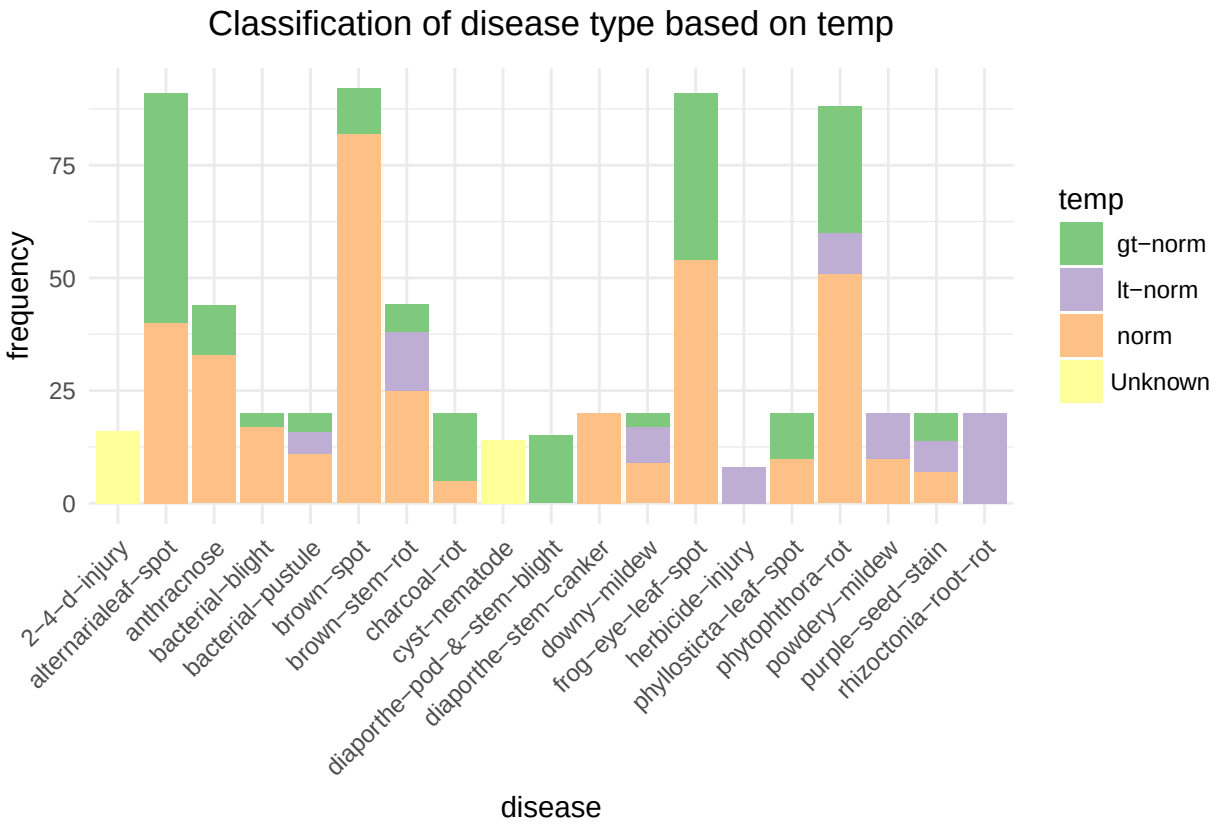
Predictors vs Target Plots

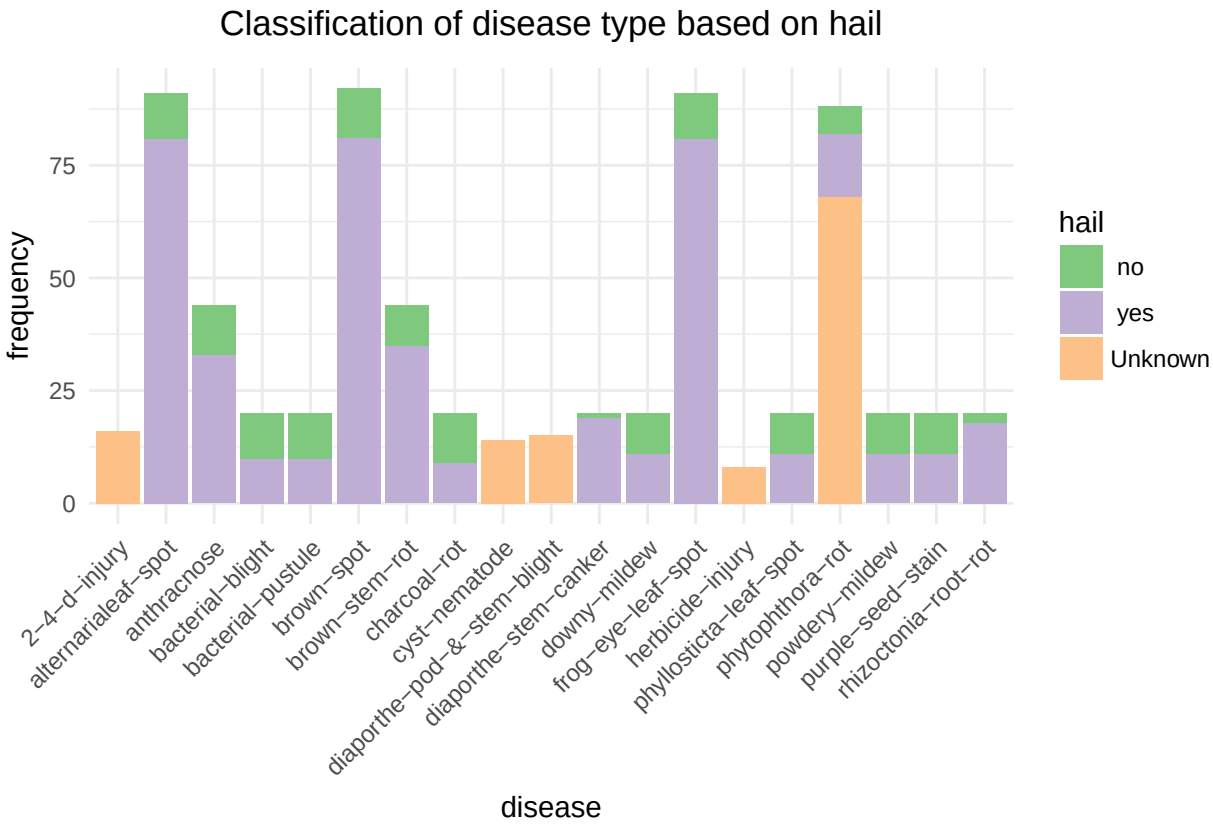
```
for(n in 1:35)
{
  col=soybean[[n]]
  column <- names(soybean[n])

y <- ggplot(data = soybean,
            aes(x = class, fill = col)) +
  geom_bar() +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1),
        plot.title = element_text(margin = margin(t=10, b=10),
                                  hjust=0.5)) +
  scale_fill_brewer(palette="Accent") +
  labs(title = "",
       y = "frequency",
       x = "disease") +
  ggtitle(paste0("Classification of disease type based on " ,column))
y <- y + guides(fill = guide_legend((title = paste0(column))))
print(y)
}
```

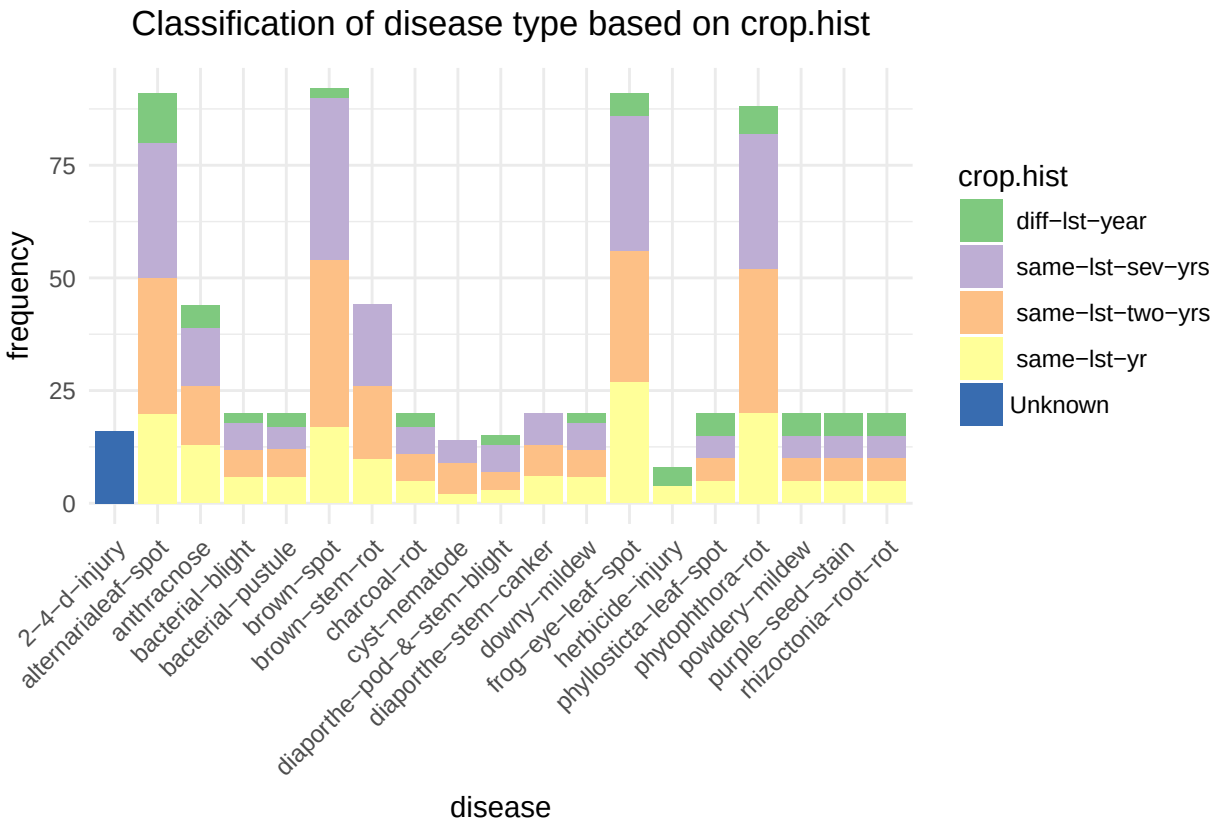


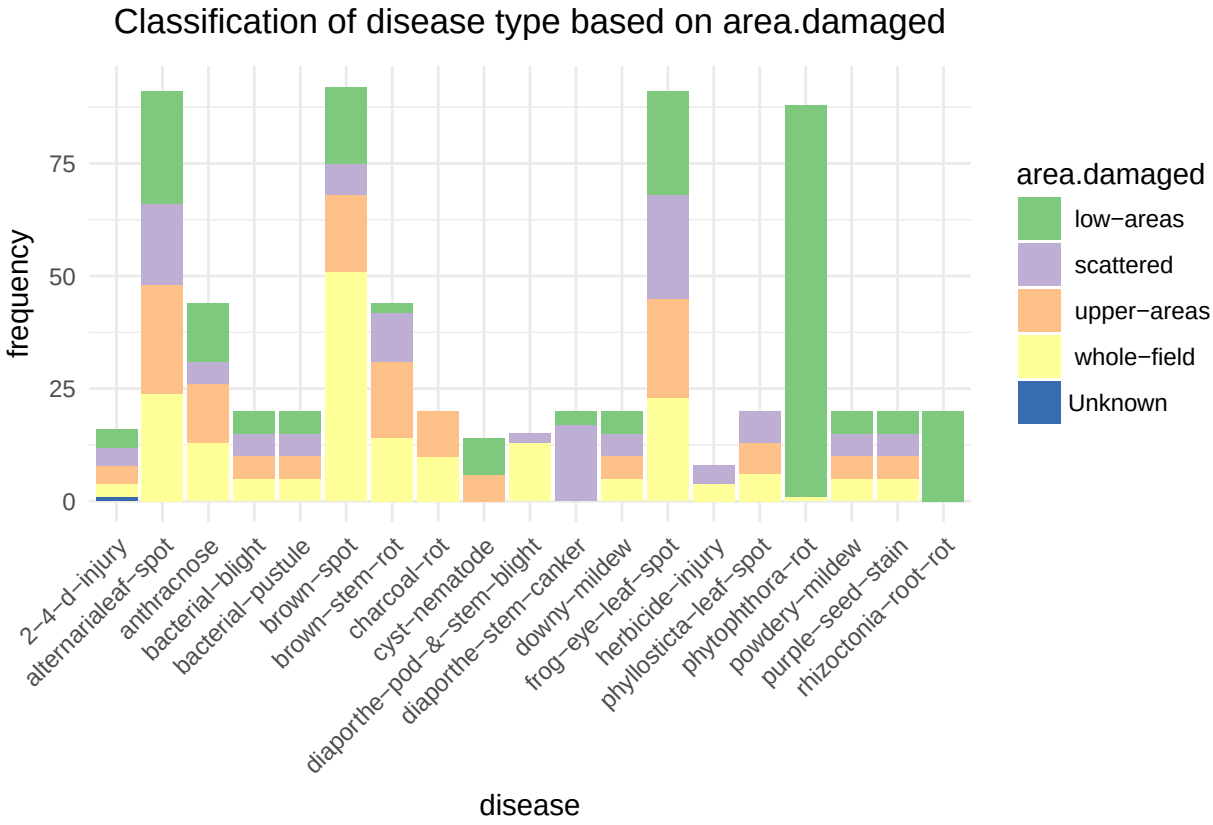

Classification of disease type based on plant.stand
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
plant.stand
lt−normal
normal
Unknown

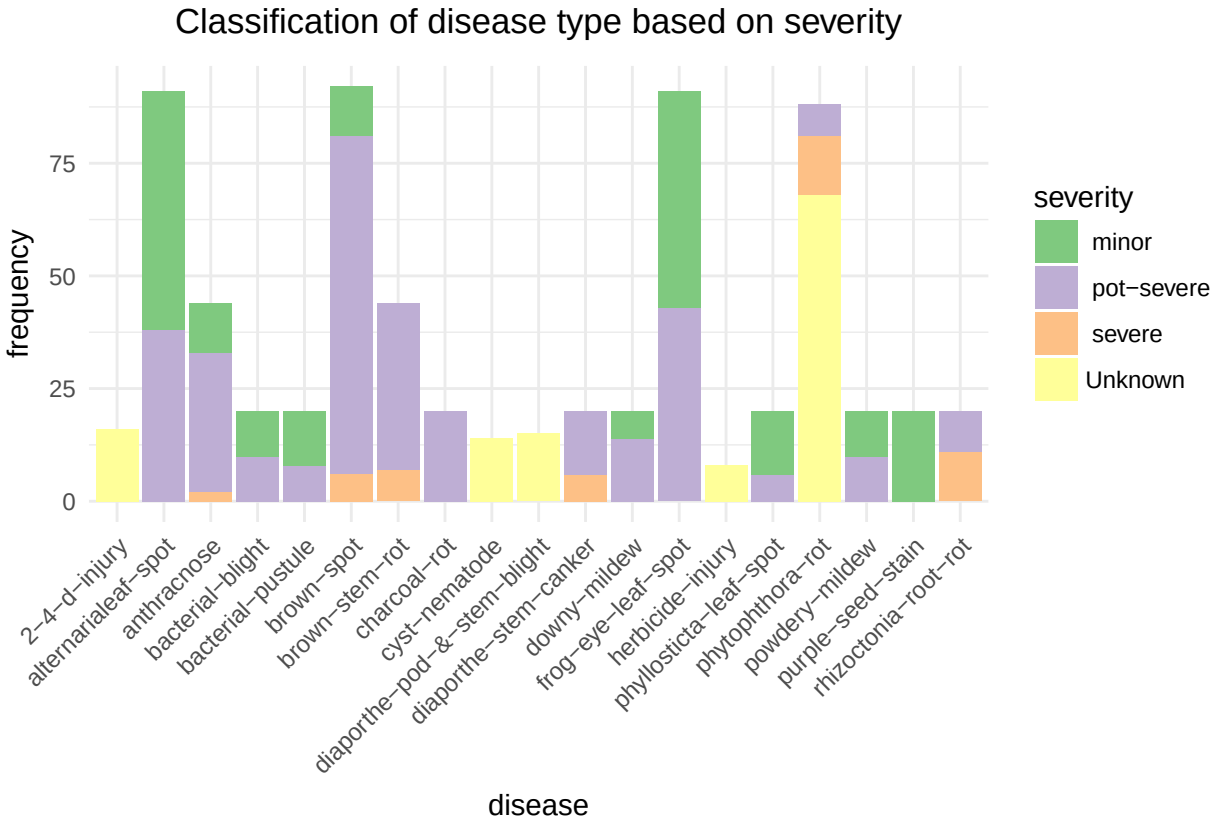

Classification of disease type based on precip
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
precip
gt–norm
lt–norm
norm
Unknown

