PCA Analysis

```
wine.df <- read.csv("Wine.csv")
head(wine.df[,-1])
```

	Alcohol <dbl>	Malic_Acid <dbl>	Ash <dbl>	Ash_Alcalinity <dbl>	Magnesium <int>	Total_Phenols <dbl>
1	14.23	1.71	2.43	15.6	127	2.80
2	13.20	1.78	2.14	11.2	100	2.65
3	13.16	2.36	2.67	18.6	101	2.80
4	14.37	1.95	2.50	16.8	113	3.85
5	13.24	2.59	2.87	21.0	118	2.80
6	14.20	1.76	2.45	15.2	112	3.27

6 rows | 1-7 of 14 columns

```
str(wine.df[,-1])
```

```
## 'data.frame':    178 obs. of  13 variables:
##  $ Alcohol             : num  14.2 13.2 13.2 14.4 13.2 ...
##  $ Malic_Acid          : num  1.71 1.78 2.36 1.95 2.59 1.76 1.87 2.15 1.64 1.35 ...
##  $ Ash                 : num  2.43 2.14 2.67 2.5 2.87 2.45 2.45 2.61 2.17 2.27 ...
##  $ Ash_Alcalinity      : num  15.6 11.2 18.6 16.8 21 15.2 14.6 17.6 14 16 ...
##  $ Magnesium           : int  127 100 101 113 118 112 96 121 97 98 ...
##  $ Total_Phenols       : num  2.8 2.65 2.8 3.85 2.8 3.27 2.5 2.6 2.8 2.98 ...
##  $ Flavanoids          : num  3.06 2.76 3.24 3.49 2.69 3.39 2.52 2.51 2.98 3.15 ...
##  $ Nonflavanoid_Phenols: num  0.28 0.26 0.3 0.24 0.39 0.34 0.3 0.31 0.29 0.22 ...
##  $ Proanthocyanins     : num  2.29 1.28 2.81 2.18 1.82 1.97 1.98 1.25 1.98 1.85 ...
##  $ Color_Intensity     : num  5.64 4.38 5.68 7.8 4.32 6.75 5.25 5.05 5.2 7.22 ...
##  $ Hue                 : num  1.04 1.05 1.03 0.86 1.04 1.05 1.02 1.06 1.08 1.01 ...
##  $ OD280_OD315         : num  3.92 3.4 3.17 3.45 2.93 2.85 3.58 3.58 2.85 3.55 ...
##  $ Proline             : int  1065 1050 1185 1480 735 1450 1290 1295 1045 1045 ...
```

```
pcs.cor <-prcomp(wine.df[,-1])
summary(pcs.cor)
```

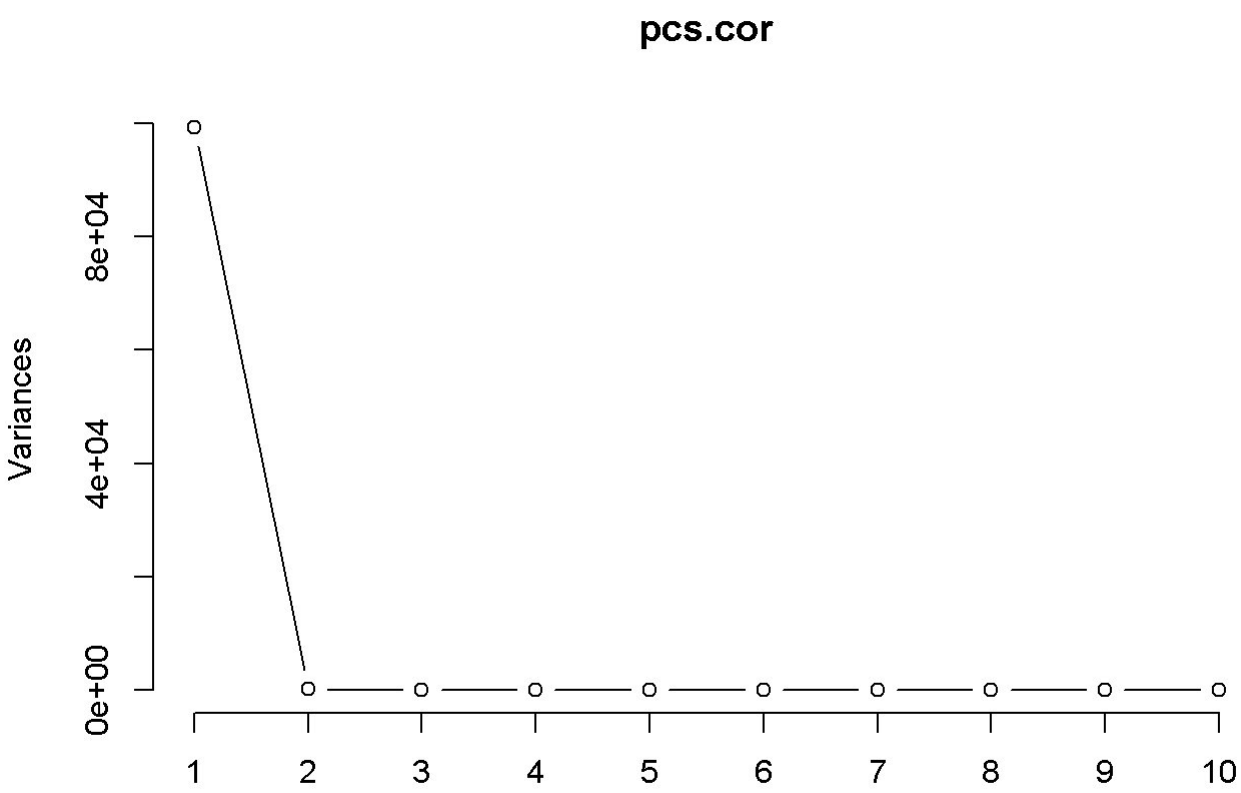
```
## Importance of components:
##                             PC1      PC2     PC3     PC4     PC5     PC6    PC7
## Standard deviation     314.9632 13.13527 3.07215 2.23409 1.10853 0.91710 0.5282
## Proportion of Variance   0.9981  0.00174 0.00009 0.00005 0.00001 0.00001 0.0000
## Cumulative Proportion    0.9981  0.99983 0.99992 0.99997 0.99998 0.99999 