

```

import pandas as pd
import numpy as np
from sklearn.preprocessing import LabelEncoder, StandardScaler
from sklearn import model_selection
from sklearn.model_selection import train_test_split
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import export_graphviz
from sklearn.metrics import confusion_matrix
import pydotplus
from sklearn.metrics import accuracy_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LinearRegression
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
import xgboost as xgb
from sklearn.model_selection import GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers

```

```

dataset1 = pd.read_csv("Crop_recommendation.csv")
dataset2 = pd.read_csv("Fertilizer Prediction.csv")
dataset3 = pd.read_csv("crop_production.csv")
dataset4 = pd.read_csv("state_wise_crop_production.csv")

```

```
print(dataset1)
```

	N	P	K	ph	label
0	24	128	196	5.521467	apple
1	7	144	197	6.133221	apple
2	14	128	205	6.226290	apple
3	8	120	201	6.321152	apple
4	20	129	201	5.587906	apple
...
2195	97	12	47	6.765095	watermelon
2196	110	7	45	6.189214	watermelon
2197	96	18	50	6.904242	watermelon
2198	83	23	55	6.463271	watermelon
2199	120	24	47	6.260839	watermelon

```
[2200 rows x 5 columns]
```

```
print(dataset2)
```

	Soil Type	Crop Type	Nitrogen	Potassium	Phosphorous	Fertilizer
Name						
0	Sandy	Maize	37	0	0	
Urea						

1	Loamy	Sugarcane	12	0	36	
DAP						
2	Black	Cotton	7	9	30	14-
35-14						
3	Red	Tobacco	22	0	20	
28-28						
4	Clayey	Paddy	35	0	0	
Urea						
...	
...						
94	Clayey	Pulses	24	0	19	
28-28						
95	Red	Tobacco	4	17	17	
10/26/2026						
96	Loamy	Wheat	39	0	0	
Urea						
97	Sandy	Millet	15	0	41	
DAP						
98	Black	Sugarcane	12	0	10	
20-20						

[99 rows x 6 columns]

```
print(dataset3)
```

	State_Name	District_Name	Crop_Year	Season	Crop Type
\					
0	Andhra Pradesh	ANANTAPUR	2014	Kharif	Arhar/Tur
1	Andhra Pradesh	ANANTAPUR	2014	Kharif	Bajra
2	Andhra Pradesh	ANANTAPUR	2014	Kharif	Brinjal
3	Andhra Pradesh	ANANTAPUR	2014	Kharif	Cabbage
4	Andhra Pradesh	ANANTAPUR	2014	Kharif	Cashewnut
...
10968	West Bengal	PURULIA	2014	Summer	Rice
10969	West Bengal	PURULIA	2014	Summer	Sesamum
10970	West Bengal	PURULIA	2014	Whole Year	Sugarcane
10971	West Bengal	PURULIA	2014	Winter	Rice
10972	West Bengal	PURULIA	2014	Winter	Sesamum

	Area	Production
0	37562.0	4845.0
1	1752.0	1028.0
2	320.0	7596.0
3	10.0	123.0
4	19.0	7.0
...
10968	306.0	801.0
10969	627.0	463.0
10970	324.0	16250.0
10971	279151.0	597899.0
10972	175.0	88.0

[10973 rows x 7 columns]

`print(dataset4)`

	Crop	State \
0	ARHAR	Uttar Pradesh
1	ARHAR	Karnataka
2	ARHAR	Gujarat
3	ARHAR	Andhra Pradesh
4	ARHAR	Maharashtra
5	COTTON	Maharashtra
6	COTTON	Punjab
7	COTTON	Andhra Pradesh
8	COTTON	Gujarat
9	COTTON	Haryana
10	GRAM	Rajasthan
11	GRAM	Madhya Pradesh
12	GRAM	Uttar Pradesh
13	GRAM	Maharashtra
14	GRAM	Andhra Pradesh
15	GROUNDNUT	Karnataka
16	GROUNDNUT	Andhra Pradesh
17	GROUNDNUT	Tamil Nadu
18	GROUNDNUT	Gujarat
19	GROUNDNUT	Maharashtra
20	MAIZE	Bihar
21	MAIZE	Karnataka
22	MAIZE	Rajasthan
23	MAIZE	Uttar Pradesh
24	MAIZE	Andhra Pradesh
25	MOONG	Orissa
26	MOONG	Rajasthan
27	MOONG	Karnataka
28	MOONG	Andhra Pradesh
29	MOONG	Maharashtra
30	PADDY	Uttar Pradesh

