```
In [1]:    # Importing libraries

           from __future__ import print_function
           import pandas as pd
           import numpy as np
           import matplotlib.pyplot as plt
           import seaborn as sns
           from sklearn.metrics import classification_report
           from sklearn import metrics
           from sklearn import tree
           import warnings
           warnings.filterwarnings('ignore')
```

```
In [2]:    df = pd.read_csv('../Data-processed/crop-recommendation.csv')
```

```
In [3]:    df.head()
```

Out[3]:

	N	P	K	temperature	humidity	ph	rainfall	label
0	90	42	43	20.879744	82.002744	6.502985	202.935536	rice
1	85	58	41	21.770462	80.319644	7.038096	226.655537	rice
2	60	55	44	23.004459	82.320763	7.840207	263.964248	rice
3	74	35	40	26.491096	80.158363	6.980401	242.864034	rice
4	78	42	42	20.130175	81.604873	7.628473	262.717340	rice

```
In [4]:    df.tail()
```

Out[4]:

	N	P	K	temperature	humidity	ph	rainfall	label
2195	107	34	32	26.774637	66.413269	6.780064	177.774507	coffee
2196	99	15	27	27.417112	56.636362	6.086922	127.924610	coffee
2197	118	33	30	24.131797	67.225123	6.362608	173.322839	coffee
2198	117	32	34	26.272418	52.127394	6.758793	127.175293	coffee
2199	104	18	30	23.603016	60.396475	6.779833	140.937041	coffee

```
In [5]:    df.size
```

Out[5]: 17600

```
In [6]:    df.shape
```

Out[6]: (2200, 8)

```
In [7]:    df.columns
```

Out[7]: Index(['N', 'P', 'K', 'temperature', 'humidity', 'ph', 'rainfall', 'label'], dtype='objec
         t')

```
In [8]:    df['label'].unique()
```

Out[8]:   array(['rice', 'maize', 'chickpea', 'kidneybeans', 'pigeonpeas',
                  'mothbeans', 'mungbean', 'blackgram', 'lentil', 'pomegranate',
                  'banana', 'mango', 'grapes', 'watermelon', 'muskmelon', 'apple',
                  'orange', 'papaya', 'coconut', 'cotton', 'jute', 'coffee'],
                 dtype=object)

```
In [9]:    df.dtypes
```

Out[9]:   N   int64
   P   int64
           K   int64
           temperature   float64
           humidity   float64
           ph   float64
           rainfall   float64
           label   object
           dtype: object

```
In [10]:   df['label'].value_counts()
```
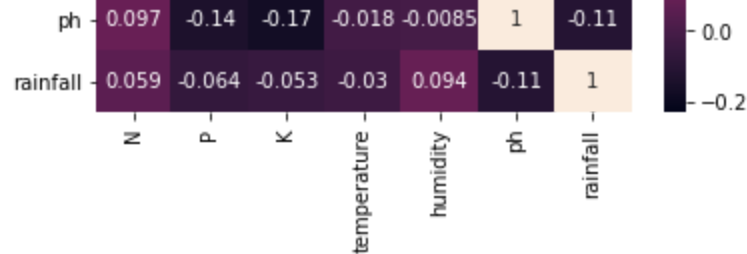
Out[10]:   muskmelon   100
           kidneybeans   100
           papaya   100
           pigeonpeas   100
           blackgram   100
           cotton   100
           mothbeans   100
           mungbean   100
           watermelon   100
           orange   100
           mango   100
           banana   100
           rice   100
           pomegranate   100
           chickpea   100
           apple   100
           jute   100
           grapes   100
           lentil   100
           coffee   100
           maize   100
           coconut   100
           Name: label, dtype: int64

```
In [11]:   sns.heatmap(df.corr(),annot=True)
```

Out[11]:
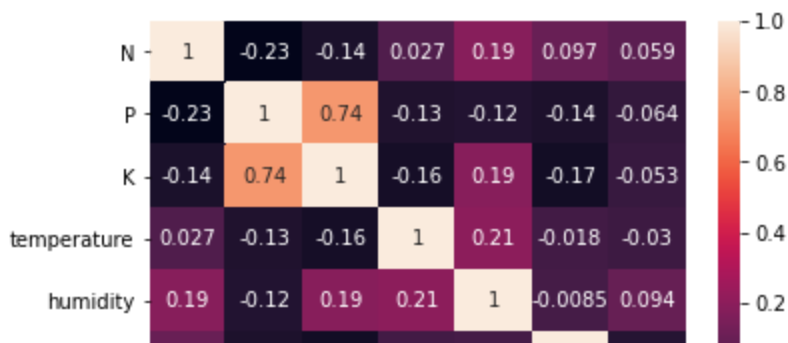
Seperating features and target label