1.0000
##                            PC8    PC9   PC10   PC11   PC12    PC13
## Standard deviation     0.3891 0.3348 0.2678 0.1938 0.1452 0.09057
## Proportion of Variance 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000
## Cumulative Proportion  1.0000 1.0000 1.0000 1.0000 1.0000 1.00000
```

```
print(pcs.cor)
```

```
## Standard deviations (1, .., p=13):
##  [1] 314.9631558  13.1352680   3.0721513   2.2340946   1.1085329   0.9170953
##  [7]   0.5281794   0.3890775   0.3348085   0.2677734   0.1938452   0.1451632
## [13]   0.0905743
##
## Rotation (n x k) = (13 x 13):
##                                PC1           PC2          PC3           PC4
## Alcohol              -0.0016592647 -1.203406e-03 -0.016873809  0.141446778
## Malic_Acid            0.0006810156 -2.154982e-03 -0.122003373  0.160389543
## Ash                  -0.0001949057 -4.593693e-03 -0.051987430 -0.009772810
## Ash_Alcalinity        0.0046713006 -2.645039e-02 -0.938593003 -0.330965260
## Magnesium            -0.0178680075 -9.993442e-01  0.029780248 -0.005393756
## Total_Phenols        -0.0009898297 -8.779622e-04  0.040484644 -0.074584656
## Flavanoids           -0.0015672883  5.185073e-05  0.085443339 -0.169086724
## Nonflavanoid_Phenols  0.0001230867  1.354479e-03 -0.013510780  0.010805561
## Proanthocyanins      -0.0006006078 -5.004400e-03  0.024659382 -0.050120952
## Color_Intensity      -0.0023271432 -1.510035e-02 -0.291398464  0.878893693
## Hue                  -0.0001713800  7.626731e-04  0.025977662 -0.060034945
## OD280_OD315          -0.0007049316  3.495364e-03  0.070323969 -0.178200254
## Proline              -0.9998229365  1.777381e-02 -0.004528682 -0.003112916
##                                PC5           PC6          PC7           PC8
## Alcohol               0.020336977 -0.194120104  0.923280337 -2.848207e-01
## Malic_Acid           -0.612883454 -0.742472963 -0.150109941  6.467447e-02
## Ash                   0.020175575 -0.041752912  0.045009549  1.493395e-01