31	PADDY	Orissa
32	PADDY	West Bengal
33	PADDY	Punjab
34	PADDY	Andhra Pradesh
35	RAPESEED AND MUSTARD	Madhya Pradesh
36	RAPESEED AND MUSTARD	Rajasthan
37	RAPESEED AND MUSTARD	Uttar Pradesh
38	RAPESEED AND MUSTARD	Gujarat
39	RAPESEED AND MUSTARD	Haryana
40	SUGARCANE	Uttar Pradesh
41	SUGARCANE	Karnataka
42	SUGARCANE	Andhra Pradesh
43	SUGARCANE	Maharashtra
44	SUGARCANE	Tamil Nadu
45	WHEAT	Madhya Pradesh
46	WHEAT	Punjab
47	WHEAT	Uttar Pradesh
48	WHEAT	Rajasthan

Cost of Cultivation (`/Hectare) C2 \	A2+FL	Cost of Cultivation
0		9794.05
23076.74		
1		10593.15
16528.68		
2		13468.82
19551.90		
3		17051.66
24171.65		
4		17130.55
25270.26		
5		23711.44
33116.82		
6		29047.10
50828.83		
7		29140.77
44756.72		
8		29616.09
42070.44		
9		29918.97
44018.18		
10		8552.69
12610.85		
11		9803.89
16873.17		
12		12833.04
21618.43		
13		12985.95
18679.33		
14		14421.98

26762.09	
15	13647.10
17314.20	
16	21229.01
30434.61	
17	22507.86
30393.66	
18	22951.28
30114.45	
19	26078.66
32683.46	
20	13513.92
19857.70	
21	13792.85
20671.54	
22	14421.46
19810.29	
23	15635.43
21045.11	
24	25687.09
37801.85	
25	5483.54
8266.98	
26	6204.23
9165.59	
27	6440.64
7868.64	
28	6684.18
13209.32	
29	10780.76
15371.45	
30	17022.00
28144.50	
31	17478.05
25909.05	
32	24731.06
33046.12	
33	25154.75
45291.24	
34	29664.84
46450.20	
35	8686.43
17705.93	
36	11385.70
19259.84	
37	12774.41
22560.30	
38	13740.64
19083.55	
39	14715.27

27507.54	
40	24538.32
45239.51	
41	55655.44
86765.77	
42	56621.16
91442.63	
43	57673.60
85801.95	
44	66335.06
89025.27	
45	12464.40
22489.75	
46	17945.58
35423.48	
47	18979.38
31902.74	
48	19119.08
29876.36	

	Cost of Production (`/Quintal) C2	Yield (Quintal/ Hectare)
0	1941.55	9.83
1	2172.46	7.47
2	1898.30	9.59
3	3670.54	6.42
4	2775.80	8.72
5	2539.47	12.69
6	2003.76	24.39
7	2509.99	17.83
8	2179.26	19.05
9	2127.35	19.90
10	1691.66	6.83
11	1551.94	10.29
12	1882.68	10.93
13	2277.68	8.05
14	1559.04	16.69
15	3484.01	4.71
16	2554.91	11.97
17	2358.00	11.98
18	1918.92	13.45
19	3207.35	9.33
20	404.43	42.95
21	581.69	31.10
22	658.77	23.56
23	1387.36	13.70
24	840.58	42.68
25	2614.14	3.01
26	2068.67	4.05
27	5777.48	1.32
28	2228.97	5.90

29	2261.24	6.70
30	732.62	36.61
31	715.04	32.42
32	731.25	39.04
33	669.86	67.41
34	789.90	56.00
35	1279.60	12.94
36	1341.29	13.54
37	1595.56	13.57
38	1610.40	11.61
39	1251.12	19.94
40	93.64	448.89
41	86.53	986.21
42	119.72	757.92
43	107.56	744.01
44	85.79	1015.45
45	810.25	23.59
46	804.80	39.83
47	769.84	34.99
48	683.58	37.19

```
print(dataset1.shape)
```

```
(2200, 5)
```

```
print(dataset2.shape)
```

```
(99, 6)
```

```
print(dataset3.shape)
```

```
(10973, 7)
```

```
print(dataset4.shape)
```

```
(49, 6)
```

```
df1 = pd.DataFrame(dataset1)
```

```
print(df1.describe())
```