In [12]:
```python
features = df[['N', 'P','K','temperature', 'humidity', 'ph', 'rainfall']]
target = df['label']
#features = df[['temperature', 'humidity', 'ph', 'rainfall']]
labels = df['label']
```

In [13]:
```python
# Initialzing empty lists to append all model's name and corresponding name
acc = []
model = []
```

In [14]:
```python
# Splitting into train and test data

from sklearn.model_selection import train_test_split
Xtrain, Xtest, Ytrain, Ytest = train_test_split(features,target,test_size = 0.2,random_sta
```

Decision Tree

In [15]:
```python
from sklearn.tree import DecisionTreeClassifier

DecisionTree = DecisionTreeClassifier(criterion="entropy",random_state=2,max_depth=5)

DecisionTree.fit(Xtrain,Ytrain)

predicted_values = DecisionTree.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Decision Tree')
print("DecisionTrees's Accuracy is: ", x*100)

print(classification_report(Ytest,predicted_values))
```

```
DecisionTrees's Accuracy is:  90.0
              precision    recall  f1-score   support

       apple       1.00      1.00      1.00        13
      banana       1.00      1.00      1.00        17
   blackgram       0.59      1.00      0.74        16
    chickpea       1.00      1.00      1.00        21
     coconut       0.91      1.00      0.95        21
      coffee       1.00      1.00      1.00        22
      cotton       1.00      1.00      1.00        20
      grapes       1.00      1.00      1.00        18
        jute       0.74      0.93      0.83        28
  kidneybeans       0.00      0.00      0.00        14
      lentil       0.68      1.00      0.81        23
       maize       1.00      1.00      1.00        21
       mango       1.00      1.00      1.00        26
```

mothbeans	0.00	0.00	0.00	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	0.84	0.91	19
pigeonpeas	0.62	1.00	0.77	18
pomegranate	1.00	1.00	1.00	17
rice	1.00	0.62	0.77	16
watermelon	1.00	1.00	1.00	15
accuracy			0.90	440
macro avg	0.84	0.88	0.85	440
weighted avg	0.86	0.90	0.87	440

In [16]:
```python
from sklearn.model_selection import cross_val_score
```

In [17]:
```python
# Cross validation score (Decision Tree)
score = cross_val_score(DecisionTree, features, target,cv=5)
```

In [18]:
```python
score
```

Out[18]: `array([0.93636364, 0.90909091, 0.91818182, 0.87045455, 0.93636364])`

Saving trained Decision Tree model

In [19]:
```python
import pickle
# Dump the trained Naive Bayes classifier with Pickle
DT_pkl_filename = '../models/DecisionTree.pkl'
# Open the file to save as pkl file
DT_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(DecisionTree, DT_Model_pkl)
# Close the pickle instances
DT_Model_pkl.close()
```

Guassian Naive Bayes

In [20]:
```python
from sklearn.naive_bayes import GaussianNB

NaiveBayes = GaussianNB()

NaiveBayes.fit(Xtrain,Ytrain)

predicted_values = NaiveBayes.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Naive Bayes')
print("Naive Bayes's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

Naive Bayes's Accuracy is: 0.990909090909091

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13

```
          banana          1.00      1.00      1.00        17
       blackgram          1.00      1.00      1.00        16
        chickpea          1.00      1.00      1.00        21
         coconut          1.00      1.00      1.00        21
          coffee          1.00      1.00      1.00        22
          cotton          1.00      1.00      1.00        20
          grapes          1.00      1.00      1.00        18
            jute          0.88      1.00      0.93        28
      kidneybeans         1.00      1.00      1.00        14
          lentil          1.00      1.00      1.00        23
           maize          1.00      1.00      1.00        21
           mango          1.00      1.00      1.00        26
        mothbeans         1.00      1.00      1.00        19
         mungbean         1.00      1.00      1.00        24
        muskmelon         1.00      1.00      1.00        23
          orange          1.00      1.00      1.00        29
          papaya          1.00      1.00      1.00        19
       pigeonpeas         1.00      1.00      1.00        18
      pomegranate         1.00      1.00      1.00        17
            rice          1.00      0.75      0.86        16
       watermelon         1.00      1.00      1.00        15