## Ash_Alcalinity        0.064352340  0.024065303  0.031526583 -1.515391e-02
## Magnesium            -0.006149345  0.001923782  0.001797363  3.552212e-03
## Total_Phenols         0.315245063 -0.278716809 -0.020185710  1.772379e-01
## Flavanoids            0.524761088 -0.433597955 -0.038868518  2.481166e-01
## Nonflavanoid_Phenols -0.029647512  0.021952834 -0.004665483 -6.497968e-03
## Proanthocyanins       0.251182529 -0.241884488 -0.309799487 -8.704332e-01
## Color_Intensity       0.331747051 -0.002739609 -0.112836514  8.128692e-02
## Hue                   0.051524077  0.023776167  0.030819813  2.951904e-03
## OD280_OD315           0.260639176 -0.288912753  0.101973518  1.867145e-01
## Proline              -0.002298569  0.001212255 -0.001076189 -1.034095e-05
##                                PC9           PC10          PC11           PC12
## Alcohol              -8.660061e-02  2.245000e-03 -0.0149715080 -1.565141e-02
## Malic_Acid           -1.566214e-02  1.850935e-02 -0.0231876506  6.729555e-02
## Ash                  -7.364985e-02  8.679965e-02  0.9540106426 -1.320630e-01
## Ash_Alcalinity       -2.044578e-03 -3.554028e-03 -0.0528216953  5.393806e-03
## Magnesium             1.963668e-03  4.051542e-05 -0.0030248882  6.208885e-04
## Total_Phenols        -2.556729e-01 -8.471951e-01  0.0088016070  3.882903e-03
## Flavanoids           -3.783067e-01  5.201384e-01 -0.1332046120 -3.748803e-02
## Nonflavanoid_Phenols -3.675204e-02 -3.771319e-02  0.1991789841  1.475524e-01
## Proanthocyanins       5.152017e-02 -9.722752e-03  0.1356214601 -1.311883e-02
## Color_Intensity       9.902908e-02  2.314712e-02 -0.0098196717  5.035557e-02
## Hue                  -3.306512e-02  3.846983e-02  0.0975106606  9.755619e-01
## OD280_OD315           8.737465e-01 -1.701708e-02  0.0284851062  1.163025e-02
## Proline               7.255852e-05 -4.926638e-05 -0.0002404522 -9.999951e-05
##                               PC13
## Alcohol               8.029245e-03
## Malic_Acid           -1.109039e-02
## Ash                  -1.736857e-01
```