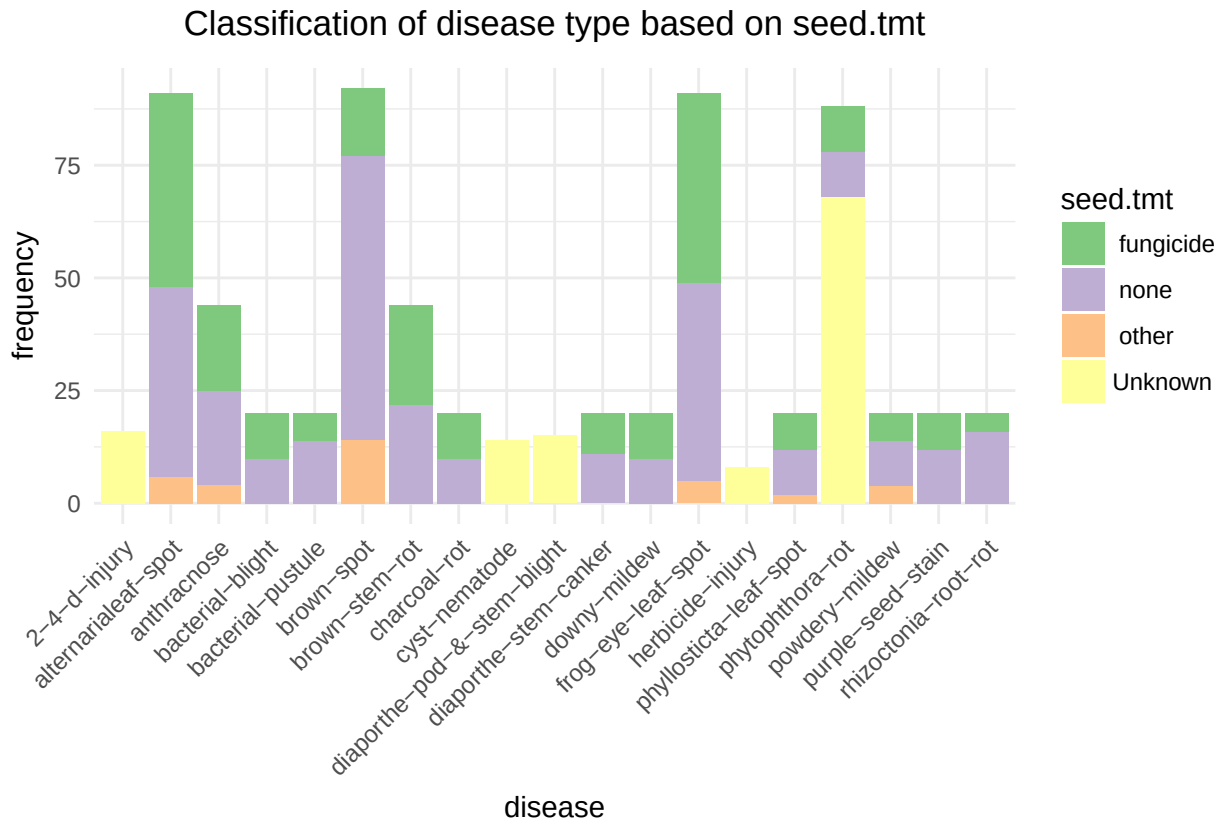

Classification of disease type based on temp
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
temp
gt–norm
lt–norm
norm
Unknown

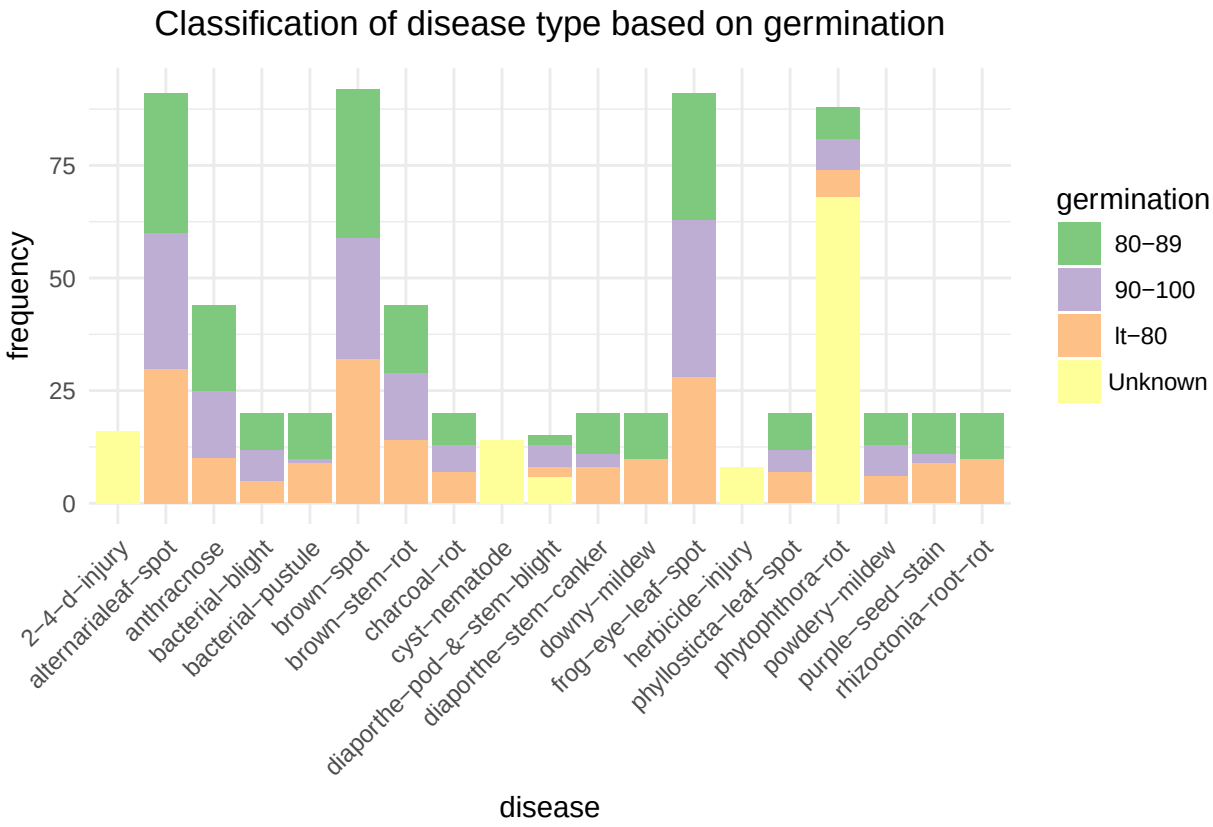

Classification of disease type based on hail
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
hail
no
yes
Unknown

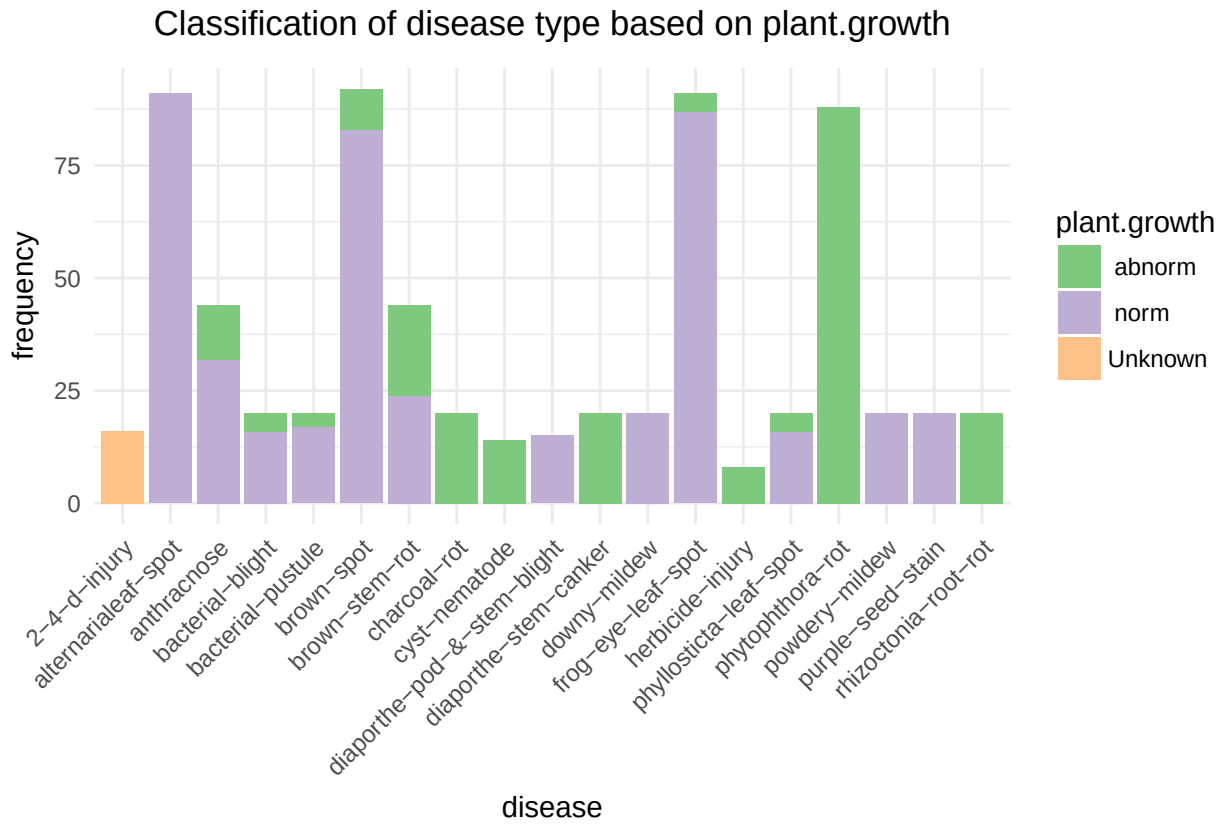

Classification of disease type based on crop.hist
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
crop.hist
diff−lst−year
same−lst−sev−yrs
same−lst−two−yrs
same−lst−yr
Unknown

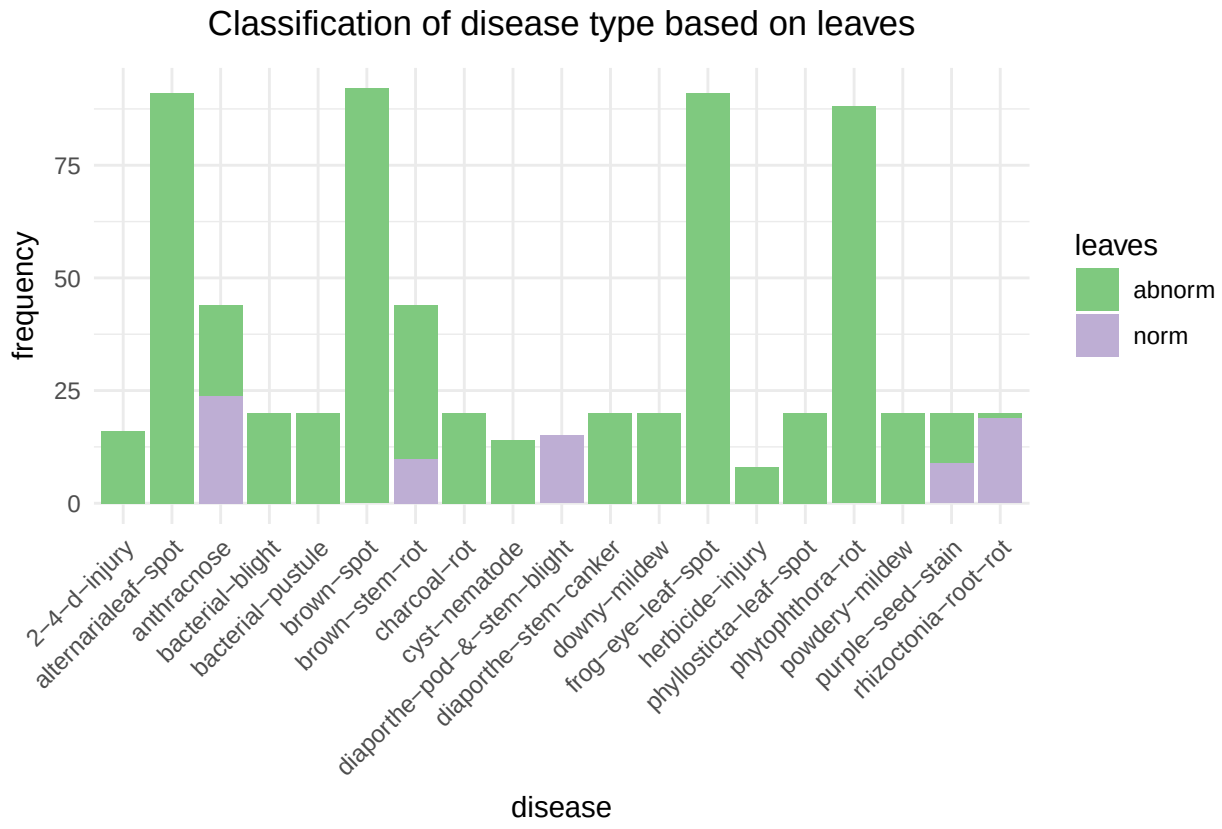

Classification of disease type based on area.damaged
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
area.damaged
low−areas
scattered
upper−areas
whole−field
Unknown