        accuracy                              0.99       440
       macro avg          0.99      0.99      0.99       440
    weighted avg          0.99      0.99      0.99       440
```

In [21]:
```python
# Cross validation score (NaiveBayes)
score = cross_val_score(NaiveBayes,features,target,cv=5)
score
```

Out[21]: `array([0.99772727, 0.99545455, 0.99545455, 0.99545455, 0.99090909])`

Saving trained Guassian Naive Bayes model

In [23]:
```python
import pickle
# Dump the trained Naive Bayes classifier with Pickle
NB_pkl_filename = '../models/NBClassifier.pkl'
# Open the file to save as pkl file
NB_Model_pkl = open(NB_pkl_filename, 'wb')
pickle.dump(NaiveBayes, NB_Model_pkl)
# Close the pickle instances
NB_Model_pkl.close()
```

Support Vector Machine (SVM)

In [24]:
```python
from sklearn.svm import SVC
# data normalization with sklearn
from sklearn.preprocessing import MinMaxScaler
# fit scaler on training data
norm = MinMaxScaler().fit(Xtrain)
X_train_norm = norm.transform(Xtrain)
# transform testing dataabs
X_test_norm = norm.transform(Xtest)
SVM = SVC(kernel='poly', degree=3, C=1)
SVM.fit(X_train_norm,Ytrain)
predicted_values = SVM.predict(X_test_norm)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
```

```python
model.append('SVM')
print("SVM's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
SVM's Accuracy is:  0.9795454545454545
               precision    recall  f1-score   support

        apple       1.00      1.00      1.00        13
       banana       1.00      1.00      1.00        17
    blackgram       1.00      1.00      1.00        16
     chickpea       1.00      1.00      1.00        21
      coconut       1.00      1.00      1.00        21
       coffee       1.00      0.95      0.98        22
       cotton       0.95      1.00      0.98        20
       grapes       1.00      1.00      1.00        18
         jute       0.83      0.89      0.86        28
   kidneybeans       1.00      1.00      1.00        14
       lentil       1.00      1.00      1.00        23
        maize       1.00      0.95      0.98        21
        mango       1.00      1.00      1.00        26
     mothbeans       1.00      1.00      1.00        19
     mungbean       1.00      1.00      1.00        24
    muskmelon       1.00      1.00      1.00        23
       orange       1.00      1.00      1.00        29
       papaya       1.00      1.00      1.00        19
    pigeonpeas       1.00      1.00      1.00        18
  pomegranate       1.00      1.00      1.00        17
         rice       0.80      0.75      0.77        16
   watermelon       1.00      1.00      1.00        15

     accuracy                           0.98       440
    macro avg       0.98      0.98      0.98       440
 weighted avg       0.98      0.98      0.98       440
```

In [37]:
```python
# Cross validation score (SVM)
score = cross_val_score(SVM,features,target,cv=5)
score
```

Out[37]: array([0.97954545, 0.975   , 0.98863636, 0.98863636, 0.98181818])

In [27]:
```python
#Saving trained SVM model
```

In [28]:
```python
import pickle
# Dump the trained SVM classifier with Pickle
SVM_pkl_filename = '../models/SVMClassifier.pkl'
# Open the file to save as pkl file
SVM_Model_pkl = open(SVM_pkl_filename, 'wb')
pickle.dump(SVM, SVM_Model_pkl)
# Close the pickle instances
SVM_Model_pkl.close()
```

Logistic Regression

In [29]:
```python
from sklearn.linear_model import LogisticRegression

LogReg = LogisticRegression(random_state=2)
```

```
LogReg.fit(Xtrain,Ytrain)

predicted_values = LogReg.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Logistic Regression')
print("Logistic Regression's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
Logistic Regression's Accuracy is:  0.9522727272727273
              precision    recall  f1-score   support

       apple       1.00      1.00      1.00        13
      banana       1.00      1.00      1.00        17
   blackgram       0.86      0.75      0.80        16
    chickpea       1.00      1.00      1.00        21
     coconut       1.00      1.00      1.00        21
      coffee       1.00      1.00      1.00        22
      cotton       0.86      0.90      0.88        20
      grapes       1.00      1.00      1.00        18
        jute       0.84      0.93      0.88        28
  kidneybeans       1.00      1.00      1.00        14
      lentil       0.88      1.00      0.94        23
       maize       0.90      0.86      0.88        21
       mango       0.96      1.00      0.98        26
    mothbeans       0.84      0.84      0.84        19
    mungbean       1.00      0.96      0.98        24
   muskmelon       1.00      1.00      1.00        23
      orange       1.00      1.00      1.00        29
      papaya       1.00      0.95      0.97        19
   pigeonpeas       1.00      1.00      1.00        18
  pomegranate       1.00      1.00      1.00        17
        rice       0.85      0.69      0.76        16
  watermelon       1.00      1.00      1.00        15