```
## Ash_Alcalinity        1.939563e-03
## Magnesium             2.284536e-03
## Total_Phenols        -2.669144e-02
## Flavanoids            6.959853e-02
## Nonflavanoid_Phenols  9.664662e-01
## Proanthocyanins      -1.760357e-02
## Color_Intensity      -4.632943e-03
## Hue                  -1.665508e-01
## OD280_OD315           4.419224e-02
## Proline               3.626701e-05
```

```
plot(pcs.cor,type="l")
```

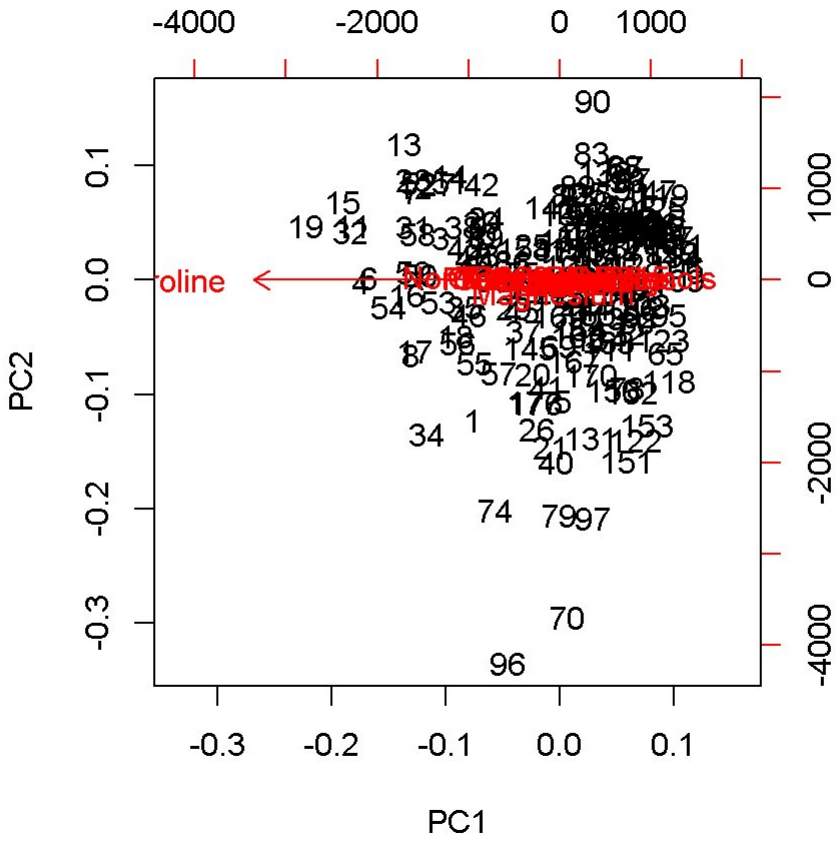



```
biplot(pcs.cor)
```

```
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped

## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped
```




```
pcs <- prcomp(data.frame(wine.df[,-1]$Alcohol,wine.df[,-1]$Magnesium))
summary(pcs)
```

```
## Importance of components:
##                             PC1     PC2
## Standard deviation     14.284 0.78140
## Proportion of Variance  0.997 0.00298
## Cumulative Proportion   0.997 1.00000
```

```
print(pcs)
```

```
## Standard deviations (1, .., p=2):
## [1] 14.2841804  0.7814007
##
## Rotation (n x k) = (2 x 2):
##                                 PC1         PC2
## wine.df....1..Alcohol    0.01543674  0.99988085
## wine.df....1..Magnesium 0.99988085 -0.01543674
```

```
pcs.cor_nor<- prcomp(na.omit(wine.df[,-1]),center=T,scale=T)
summary(pcs.cor_nor)
```

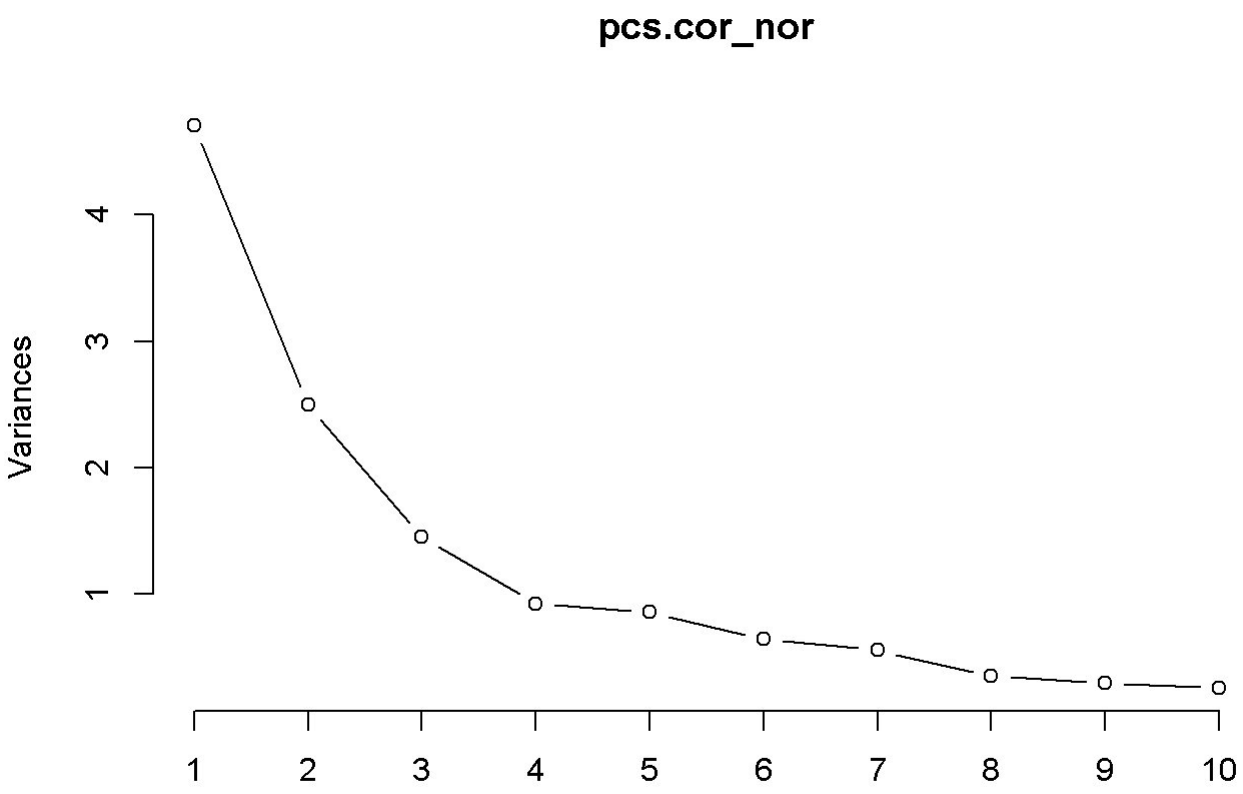
```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6     PC7
## Standard deviation     2.169 1.5802 1.2025 0.95863 0.92370 0.80103 0.74231
## Proportion of Variance 0.362 0.1921 0.1112 0.07069 0.06563 0.04936 0.04239
## Cumulative Proportion  0.362 0.5541 0.6653 0.73599 0.80162 0.85098 0.89337
##                           PC8     PC9   PC10    PC11    PC12    PC13
## Standard deviation     0.59034 0.53748 0.5009 0.47517 0.41082 0.32152
## Proportion of Variance 0.02681 0.02222 0.0193 0.01737 0.01298 0.00795
## Cumulative Proportion  0.92018 0.94240 0.9617 0.97907 0.99205 1.00000
```

```
print(pcs.cor_nor)
```