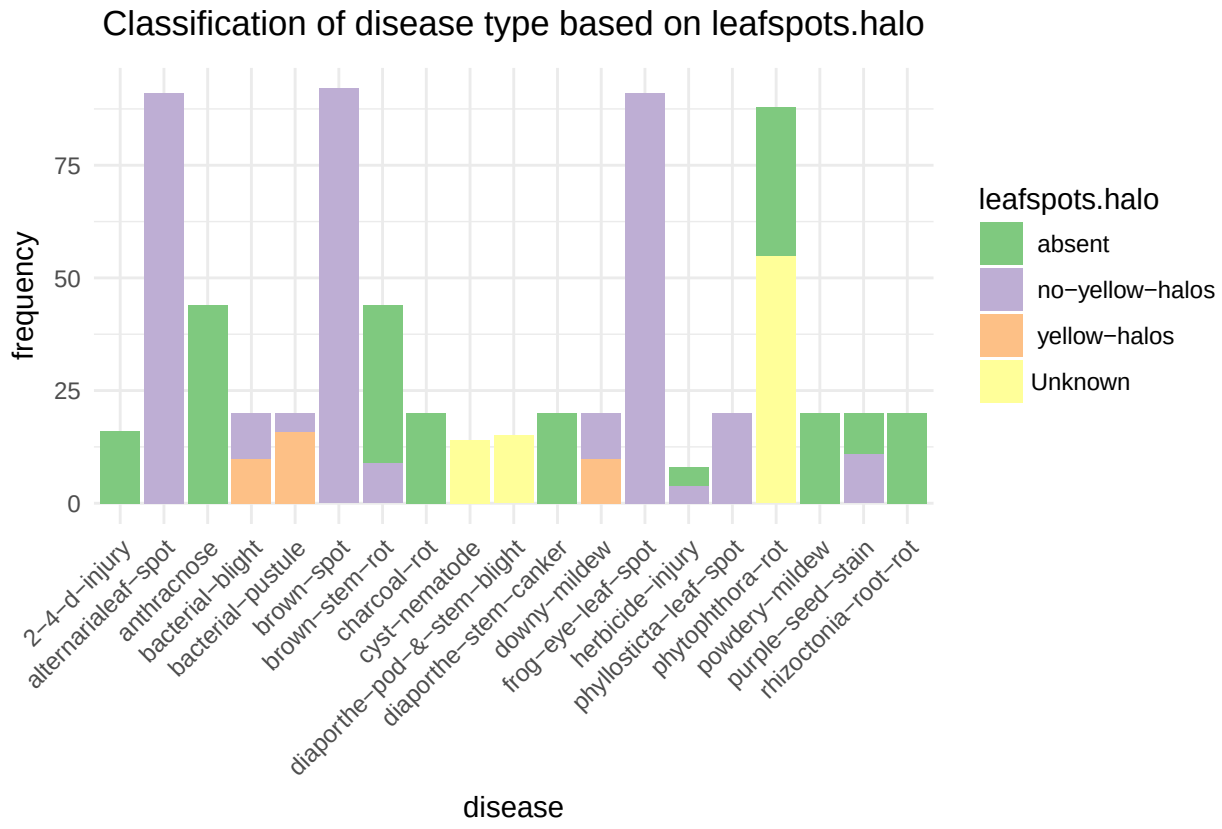

Classification of disease type based on severity
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
severity
minor
pot−severe
severe
Unknown

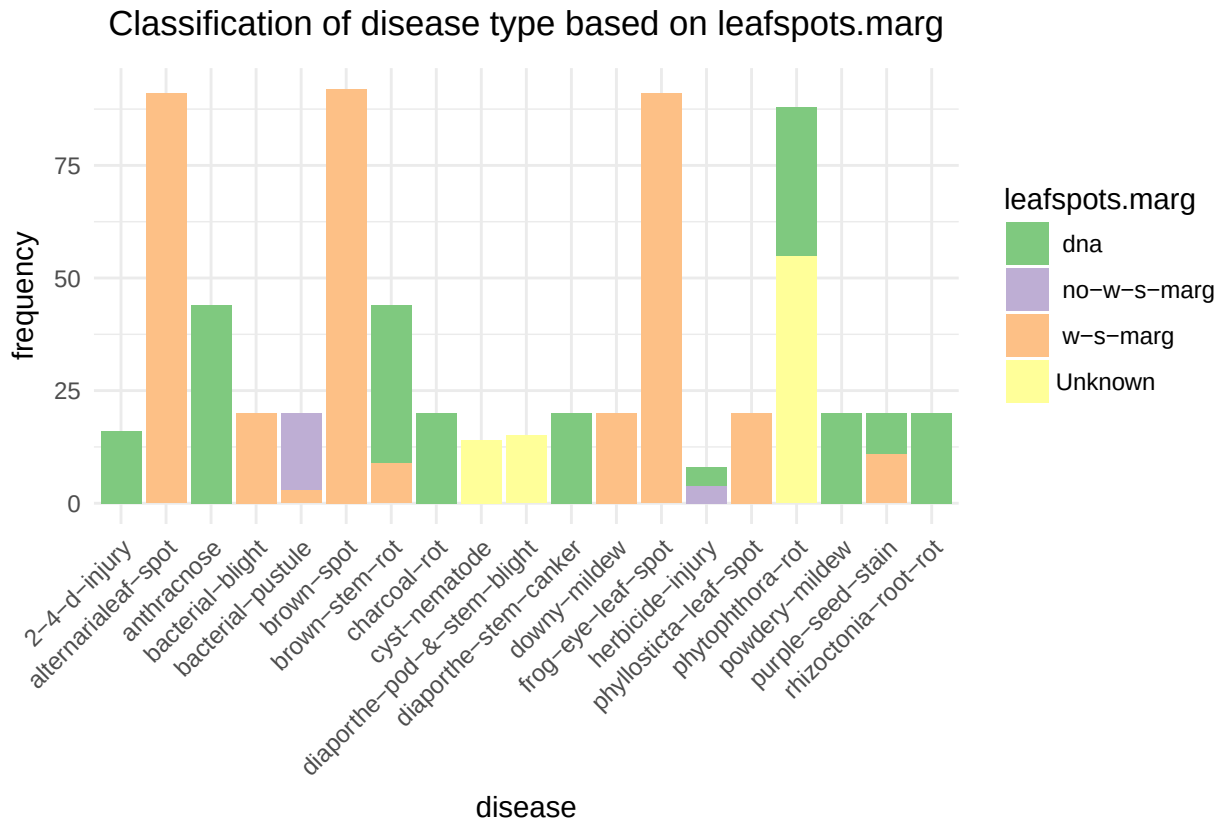

Classification of disease type based on seed.tmt
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
seed.tmt
fungicide
none
other
Unknown

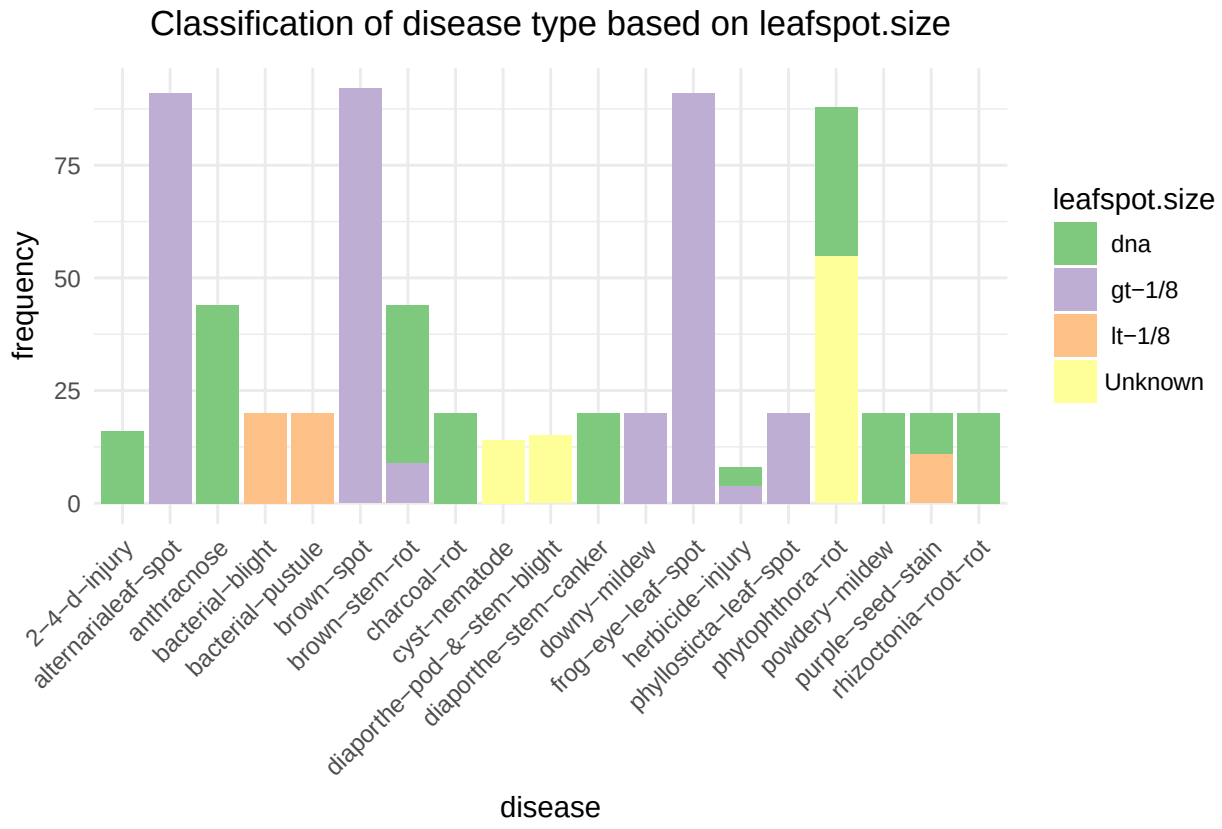

Classification of disease type based on germination
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
germination
80−89
90−100
lt−80
Unknown

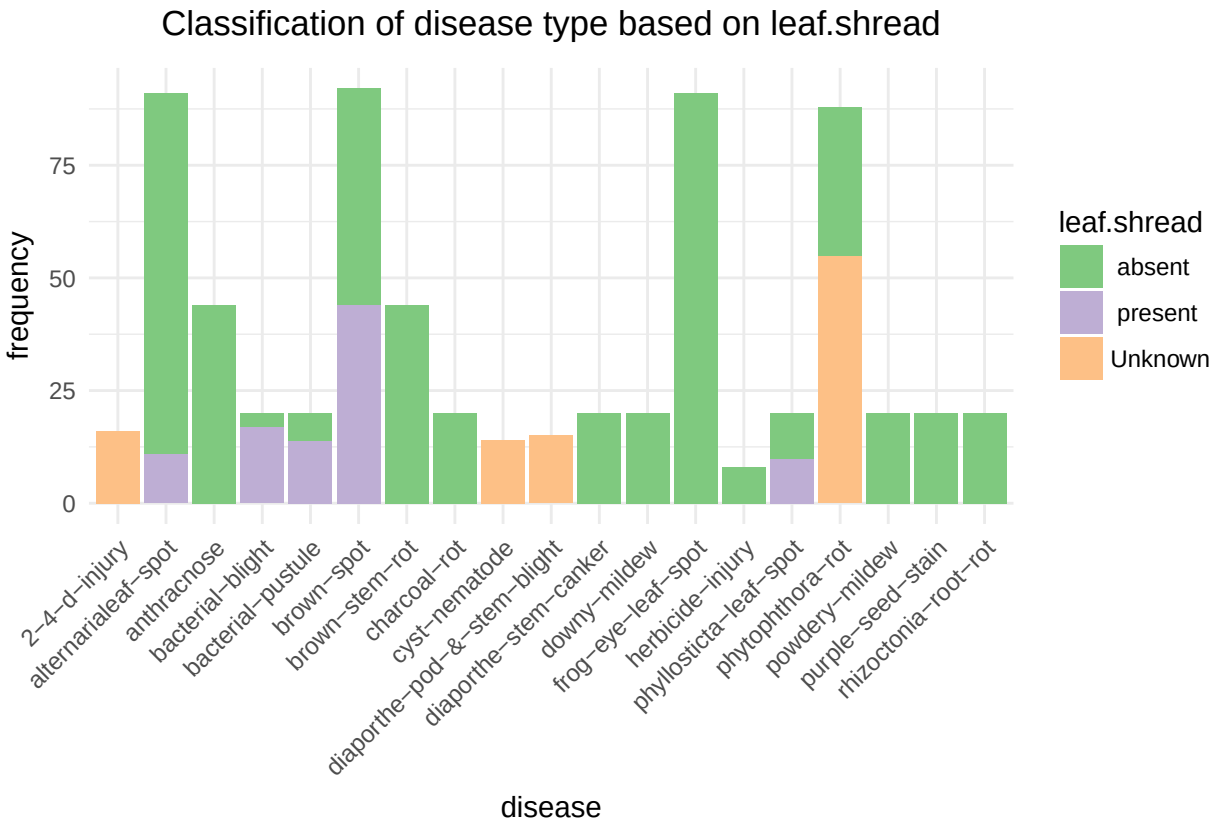

Classification of disease type based on plant.growth
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
plant.growth
abnorm
norm
Unknown

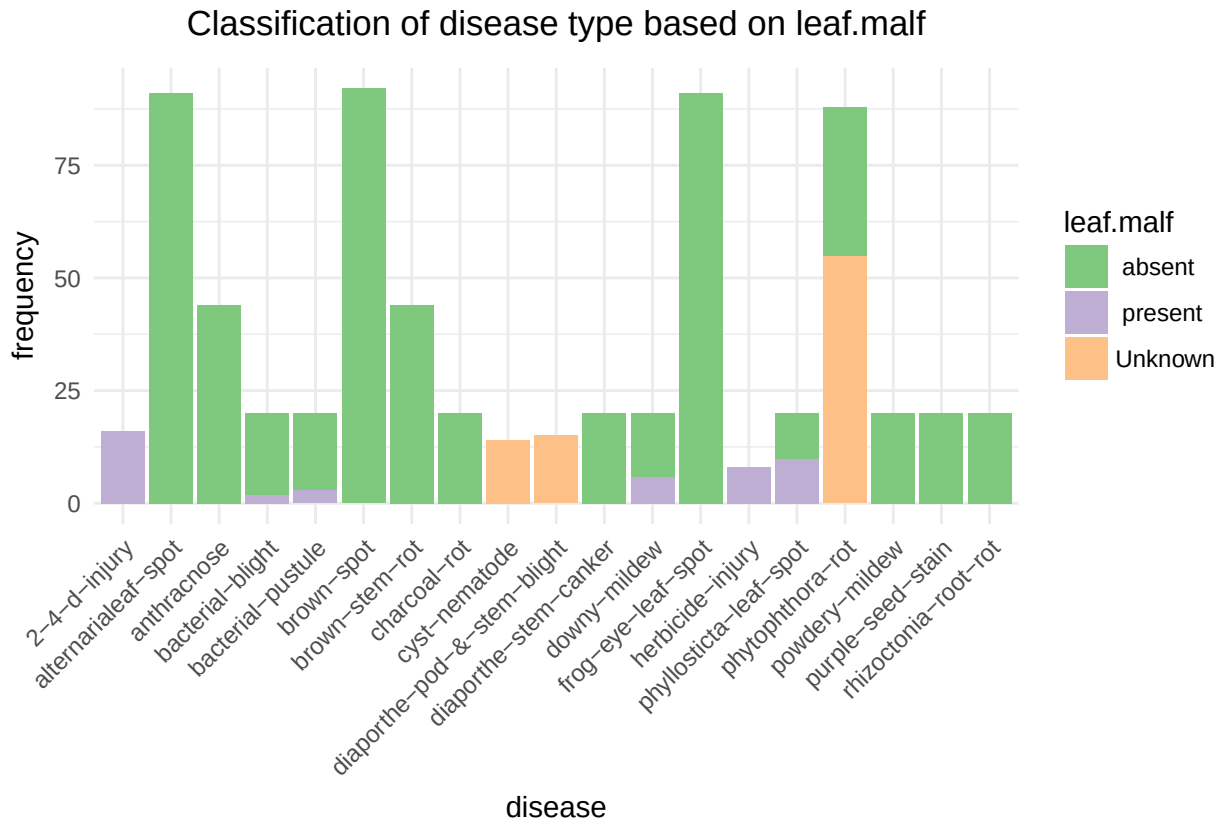

Classification of disease type based on leaves
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
leaves
abnorm
norm