	N	P	K	ph
count	2200.000000	2200.000000	2200.000000	2200.000000
mean	50.551818	53.362727	48.149091	6.469480
std	36.917334	32.985883	50.647931	0.773938
min	0.000000	5.000000	5.000000	3.504752
25%	21.000000	28.000000	20.000000	5.971693
50%	37.000000	51.000000	32.000000	6.425045
75%	84.250000	68.000000	49.000000	6.923643
max	140.000000	145.000000	205.000000	9.935091

```
df2 = pd.DataFrame(dataset2)
```

```
print(df2.describe())
```

	Nitrogen	Potassium	Phosphorous
count	99.000000	99.000000	99.000000
mean	18.909091	3.383838	18.606061
std	11.599693	5.814667	13.476978
min	4.000000	0.000000	0.000000
25%	10.000000	0.000000	9.000000
50%	13.000000	0.000000	19.000000
75%	24.000000	7.500000	30.000000
max	42.000000	19.000000	42.000000

```
df3 = pd.DataFrame(dataset3)
print(df3.describe())
```

	Crop_Year	Area	Production
count	10973.0	10973.000000	1.081500e+04
mean	2014.0	10549.306622	8.011596e+05
std	0.0	34980.189100	2.164016e+07
min	2014.0	0.070000	0.000000e+00
25%	2014.0	65.000000	8.000000e+01
50%	2014.0	425.000000	6.730000e+02
75%	2014.0	3227.000000	6.204500e+03
max	2014.0	622800.000000	1.001000e+09

```
df4 = pd.DataFrame(dataset4)
print(df4.describe())
```

	Cost of Cultivation (`/Hectare) A2+FL \
count	49.000000
mean	20363.537347
std	13561.435306
min	5483.540000
25%	12774.410000
50%	17022.000000
75%	24731.060000
max	66335.060000

	Cost of Cultivation (`/Hectare) C2 \	Cost of Production (`/Quintal) C2 \
count	49.000000	49.000000
49.000000		
mean	31364.666735	1620.537755
std	20095.783569	1104.990472
min	7868.640000	85.790000
25%	19259.840000	732.620000
50%	25909.050000	1595.560000
75%	35423.480000	


```
2228.970000
max          91442.630000
5777.480000
```

```
      Yield (Quintal/ Hectare)
count          49.000000
mean          98.086735
std          245.293123
min           1.320000
25%           9.590000
50%          13.700000
75%          36.610000
max         1015.450000
```

```
def preprocess_data(data):
    num_cols = data.select_dtypes(include=['float64',
'int64']).columns
    data[num_cols] = data[num_cols].fillna(data[num_cols].median())
    cat_cols = data.select_dtypes(include=['object']).columns
    data[cat_cols] =
data[cat_cols].fillna(data[cat_cols].mode().iloc[0])

    for col in cat_cols:
        encoder = LabelEncoder()
        data[col] = encoder.fit_transform(data[col])

    for col in num_cols:
        q1 = data[col].quantile(0.25)
        q3 = data[col].quantile(0.75)
        iqr = q3 - q1
        lower_cap = q1 - 1.5 * iqr
        upper_cap = q3 + 1.5 * iqr
        data[col] = np.clip(data[col], lower_cap, upper_cap)

    scaler = StandardScaler()
    data[num_cols] = scaler.fit_transform(data[num_cols])

    return data

preprocessed_dataset1 = preprocess_data(dataset1)
preprocessed_dataset1.to_csv('preprocessed_dataset1.csv', index=False)

preprocessed_dataset2 = preprocess_data(dataset2)
preprocessed_dataset2.to_csv('preprocessed_dataset2.csv', index=False)

preprocessed_dataset3 = preprocess_data(dataset3)
preprocessed_dataset3.to_csv('preprocessed_dataset3.csv', index=False)

preprocessed_dataset4 = preprocess_data(dataset4)
preprocessed_dataset4.to_csv('preprocessed_dataset4.csv', index=False)
```

```

dataset1_x = preprocessed_dataset1[['N', 'P', 'K', 'ph']].values
dataset2_x = preprocessed_dataset2[['Soil Type', 'Crop Type',
'Nitrogen', 'Potassium', 'Phosphorous']].values
dataset3_x = preprocessed_dataset3[['State_Name', 'District_Name',
'Season', 'Crop_Year']]
dataset4_x = preprocessed_dataset4[['Cost of Cultivation (`/Hectare)
C2', 'Cost of Production (`/Quintal) C2']].values

dataset1_y = preprocessed_dataset1[['label']]
dataset2_y = preprocessed_dataset2[['Fertilizer Name']]
dataset3_y = preprocessed_dataset3[['Crop Type']]
dataset4_y = preprocessed_dataset4[['Crop']]