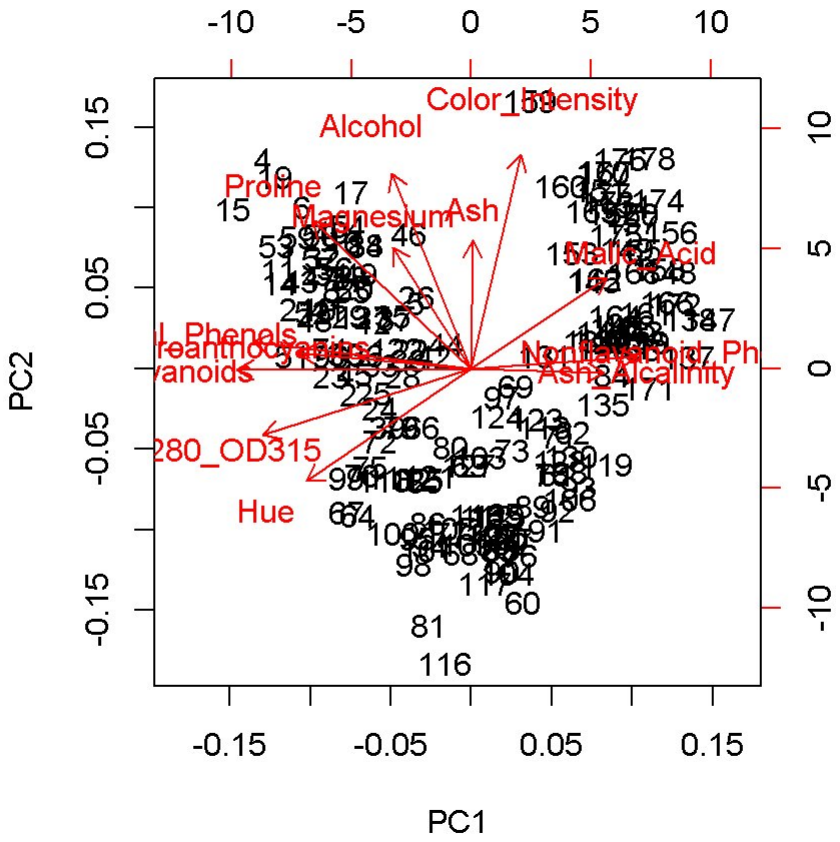
```
## Standard deviations (1, .., p=13):
##  [1] 2.1692972 1.5801816 1.2025273 0.9586313 0.9237035 0.8010350 0.7423128
##  [8] 0.5903367 0.5374755 0.5009017 0.4751722 0.4108165 0.3215244
##
## Rotation (n x k) = (13 x 13):
##                               PC1          PC2         PC3         PC4
## Alcohol              -0.144329395  0.483651548 -0.20738262  0.01785630
## Malic_Acid            0.245187580  0.224930935  0.08901289 -0.53689028
## Ash                   0.002051061  0.316068814  0.62622390  0.21417556
## Ash_Alcalinity        0.239320405 -0.010590502  0.61208035 -0.06085941
## Magnesium            -0.141992042  0.299634003  0.13075693  0.35179658
## Total_Phenols        -0.394660845  0.065039512  0.14617896 -0.19806835
## Flavanoids           -0.422934297 -0.003359812  0.15068190 -0.15229479
## Nonflavanoid_Phenols  0.298533103  0.028779488  0.17036816  0.20330102
## Proanthocyanins      -0.313429488  0.039301722  0.14945431 -0.39905653
## Color_Intensity       0.088616705  0.529995672 -0.13730621 -0.06592568
## Hue                  -0.296714564 -0.279235148  0.08522192  0.42777141
## OD280_OD315          -0.376167411 -0.164496193  0.16600459 -0.18412074
## Proline              -0.286752227  0.364902832 -0.12674592  0.23207086
##                               PC5         PC6         PC7         PC8
## Alcohol              -0.26566365  0.21353865 -0.05639636  0.39613926
## Malic_Acid            0.03521363  0.53681385  0.42052391  0.06582674
## Ash                  -0.14302547  0.15447466 -0.14917061 -0.17026002
## Ash_Alcalinity        0.06610294 -0.10082451 -0.28696914  0.42797018
## Magnesium             0.72704851  0.03814394  0.32288330 -0.15636143
## Total_Phenols        -0.14931841 -0.08412230 -0.02792498 -0.40593409
## Flavanoids           -0.10902584 -0.01892002 -0.06068521 -0.18724536
## Nonflavanoid_Phenols -0.50070298 -0.25859401  0.59544729 -0.23328465
## Proanthocyanins       0.13685982 -0.53379539  0.37213935  0.36822675