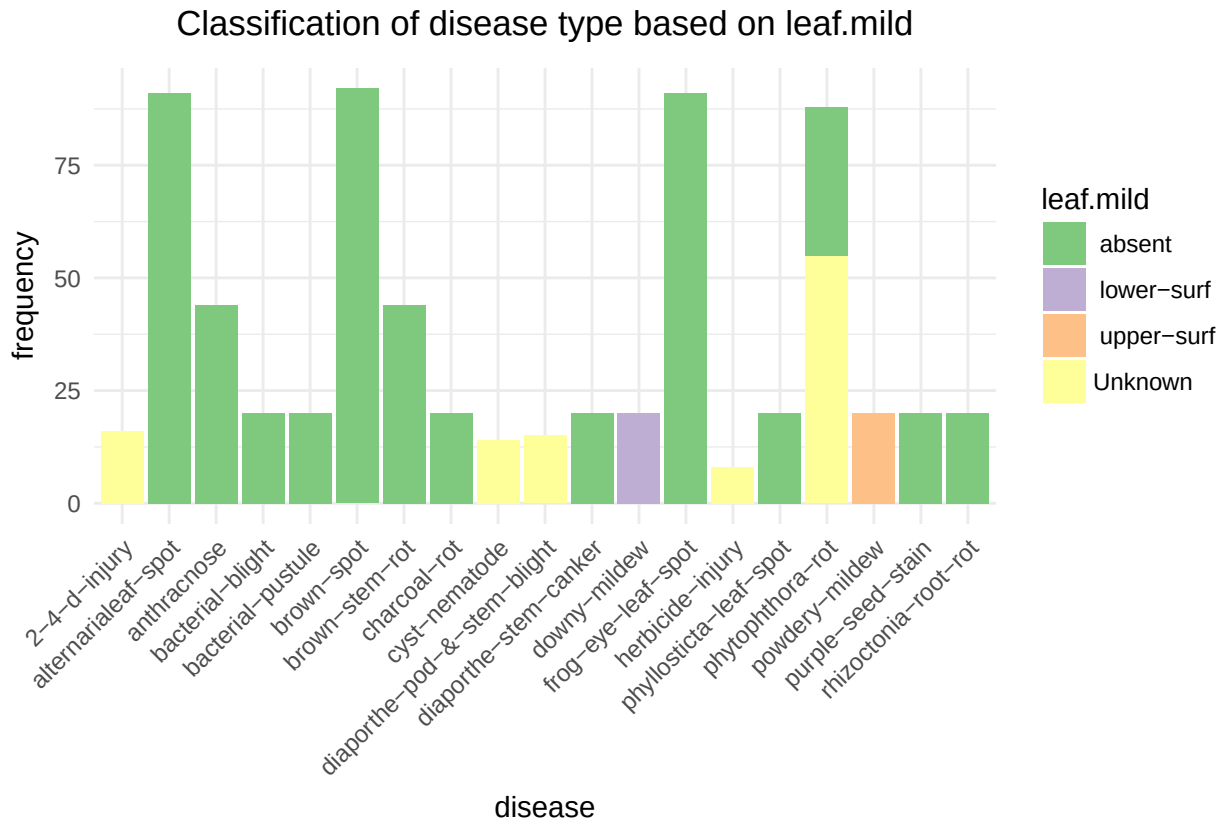

Classification of disease type based on leafspots.halo
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
leafspots.halo
absent
no−yellow−halos
yellow−halos
Unknown

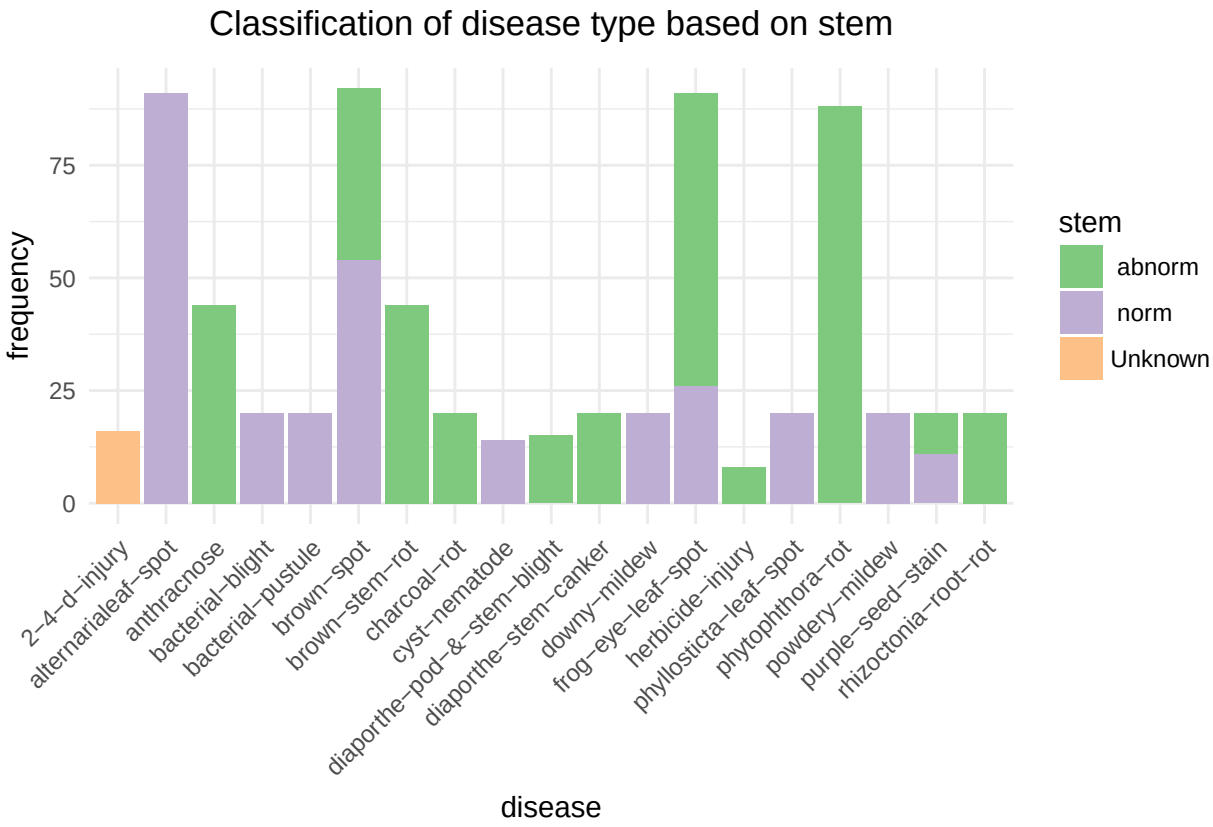

Classification of disease type based on leafspots.marg
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
leafspots.marg
dna
no−w−s−marg
w−s−marg
Unknown

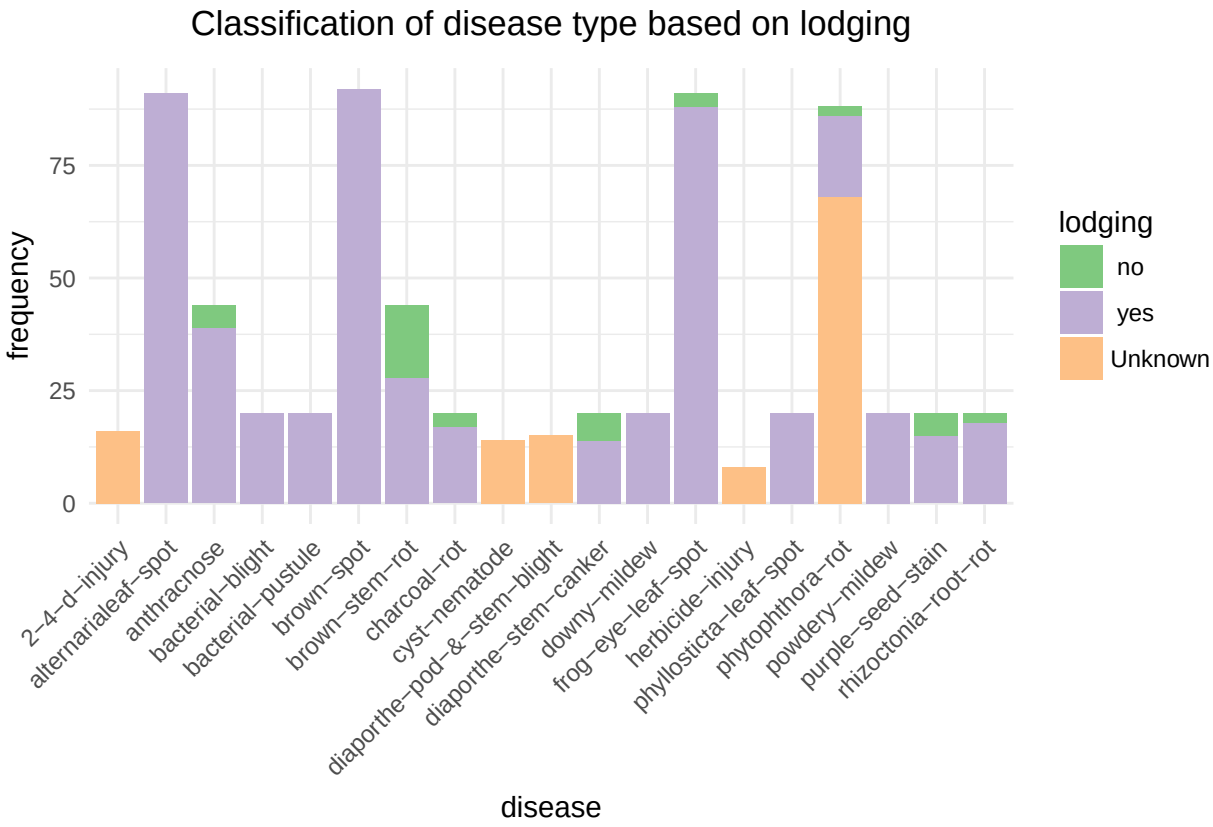

Classification of disease type based on leafspot.size
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
leafspot.size
dna
gt−1/8
lt−1/8
Unknown

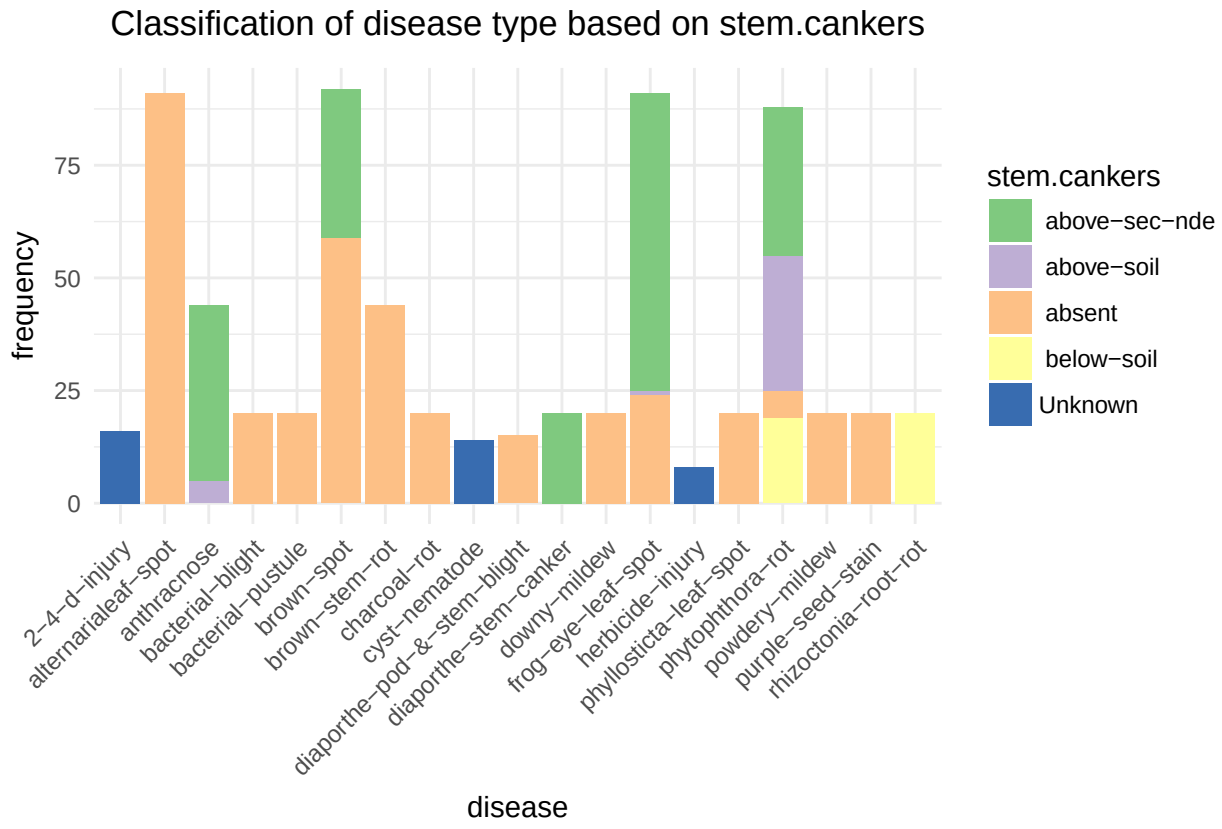

Classification of disease type based on leaf.shread
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
leaf.shread
absent
present
Unknown

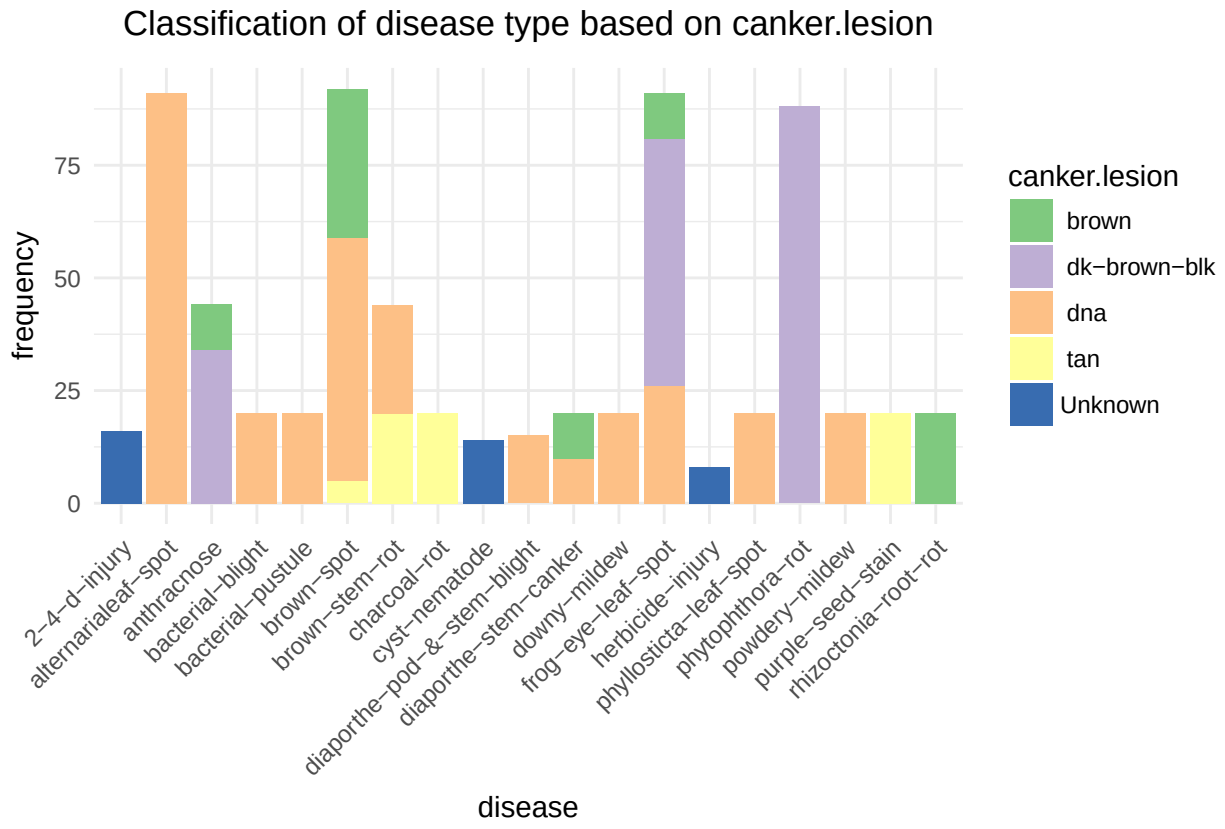

Classification of disease type based on leaf.malf
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
leaf.malf
absent
present
Unknown

