```
# 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

	N	P	K	temperature	humidity	ph	rainfall	label
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='object')
```

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]:

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

In [13]:

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

In [14]:

```
# 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_state =2)
```

Decision Tree

In [15]:

```
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]:

```
from sklearn.model_selection import cross_val_score
```

In [17]:

```
# Cross validation score (Decision Tree)
score = cross_val_score(DecisionTree, features, target,cv=5)
```

In [18]:

```
score
```

Out[18]:

```
array([0.93636364, 0.90909091, 0.91818182, 0.87045455, 0.93636364])
```

Saving trained Decision Tree model

In [19]:

```
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]:

```
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]:

```
# 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]:

```
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]:

```
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)
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]:

```
# 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]:

```
#Saving trained SVM model
```

In [28]:

```
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]:

```
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]:

```
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]:

```
# 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]:

```
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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation
metric used with the objective '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]:

```
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]:

```
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]:

```
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]:

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

```
['coffee']
```

In [44]:

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

```
['jute']
```