## Color_Intensity      -0.07643678 -0.41864414 -0.22771214 -0.03379692
## Hue                  -0.17361452  0.10598274  0.23207564  0.43662362
## OD280_OD315          -0.10116099  0.26585107 -0.04476370 -0.07810789
## Proline              -0.15786880  0.11972557  0.07680450  0.12002267
##                               PC9        PC10        PC11        PC12
## Alcohol              -0.50861912  0.21160473  0.22591696 -0.26628645
## Malic_Acid            0.07528304 -0.30907994 -0.07648554  0.12169604
## Ash                   0.30769445 -0.02712539  0.49869142 -0.04962237
## Ash_Alcalinity       -0.20044931  0.05279942 -0.47931378 -0.05574287
## Magnesium            -0.27140257  0.06787022 -0.07128891  0.06222011
## Total_Phenols        -0.28603452 -0.32013135 -0.30434119 -0.30388245
## Flavanoids           -0.04957849 -0.16315051  0.02569409 -0.04289883
## Nonflavanoid_Phenols -0.19550132  0.21553507 -0.11689586  0.04235219
## Proanthocyanins       0.20914487  0.13418390  0.23736257 -0.09555303
## Color_Intensity      -0.05621752 -0.29077518 -0.03183880  0.60422163
## Hue                  -0.08582839 -0.52239889  0.04821201  0.25921400
## OD280_OD315          -0.13722690  0.52370587 -0.04642330  0.60095872
## Proline               0.57578611  0.16211600 -0.53926983 -0.07940162
##                              PC13
## Alcohol               0.01496997
## Malic_Acid            0.02596375
## Ash                  -0.14121803
## Ash_Alcalinity        0.09168285
```

```
## Magnesium             0.05677422
## Total_Phenols        -0.46390791
## Flavanoids            0.83225706
## Nonflavanoid_Phenols  0.11403985
## Proanthocyanins      -0.11691707
## Color_Intensity      -0.01199280
## Hue                  -0.08988884
## OD280_OD315          -0.15671813
## Proline               0.01444734
```

```
plot(pcs.cor_nor,type="l")
```




```
biplot(pcs.cor_nor)
```


Color_Intensity
Alcohol
Proline
Magnesium
Ash
Malic_Acid
Alcalinity
Hue
-10
-5
0
5
10
0.15
0.05
-0.05
-0.15
PC1
PC2