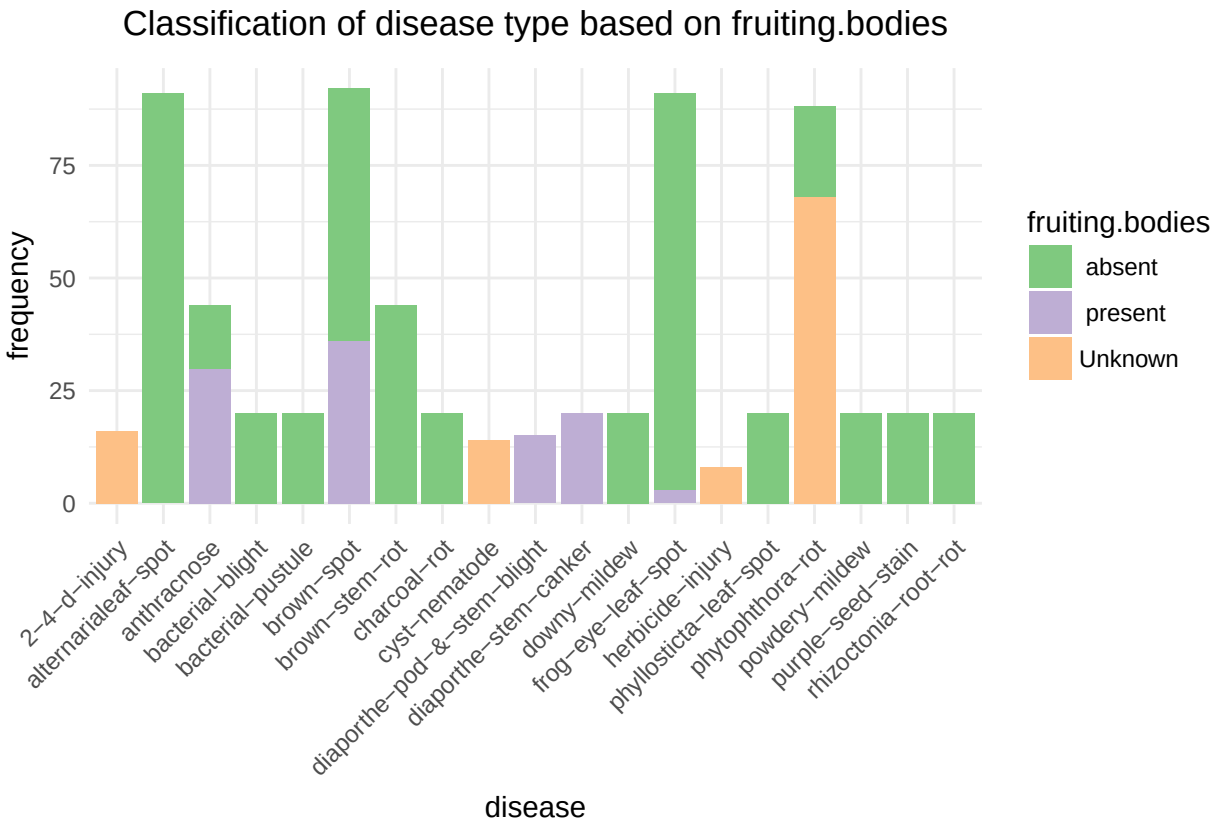

Classification of disease type based on leaf.mild
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
leaf.mild
absent
lower−surf
upper−surf
Unknown

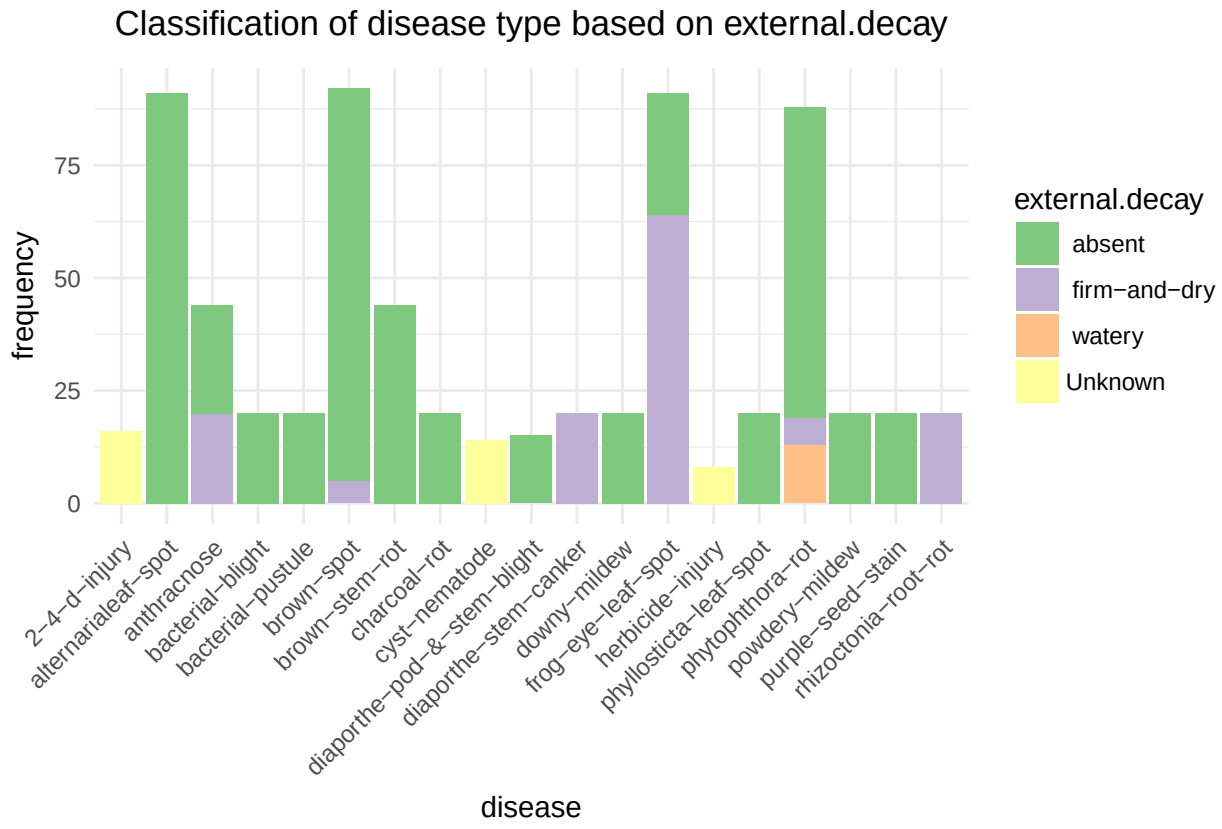

Classification of disease type based on stem
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
stem
abnorm
norm
Unknown

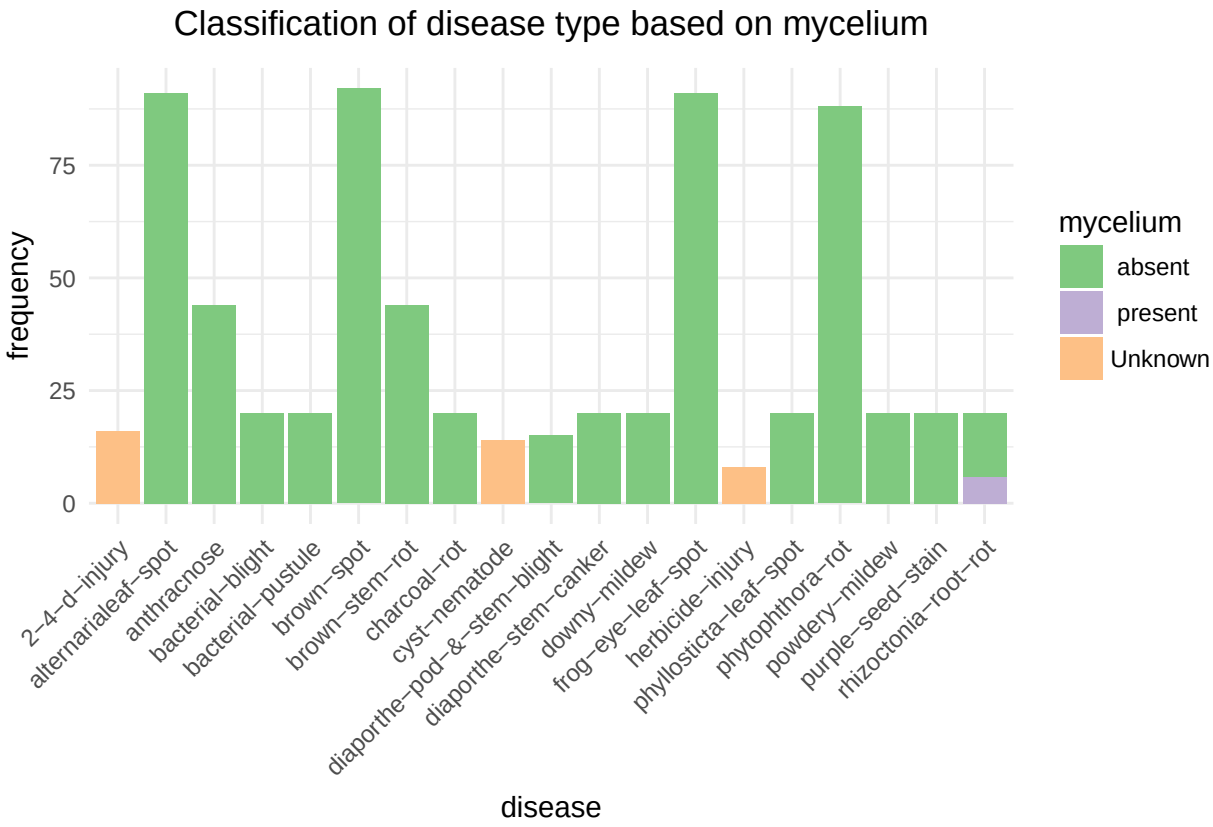

Classification of disease type based on lodging
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
lodging
no
yes
Unknown

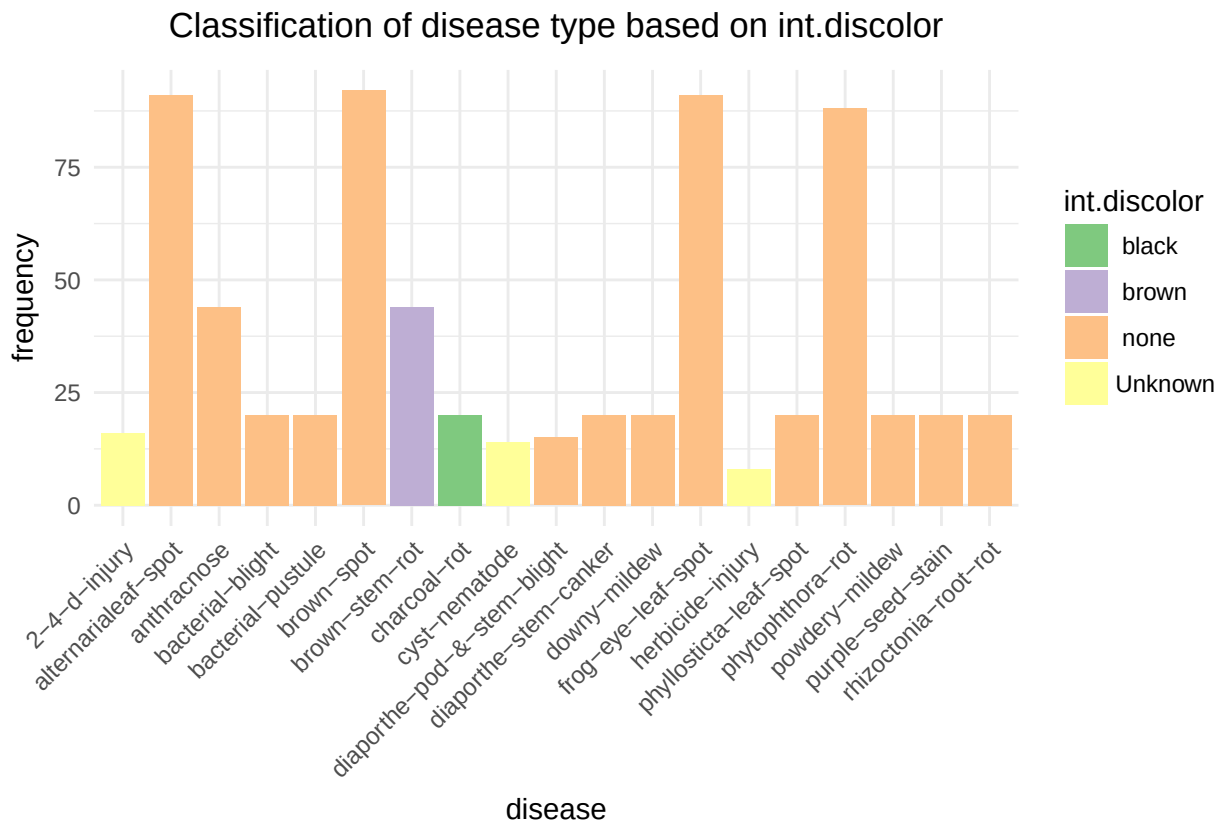

Classification of disease type based on stem.cankers
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
stem.cankers
above−sec−nde
above−soil
absent
below−soil
Unknown

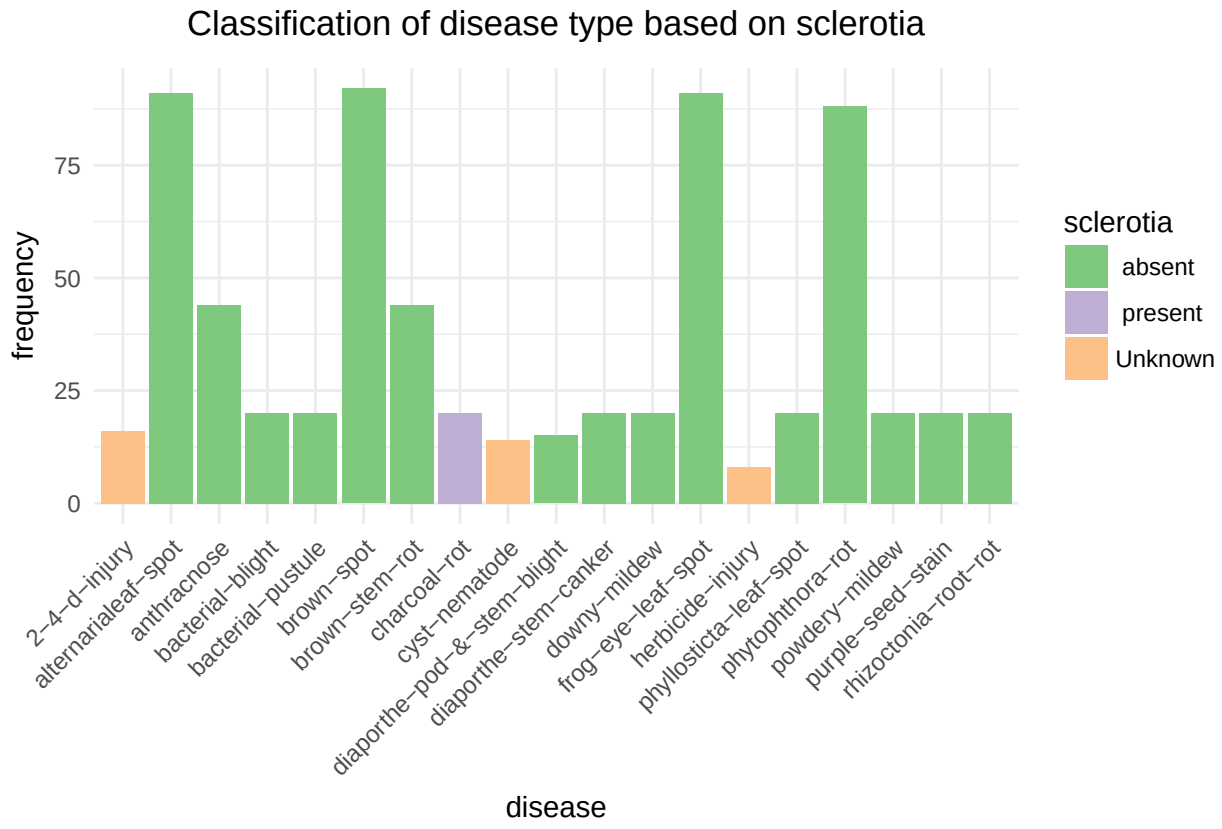

Classification of disease type based on canker.lesion
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
canker.lesion
brown
dk−brown−blk
dna
tan
Unknown