    accuracy                           0.95       440
   macro avg       0.95      0.95      0.95       440
weighted avg       0.95      0.95      0.95       440
```

In [30]:
```
# Cross validation score (Logistic Regression)
score = cross_val_score(LogReg,features,target,cv=5)
score
```

Out[30]: array([0.95   , 0.96590909, 0.94772727, 0.96590909, 0.94318182])

Saving trained Logistic Regression model

In [35]:
```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
LR_pkl_filename = '../models/LogisticRegression.pkl'
# Open the file to save as pkl file
LR_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(LogReg, LR_Model_pkl)
# Close the pickle instances
LR_Model_pkl.close()
```

Random Forest

In [36]:
```python
from sklearn.ensemble import RandomForestClassifier

RF = RandomForestClassifier(n_estimators=20, random_state=0)
RF.fit(Xtrain,Ytrain)

predicted_values = RF.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('RF')
print("RF's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
RF's Accuracy is:  0.990909090909091
              precision    recall  f1-score   support

       apple       1.00      1.00      1.00        13
      banana       1.00      1.00      1.00        17
   blackgram       0.94      1.00      0.97        16
    chickpea       1.00      1.00      1.00        21
     coconut       1.00      1.00      1.00        21
      coffee       1.00      1.00      1.00        22
      cotton       1.00      1.00      1.00        20
      grapes       1.00      1.00      1.00        18
        jute       0.90      1.00      0.95        28
  kidneybeans       1.00      1.00      1.00        14
      lentil       1.00      1.00      1.00        23
       maize       1.00      1.00      1.00        21
       mango       1.00      1.00      1.00        26
    mothbeans       1.00      0.95      0.97        19
    mungbean       1.00      1.00      1.00        24
   muskmelon       1.00      1.00      1.00        23
      orange       1.00      1.00      1.00        29
      papaya       1.00      1.00      1.00        19
  pigeonpeas       1.00      1.00      1.00        18
 pomegranate       1.00      1.00      1.00        17
        rice       1.00      0.81      0.90        16
  watermelon       1.00      1.00      1.00        15

    accuracy                           0.99       440
   macro avg       0.99      0.99      0.99       440
weighted avg       0.99      0.99      0.99       440
```

In [37]:
```python
# Cross validation score (Random Forest)
score = cross_val_score(RF,features,target,cv=5)
score
```

Out[37]: array([0.99772727, 0.99545455, 0.99772727, 0.99318182, 0.98863636])

Saving trained Random Forest model

In [38]:
```python
import pickle
# Dump the trained Naive Bayes classifier with Pickle
RF_pkl_filename = '../models/RandomForest.pkl'
# Open the file to save as pkl file
RF_Model_pkl = open(RF_pkl_filename, 'wb')
```

```
pickle.dump(RF, RF_Model_pkl)
# Close the pickle instances
RF_Model_pkl.close()
```

XGBoost

In [39]:
```
import xgboost as xgb
XB = xgb.XGBClassifier()
XB.fit(Xtrain,Ytrain)

predicted_values = XB.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('XGBoost')
print("XGBoost's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
[14:16:03] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.
XGBoost's Accuracy is:  0.9931818181818182
```

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	1.00	1.00	1.00	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	0.96	1.00	0.98	22
cotton	1.00	1.00	1.00	20
grapes	1.00	1.00	1.00	18
jute	1.00	0.93	0.96	28
kidneybeans	1.00	1.00	1.00	14
lentil	0.96	1.00	0.98	23
maize	1.00	1.00	1.00	21
mango	1.00	1.00	1.00	26
mothbeans	1.00	0.95	0.97	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	1.00	1.00	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	0.94	1.00	0.97	16
watermelon	1.00	1.00	1.00	15
accuracy			0.99	440
macro avg	0.99	0.99	0.99	440
weighted avg	0.99	0.99	0.99	440

In [46]:
```
# Cross validation score (XGBoost)
score = cross_val_score(XB,features,target,cv=5)
score
```