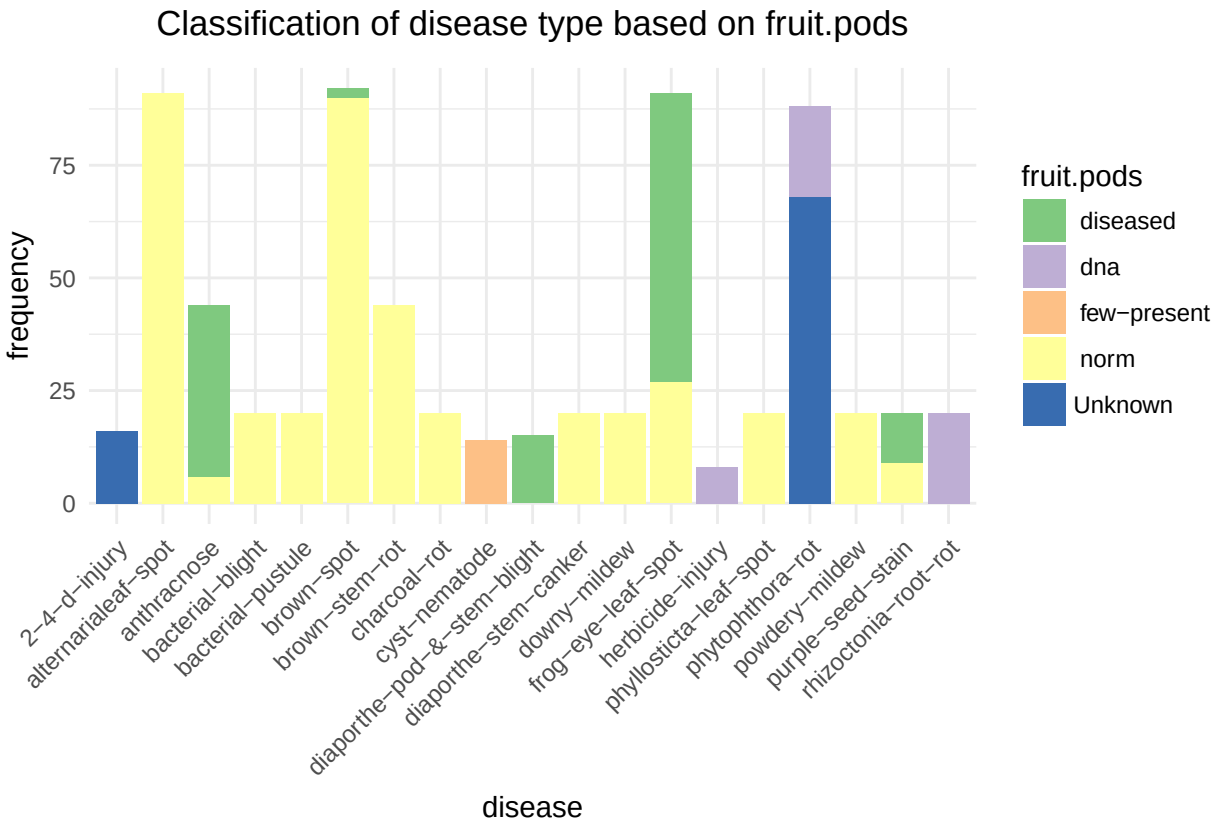

Classification of disease type based on fruiting.bodies
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
fruiting.bodies
absent
present
Unknown

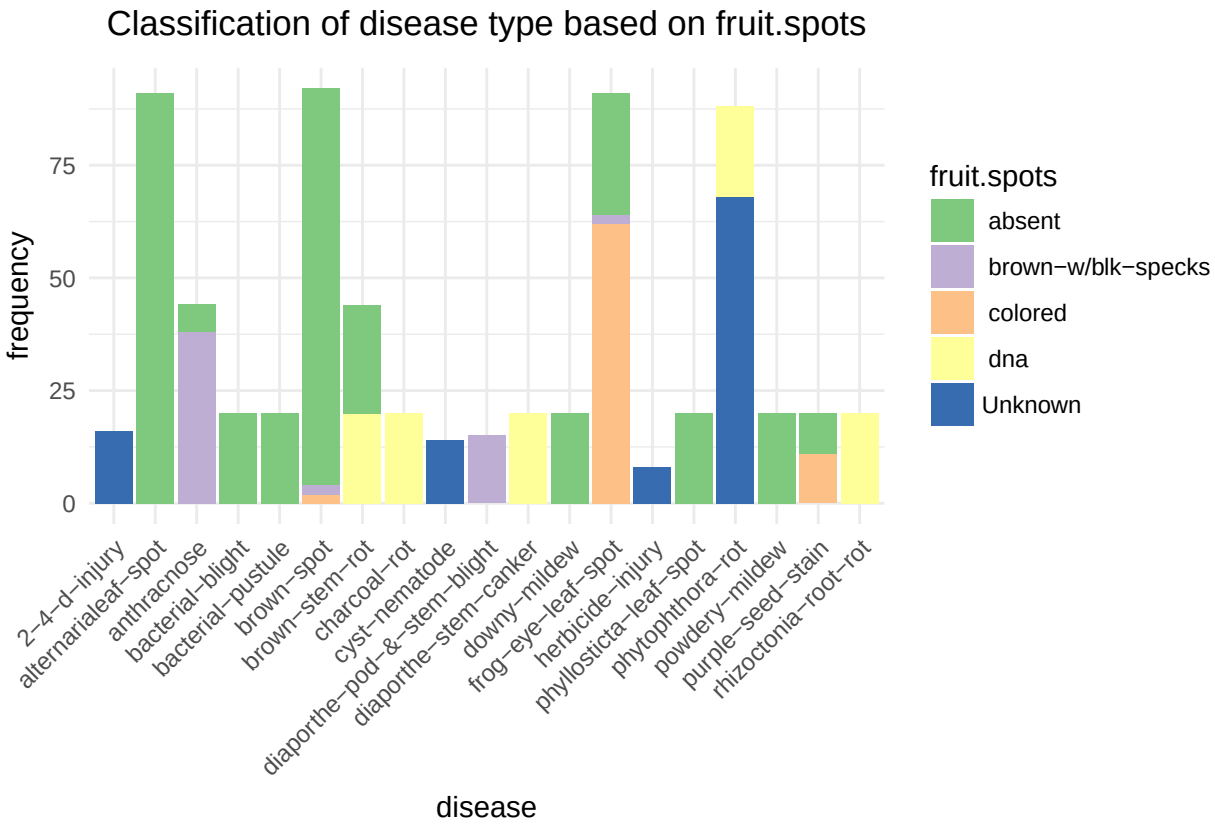

Classification of disease type based on external.decay
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
external.decay
absent
firm−and−dry
watery
Unknown

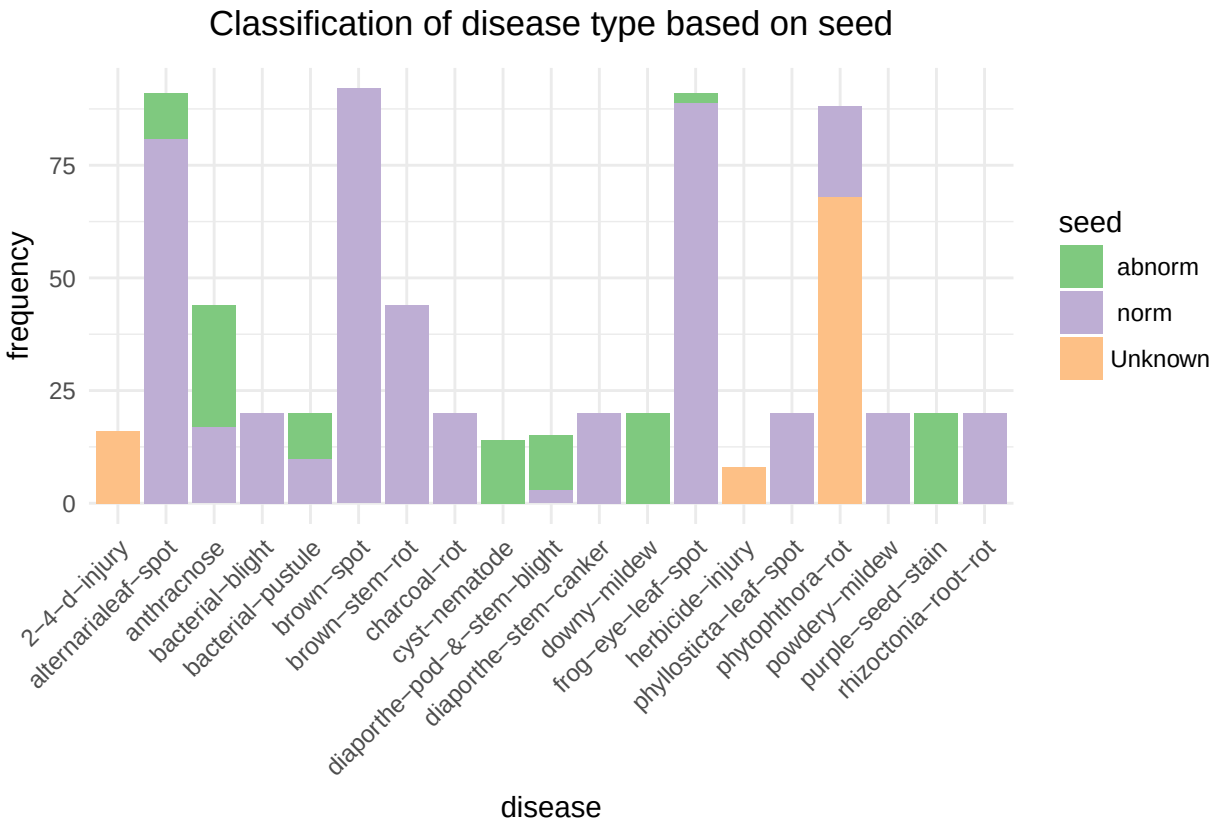

Classification of disease type based on mycelium
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
mycelium
absent
present
Unknown

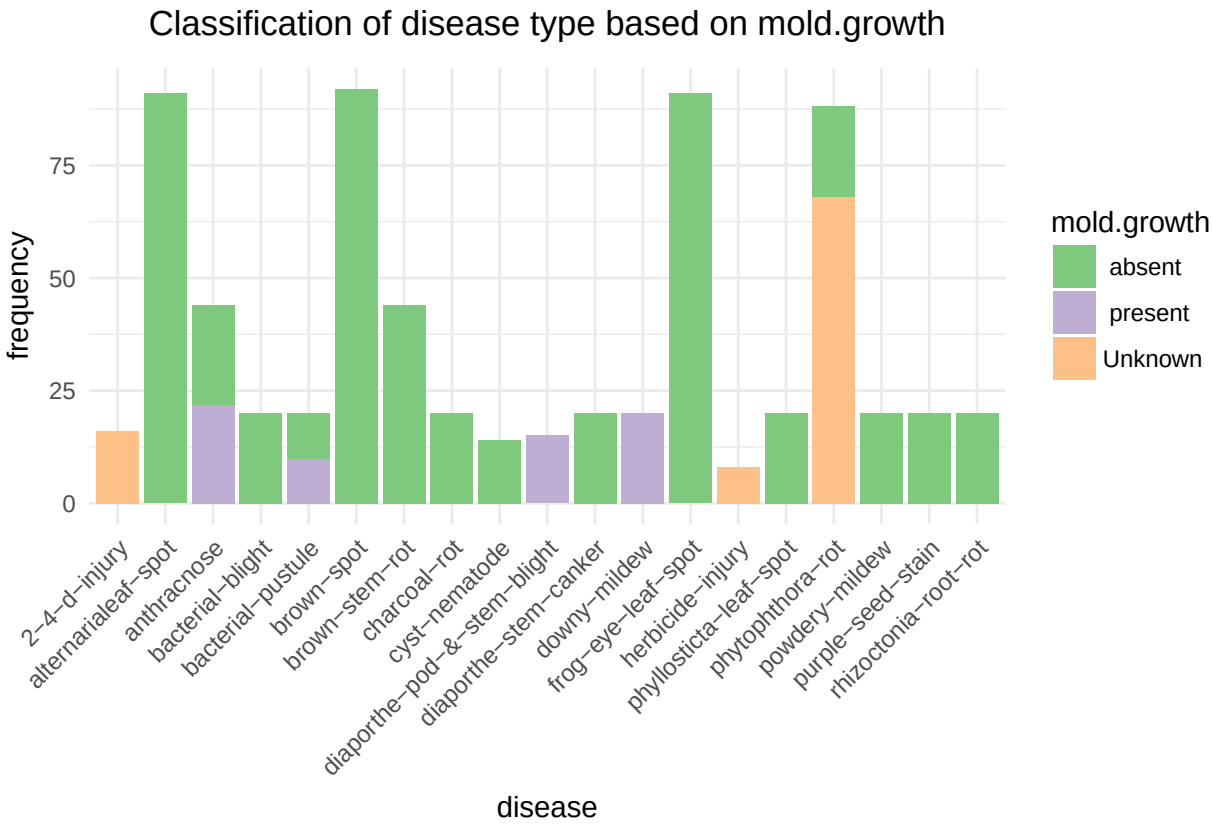

Classification of disease type based on int.discolor
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
int.discolor
black
brown
none
Unknown

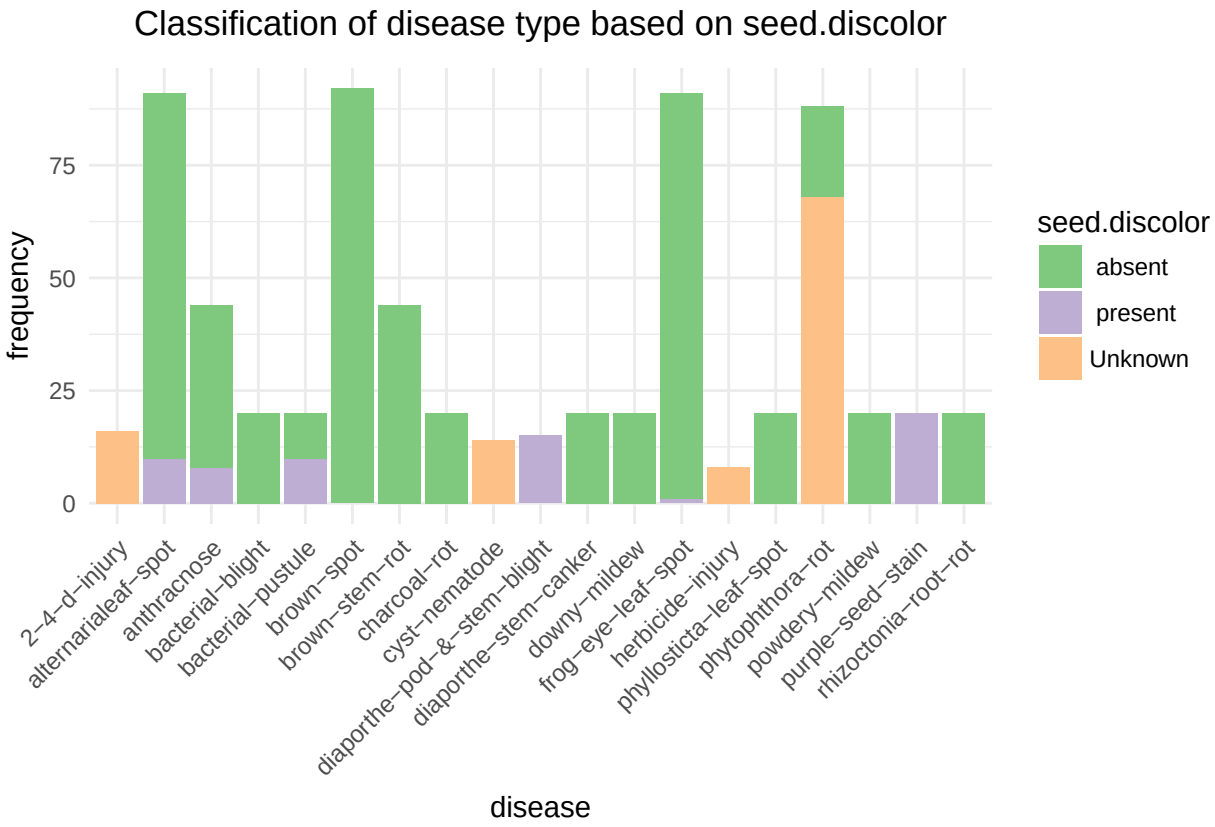

Classification of disease type based on sclerotia
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
sclerotia
absent
present
Unknown

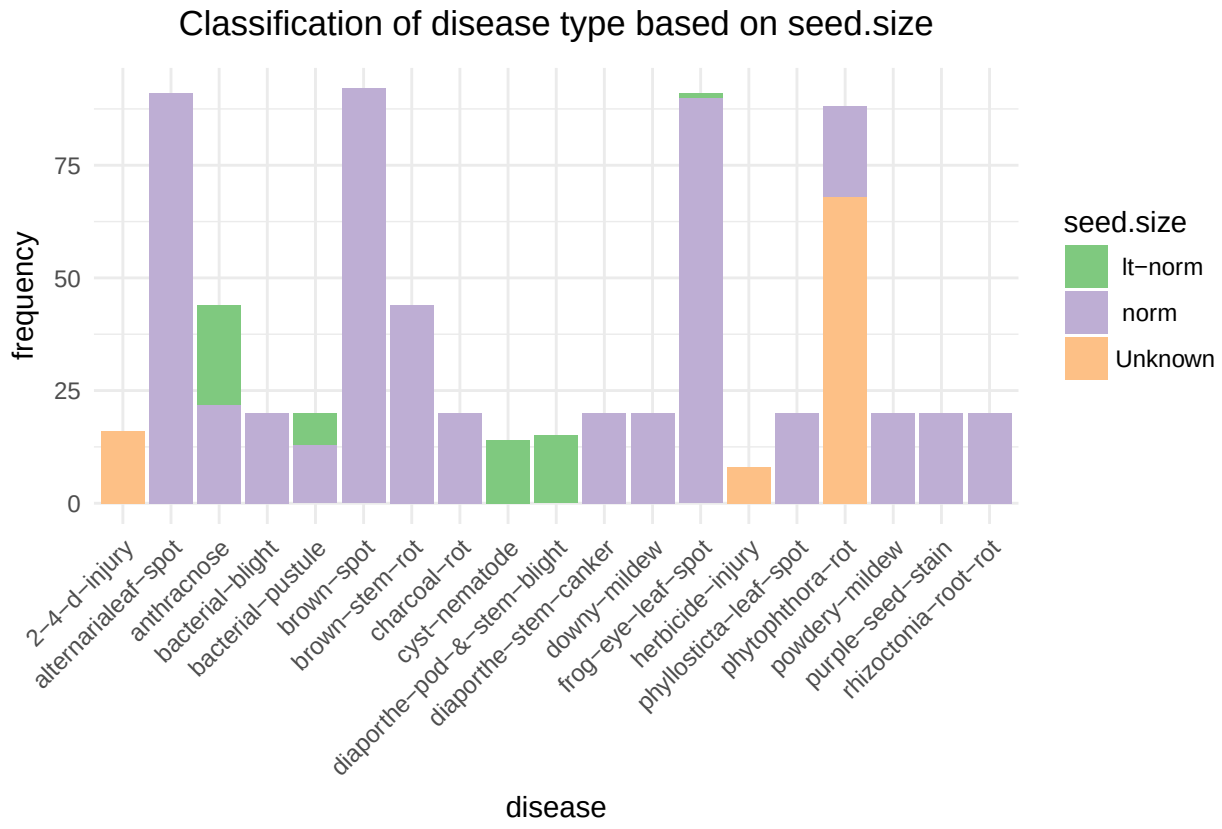

Classification of disease type based on fruit.pods
frequency
0
25
50
75
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
fruit.pods
diseased
dna
few−present
norm
Unknown

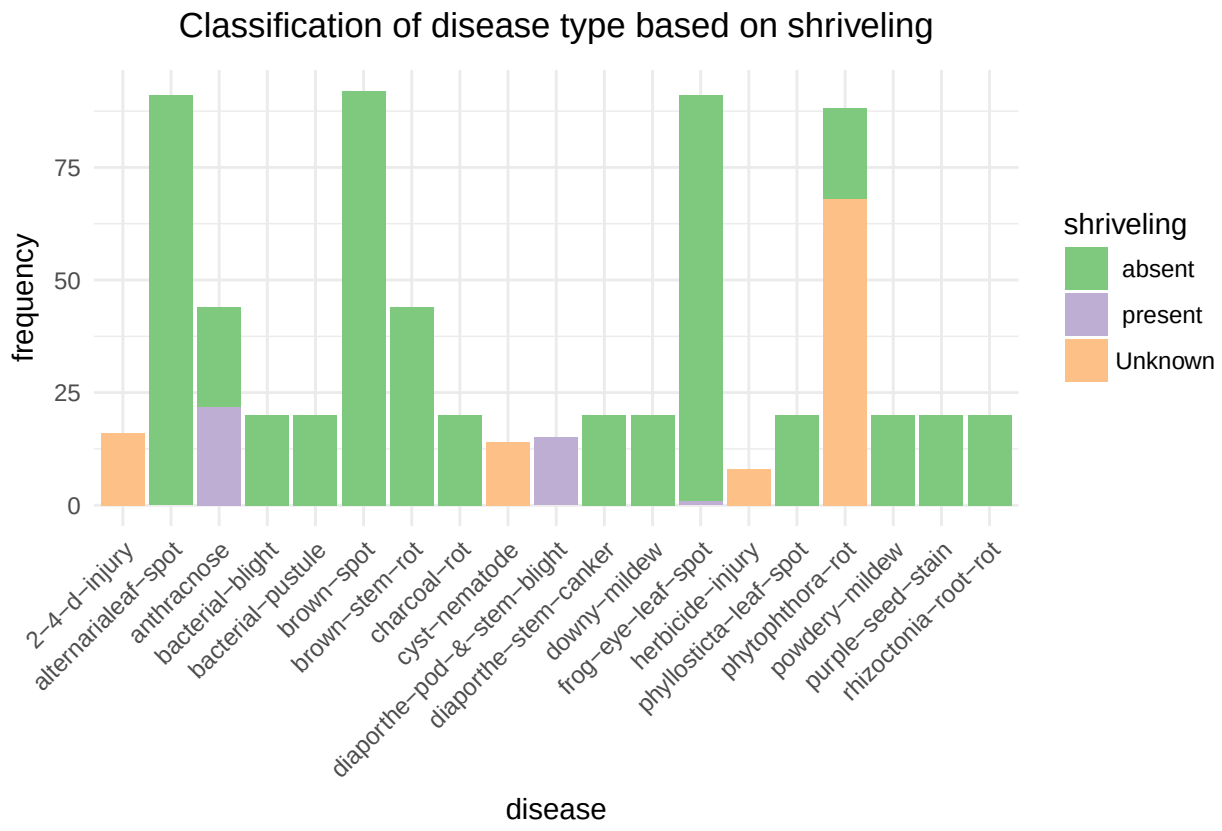

Classification of disease type based on fruit.spots
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
fruit.spots
absent
brown−w/blk−specks
colored
dna
Unknown

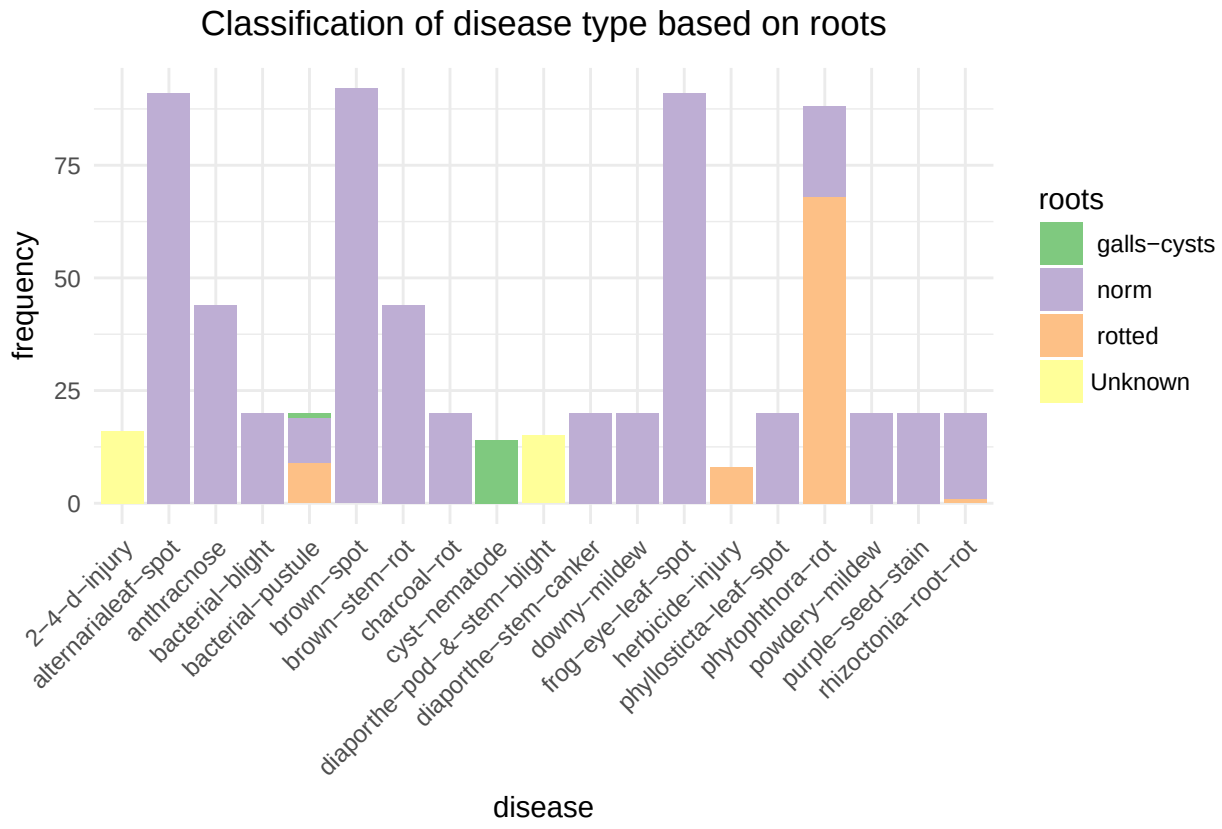

Classification of disease type based on seed
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
seed
abnorm
norm
Unknown


Classification of disease type based on mold.growth
frequency
75
50
25
0
2−4−d−injury
alternarialeaf−spot
anthracnose
bacterial−blight
bacterial−pustule
brown−spot
brown−stem−rot
charcoal−rot
cyst−nematode
diaporthe−pod−&−stem−blight
diaporthe−stem−canker
downy−mildew
frog−eye−leaf−spot
herbicide−injury
phyllosticta−leaf−spot
phytophthora−rot
powdery−mildew
purple−seed−stain
rhizoctonia−root−rot
disease
mold.growth
absent
present
Unknown


Classification of disease type based on seed.discolor
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
seed.discolor
absent
present
Unknown


Classification of disease type based on seed.size
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
seed.size
lt–norm
norm
Unknown


Classification of disease type based on shriveling
frequency
75
50
25
0
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
shriveling
absent
present
Unknown


Classification of disease type based on roots
frequency
0
25
50
75
2–4–d–injury
alternarialeaf–spot
anthracnose
bacterial–blight
bacterial–pustule
brown–spot
brown–stem–rot
charcoal–rot
cyst–nematode
diaporthe–pod–&–stem–blight
diaporthe–stem–canker
downy–mildew
frog–eye–leaf–spot
herbicide–injury
phyllosticta–leaf–spot
phytophthora–rot
powdery–mildew
purple–seed–stain
rhizoctonia–root–rot
disease
roots
galls–cysts
norm
rotted
Unknown

Results and Discussion

For further analysis, we split the whole datasets into 19 subsets comprising of 1 subset for each class type. For example one for 2-4-d injury another for brown-spot and so on. The frequency tables for all the predictors for each dataframe are created and the insights are drawn based on the above plots and the following tables.

1. For 2-4-d injury:

```
d <- split(soybean, soybean$class)

d1 <- d[[1]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
```

```
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
```

```
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
```

```
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

2-4-d injury: This disease occurrence is found in all months equally from April to October. Area damaged is not specific, it might be low, upper, scattered or wholefield.Leaves are found to be abnormal and leaf-malformation is present in all 2-4-d injury affected cases. But there is no case of halo leafspots. These are few features observed but there is no information available for precipitation, hail, temperature, effect on plant growth and germination, plant standing, leaf shreading, stem, roots, seed size and other features.

2. For Alternarialeaf-spot:

```
d2 <- d[[2]]

for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
```

```
##   80-89  90-100   lt-80 Unknown
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
```

```
## [1] "external.decay"
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Alternarialea-spot: Maximum number of cases are found in October and September and few in August.Plant standing is in many cases found to be less than normal, Precipitation is found to be greater than normal for all the occurrences. Hail was also present in all resulting cases. Temperature was greater than normal in

many cases and hence, plays an importanrt role in occurrence of this disease. Crop history is an important deciding factor in occurrence of disease. Area damaged is not a distinct factor for this disease. Plant growth is not affected, leaves show abnormality, no-yellow halos are found in all cases, w-s marginal leafspots are found in all cases, leafspot size is found to be greater than 1/8 in all cases, leaf shreading is not found, seeds are affected in few cases and seed color ischanged here but in majority of cases seeds are normal. But seed size and roots are normal.