```
[08:54:44] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
```

ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.
[08:54:45] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.
[08:54:46] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.
[08:54:47] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.
[08:54:48] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.4.0/src/learn
er.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objecti
ve 'multi:softprob' was changed from 'merror' to 'mlogloss'. Explicitly set eval_metric if
you'd like to restore the old behavior.

Out[46]: array([0.99318182, 0.99318182, 0.99318182, 0.99090909, 0.99090909])

Saving trained XGBoost model

In [40]:
```python
import pickle
# Dump the trained Naive Bayes classifier with Pickle
XB_pkl_filename = '../models/XGBoost.pkl'
# Open the file to save as pkl file
XB_Model_pkl = open(XB_pkl_filename, 'wb')
pickle.dump(XB, XB_Model_pkl)
# Close the pickle instances
XB_Model_pkl.close()
```

Accuracy Comparison

In [41]:
```python
plt.figure(figsize=[10,5],dpi = 100)
plt.title('Accuracy Comparison')
plt.xlabel('Accuracy')
plt.ylabel('Algorithm')
sns.barplot(x = acc,y = model,palette='dark')
```

Out[41]:
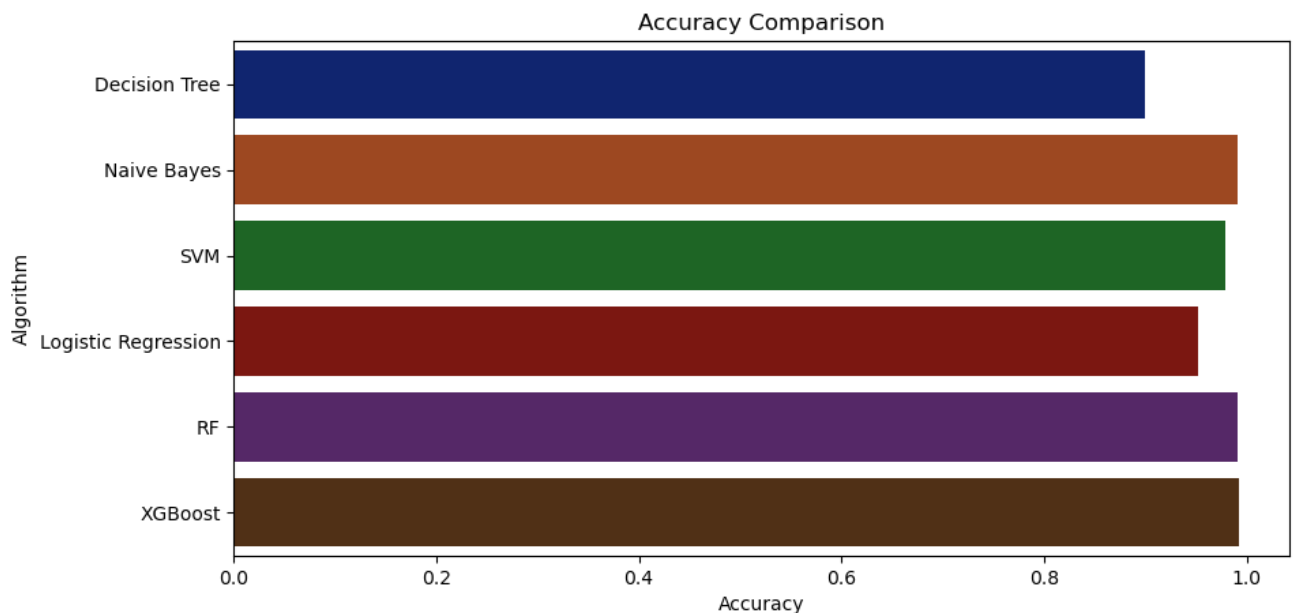
In [42]:
```python
accuracy_models = dict(zip(model, acc))
for k, v in accuracy_models.items():
    print (k, '-->', v)
```

```
Decision Tree --> 0.9
Naive Bayes --> 0.990909090909091
SVM --> 0.9795454545454545
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
XGBoost --> 0.9931818181818182
```

Making a prediction

In [43]:
```python
data = np.array([[104,18, 30, 23.603016, 60.3, 6.7, 140.91]])
prediction = RF.predict(data)
print(prediction)
```

```
['coffee']
```

In [44]:
```python
data = np.array([[83, 45, 60, 28, 70.3, 7.0, 150.9]])
prediction = RF.predict(data)
print(prediction)
```

```
['jute']
```