3. For Anthracnose:

```
d3 <- d[[3]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Anthracnose: Maximum number of cases are found in Sept and october. But evn in other months the disease is found to occur.Plant stand is found less than normal in many cases. Precipitation is found to be greater than normal in all the affected cases. Higher temperatures do seem to have certain effect in causing this disease, Hail does contribute to this disease. Effect is seen on plant growth and leaves also in some cases.

But stem is found to be abnormal in all cases under this disease. Lodging is very prominent condition seen under this disease. Stem cankers are found generally above second node under this condition but in few cases they are found just above the soil. Canker lesion are dark brown-black in majority of cases but in some it's also found to be brown.Fruit pods are diseased in all cases and fruit spots are brown-white-black specks.Fruiting bodies are found in many affected cases. Other factors are either nornmal or do not have much contribution in causing the disease.

4. For Bacterial Blight:

```
d4 <- d[[4]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Bacterial Blight: Major occurrence in July and August. Greater than normal precipitation apparently causes this disease. Hail is a clear factor in this disease's occurrence.Crop history does plays an important role in causing this disease. Leaves show abnormality in all affected cases and yellow or non-yellow halo leafspots are seen in all the cases. w-s marginal leaf spots are also found in all the affected cases. Leafspot size is less

than 1/8 in all cases. Leaf shredding is observed in all cases. Lodging is also prominent feature. But Other features like plant standing, growth, germination, seeds, root, stem are not affected.

5. For Bacterial-Pustule:

```
d5 <- d[[5]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Bacterial Pustule: Major occurrence in June and July. Germination is affected and in most cases is less than 80. Leaves show abnormality. Yellow halos are frequent occurrence under this condition. No-ws-marg leafspots observed. Leaf spot size is in all cases less than 1/8. Leaf shredding and lodging are major occurrences. Rotted roots are distinguishing feature for this disease. On the other hand, stem, plant growth,

fruit pods internal color, remain unaffected. Hail doesn;t play a role in causing this disease.

6. For Brown spot:

```
d6 <- d[[6]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks              colored
##                   0                   0                    0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Brown spot: Maximum cases observed in May and June but some cases are also found to occur in other months August, September and April. Plant stand is less than normal in many cases. Precipitation is greater than normal in majority of cases. Hail is an important contributor. Crop history is a ver important role in causing this disease. Mostly whole fields are affected but sometimes it's just scatters or lower-upper areas.

Fungicide treatment does seem to reduce the occurrence of this disease. Leaves are found to be abnormal in all the cases with no-yellow halos being observed. w-s-marg leafspots is also prevailing phenomenon in all the observed cases. Moreover, leafspot size is found to be greater than 1/8 in all cases. Leaf shredding and abnormal stem is a very frequent occurrence under this condition. Lodging is prominent occurrence. Stem cankers are observed above second nodes if present in the affected cases. Canker lesions are either brown or in few cases even tan. Fruiting bodies do play the role in causing this disease. But fruit pods are not generally affected. Other features are either absent or do not play the significant role in causing this infection.

7. For Brown stem rot:

```
d7 <- d[[7]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Brown-stem-rot: Mainly happen in September, August and july. Plant stand does get affected. Less than normal precipitation increases the chances of occurrence of this disease. Hail is again a very strong reason for this disease. Crop history plays an important role. Low areas are rarely affected under this disease, either it is whole fields or upper areas. Plant growth does get affected with this disease. In majority of cases leaves

show abnormality. And stems are affected in all the cases. Lodging is again a prominent occurrence under this disease. Canker lesion cases are tan coloured and internal discolour is brown in all cases.

8. For Charcoal rot:

```
d8 <- d[[8]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Charcoal-Rot: Major occurrence in August, September and October but few cases found to occur in July also. Precipitation is less than normal and temperature greater than normal in all the cases.Hail effect is also found to be present in many cases.Mainly upper areas or whole fields are seem to be affected by this disease. Plant growth gets abnormal with this disease. Leaves and stem are abnormal in all the affected

cases. Lodging is found to happen in all the affected cases. Canker-lesions are tan in all the cases.Internal discolor is found to be black in all the cases. Main distinct feature for this disease is presence of sclerotia in all the charcoal-rot affected cases.

9. For cyst-nematode:

```
d9 <- d[[9]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks              colored
##                   0                   0                    0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Cyst Nematode: Observed in the months of july, august and june. Crop history plays a clear role in the occurrence of this disease. Either upper or lower fields affected. Leaves, seeds and roots are abnormal in all observed cases. Roots got galls cysts as an effect. Seeds size is less than normal and fruit pods are present in all infected cases. But there is no information available for precipitation, temperature and hail effect. Even

information related to leafspots, leafspot size, leaf shreading, malformation, stem cankers, fruiting bodies, external decay is unknown.

10. For Diaporthe-pod-&-stem-blight

```
d10 <- d[[10]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Diaporthe-pod-&-stem-blight: Major occurrence in September and October and a few cases in May. Plant stand is affected in some cases under this disease. Precipitation and temperature are greater than normal in the infected cases. Crop history plays role. Area damaged constitutes majorly of whole fields with very few cases of scattered infection. Stems show abnormality in all the affected cases.Fruiting bodies are found

to be present and fruit pods are also found to be diseased in all the infected cases. Fruitspots are in the form of brown-w/black specks.Seeds were abnormal in majority of cases and shows discolor and reduced size. Besides this shriveling was observed. Mould growth is also significant factor in causing this disease. But information regarding hail, seed treatment, stem cankers, halo and marg leafspots, leaf shreading, mildew and malformation, roots condition and lodging is unknown.

11. For diaprthe-stem-canker:

```
d11 <- d[[11]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Diaporthe-stem-canker: Equal number of cases found in July, August, September and October. Precipitation is greater than normal in all cases. Hail is present in all observed cases. Crop history plays significant role. Mainly scattered areas are infected and in few cases lower areas. Seed treatment doesn't seem to help much in preventing this disease. Seed germination is affected and gets to less than 80 in many cases. Plant growth

and leaves found to be abnormal in all the infected cases. Lodging happens as a result of this disease. Stem cankers are found to be present above second node in all the cases. and canker lesions are brown in all cases. But no internal discoloration is found. Fruiting bodies are also found to be present in all cases. As under external decay all crops are found to be firm and dry.

12. For Downy-milldew:

```
d12 <- d[[12]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
##       0       0       0      16
```

```
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16               0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
##
```

```
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks              colored
##                   0                   0                    0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Downy-Mildew: Observed mostly in the month of june, july, august and september. Plant stand happens to be less than normal, precipitation is found to be greater than normal. Temperature is noted to be less than normal in many cases. Hail is also observed in most occurrences. Crop history plays important role. Plant growth stays normal and so are the stems of the plant but there leafspot halos are found on the leaves and the leafspot size is found to be greater than 1/8.Abnormality in seeds is observed and seed size is affected.

Mould growth was present in all the cases infected. Other factors were either absent or not significant in causing this disease.

13. For frog-eye-leaf-spot:

```
d13 <- d[[13]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Frog-Eye-Leaf-Spot: Observed in the months from july to october but most of the cases are recorded in aug and sept; Plant standing is normal for most of the cases but there are few in which it is less than normal.Precipitation is greater than normal and in most of the cases hail is recorded. Even higher temperature is observed in many cases. Seed treatment doesn't help much in preventing the disease. Plant growth stays

normal. Stem and leaves are affected in all the cases. Non-Yellow halo leafspot are found in all the cases and the leafspot size is found to be greater than 1/8. Fruit pods are also found to be diseased in all the cases. Other factors are either absent or not significant in causing the disease.

14. For Herbicide injury:

```
d14 <- d[[14]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Herbicide-Injury: Observed in the month of April, May and June. Plant stand is less than normal. Either the whole field is damaged by this or the damage is scattered through the field.Abnormality is noticed in plant growth, stem and leaves. And Non-yellow halo leafspots are found in some cases. Even in some cases no-ws-marg leaf spots are observed. Leaf spot size is found to be greater than 1/8. Crop history is not

the deciding factor for the disease occurrence. Roots are rotted in all the infected cases. Leaf shreading is absent. Involvement of factors like hail, external decay, presence or absence of fruiting.bodies, sclerotia, internal discolor, mould growth, seed discolor, effect on seed size were unknown.

15. For phyllosticta-leaf-spot:

```
d15 <- d[[15]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Phyllosticta-leaf-spot: Observed in the month of May, June, July and Aug. Precipitation is found to be less than normal and temperature greater than normal in many cases.Hail is also observed in most cases. Crop history is not a deciding factorfor occurrence of the disease. Lower areas not affected.Plant growth stays normal even in the disease occurrence. Seed treatment is also not a deciding factor. Abnormality in leaves is

observed and non-yellow halo leafspots and marginal w-s marg leafspots are observed. Leaf spot size is found to be greater than 1/8. Leaf shreading and leaf malformation is observed in half of the cases.Conditions like leaf mildew, stem cankers,fruiting.bodies, external decay, mycelium, sclerotia, fruit spots, mould growth, seed discolor are absent. Remaining factors are either normal or insignificant.

16. For phytophthora-rot:

```
d16 <- d[[16]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Phytophthora-Rot: Observed majorly from May to July but few cases are observed in April and August.Plant standing is less than normal. Precipitation and temperature are greater than normal in many cases.Hail is present in majority of known cases.Area damaged are all low lying areas.Lot of unknown data in germination and seed treatment and in halo and marginal leaf spots. Abnormailty in plant growth, leaves and stem is

prominent. Lodging is prevalent feature in this infection. Stem cankers are seen to be present both below and above soil and even above second node. Canker lesions are dark brown-black in color. Roots are found to be rotted in all observed infected cases. Factors like leafspot size, leaf shread, leaf malformation, mould growth, seed discoloration, shriveling are absent in the collected data or are unknown.

17. For powdery mildew:

```
d17 <- d[[17]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Powdery-Mildew: Observed from May to October. Plant stand is less than normal in most cases. Precipitation and temperature is found to be less than normal in many cases. Hail is also recorded in most cases. Crop history and area damaged are not important indicators in this case. Seed treatment doesn;t seem to prevent the occurrence of the disease. Even germination status is uniformly distributed so it doesn't seem to

be good indicator for disease detection. Normal plant growth recorded in all the cases. As a distinguishing featurelLeaf mildew is found on upper surface of leaves in all cases.Abnormality in leaves is a general occurrence under this disease type.Lodging is observed in all cases.Fruit pods are found normal and fruit spots absent, seeds are also found to be normal, mould growth , seed discoloration is absent in all cases, seed size normal, shriveling absent and roots are also normal.

18. For purple-seed-stain:

```
d18 <- d[[18]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Purple-seed-stain: Observed from July to October. No abnormality in plant stand. Precipitation is found to be greater than normal,and temperature is not a deciding factor in this case.Hail is present in majority of cases. Crop history and area damaged are also not the deciding factors. Seed treatment doesn't play important role in prevention of the disease. Germination is found to be less than 90. Leaves are found to be

abnormal, no-Yellow Halos and w-s marginal leafspots are found in majority of cases. Leaf spot size is less than 1/8, lodging is prevalent in most cases and besides this fruit spots are also coloured in all cases and fruit pods diseased.Seeds show abnormality and discoloration.Absence of leaf shreading, leaf malformation, leaf mildow, stem cankers, fruiting bodies, external decay, mycelium, sclerotia and mould growth is observed.

19. For: Rhizoctonia-root-rot:

```
d19 <- d[[19]]
for(n in 1:35)
{
   n <- names(d1[n])
   t <- table(d1[n])
   print(names(d1[n]))
   print(t)
}
```

```
## [1] "date"
##
##     april    august      july      june       may   october september
##         3         2         2         2         2         2         2
##   Unknown
##         1
## [1] "plant.stand"
##
##  lt-normal     normal    Unknown
##          0          0         16
## [1] "precip"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "temp"
##
##  gt-norm  lt-norm     norm  Unknown
##        0        0        0       16
## [1] "hail"
##
##      no     yes Unknown
##       0       0      16
## [1] "crop.hist"
##
##     diff-lst-year  same-lst-sev-yrs  same-lst-two-yrs       same-lst-yr
##                 0                 0                 0                 0
##           Unknown
##                16
## [1] "area.damaged"
##
##    low-areas    scattered  upper-areas  whole-field      Unknown
##            4            4            4            3            1
## [1] "severity"
##
##       minor  pot-severe      severe     Unknown
##           0           0           0          16
## [1] "seed.tmt"
##
##  fungicide       none      other    Unknown
##          0          0          0         16
## [1] "germination"
##
##   80-89  90-100   lt-80 Unknown
```

```
##       0       0       0      16
## [1] "plant.growth"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "leaves"
##
##  abnorm    norm
##      16       0
## [1] "leafspots.halo"
##
##           absent  no-yellow-halos     yellow-halos          Unknown
##               16                0                0                0
## [1] "leafspots.marg"
##
##          dna  no-w-s-marg     w-s-marg      Unknown
##           16            0            0            0
## [1] "leafspot.size"
##
##     dna  gt-1/8  lt-1/8 Unknown
##      16       0       0       0
## [1] "leaf.shread"
##
##   absent  present  Unknown
##        0        0       16
## [1] "leaf.malf"
##
##   absent  present  Unknown
##        0       16        0
## [1] "leaf.mild"
##
##      absent  lower-surf  upper-surf     Unknown
##           0           0           0          16
## [1] "stem"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "lodging"
##
##      no     yes Unknown
##       0       0      16
## [1] "stem.cankers"
##
##  above-sec-nde     above-soil         absent     below-soil        Unknown
##              0              0              0              0             16
## [1] "canker.lesion"
##
##         brown  dk-brown-blk           dna           tan       Unknown
##             0             0             0             0            16
## [1] "fruiting.bodies"
##
##   absent  present  Unknown
##        0        0       16
## [1] "external.decay"
```

```
##
##        absent  firm-and-dry        watery       Unknown
##             0             0             0            16
## [1] "mycelium"
##
##   absent  present  Unknown
##        0        0       16
## [1] "int.discolor"
##
##   black   brown    none Unknown
##       0       0       0      16
## [1] "sclerotia"
##
##   absent  present  Unknown
##        0        0       16
## [1] "fruit.pods"
##
##     diseased          dna  few-present         norm      Unknown
##            0            0            0            0           16
## [1] "fruit.spots"
##
##              absent  brown-w/blk-specks             colored
##                   0                   0                   0
##                 dna             Unknown
##                   0                  16
## [1] "seed"
##
##  abnorm    norm Unknown
##       0       0      16
## [1] "mold.growth"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.discolor"
##
##   absent  present  Unknown
##        0        0       16
## [1] "seed.size"
##
##  lt-norm     norm  Unknown
##        0        0       16
## [1] "shriveling"
##
##   absent  present  Unknown
##        0        0       16
## [1] "roots"
##
##  galls-cysts         norm       rotted      Unknown
##            0            0            0           16
```

Rhizoctonia-Root-Rot:Observed mostly from april to june. Plant stand is recorded less than normal for most cases. Precipitation is found to be greater than normal and temperature less than normal. Hail is a major factor. Crop history is not a determining factor for the disease. Area damaged are all low areas. Lesser cases with seed treatment found infected.Germination affected and is found to be less than 90 in

all cases. Abnormality in plant growth and stem is seen but not in leaves.No halo or marginal leafspots observed. Absence of leaf shreading, leaf mildew, and fruiting bodies. Lodging is found present. Stem cankers are found all below soil and canker lesion all brown, Lastly mycelium is also found in few cases. All the remaining factors are either absent or insignificant.

Conclusion

Preliminary analysis of the data suggests that there are several distinct symptoms associated with the particular soybean crop disease. The various condition of leaves, stem, roots, fruiting pods; Level of precipitation, degree of temperature, presence or absence of hail; presence or absence of fungal infections like stem cankers, fruiting bodies, mycelium, sclerotia and other conditions to categorizing the symptoms for different diseases.

Formulating a machine learning model will help diagnosing the disease given the symptoms for any new soybean crop, utilizing the model generated by the given data.

References

- https://www.openml.org/d/42
- R.S. Michalski and R.L. Chilausky "Learning by Being Told and Learning from Examples: An Experimental Comparison of the Two Methods of Knowledge Acquisition in the Context of Developing an Expert System for Soybean Disease Diagnosis", International Journal of Policy Analysis and Information Systems, Vol. 4, No. 2, 1980.