```

```
print(dataset1_x)
```

```

[[-7.19387128e-01  2.39518735e+00  2.30755321e+00 -1.29120476e+00]
 [-1.17998011e+00  2.39518735e+00  2.30755321e+00 -4.53326713e-01]
 [-9.90324177e-01  2.39518735e+00  2.30755321e+00 -3.25856359e-01]
 ...
 [ 1.23135963e+00 -1.10576599e+00  4.95572013e-01  6.02689435e-01]
 [ 8.79141464e-01 -9.46631743e-01  7.08746272e-01 -1.27859434e-03]
 [ 1.88160855e+00 -9.14804895e-01  3.67667458e-01 -2.78536340e-01]]

```

```
print(dataset2_x)
```

```

[[ 4.          3.          1.56753938 -0.58540771 -1.38760694]
 [ 2.          8.         -0.59865825 -0.58540771  1.29720909]
 [ 0.          1.         -1.03189778  0.97392942  0.84973976]
 [ 3.          9.          0.2678208  -0.58540771  0.10395752]
 [ 1.          6.          1.39424356 -0.58540771 -1.38760694]
 [ 4.          0.         -0.59865825  1.1471891  -0.41809004]
 [ 3.          1.         -0.85860197 -0.58540771 -0.64182471]
 [ 2.         10.          1.914131  -0.58540771 -1.38760694]
 [ 4.          4.          0.18117289 -0.58540771 -0.04519892]
 [ 0.          5.         -0.85860197  0.62741006  0.84973976]
 [ 1.          7.         -0.51201035 -0.58540771  1.59552199]
 [ 4.          3.         -0.42536244  2.0134875  -0.49266826]
 [ 2.          1.          1.48089147 -0.58540771 -1.38760694]
 [ 1.          6.          0.44111661 -0.58540771  0.25311397]
 [ 3.          2.         -0.42536244 -0.58540771  1.67010021]
 [ 0.          8.         -0.77195406  1.66696814 -0.34351182]
 [ 1.          7.          1.65418728 -0.58540771 -1.38760694]
 [ 4.          0.          0.18117289 -0.58540771  0.0293793 ]
 [ 0.          1.          1.74083519 -0.58540771 -1.38760694]
 [ 2.         10.         -0.51201035 -0.58540771  1.29720909]
 [ 4.          4.         -0.77195406 -0.58540771 -0.71640293]
 [ 2.          8.         -0.59865825  1.84022782 -0.49266826]
 [ 3.          9.         -0.68530616 -0.58540771  1.37178732]
 [ 0.          4.          1.48089147 -0.58540771 -1.38760694]
 [ 1.          6.         -0.51201035 -0.58540771 -0.64182471]
 [ 4.          3.          0.3544687  -0.58540771  0.10395752]

```

[3.	1.	-0.85860197	0.97392942	0.77516153]
[2.	8.	1.65418728	-0.58540771	-1.38760694]
[0.	5.	-0.59865825	-0.58540771	1.52094376]
[1.	7.	-0.42536244	-0.58540771	-0.41809004]
[3.	2.	0.44111661	-0.58540771	0.32769219]
[2.	8.	-0.59865825	-0.58540771	1.59552199]
[1.	6.	1.74083519	-0.58540771	-1.38760694]
[4.	0.	-1.03189778	0.97392942	0.84973976]
[2.	10.	0.3544687	-0.58540771	0.0293793]
[0.	4.	1.914131	-0.58540771	-1.38760694]
[2.	1.	-0.94524987	1.1471891	0.92431798]
[1.	6.	-0.59865825	-0.58540771	1.67010021]
[3.	2.	-0.33871454	1.84022782	-0.56724649]
[4.	4.	-0.33871454	-0.58540771	1.37178732]
[1.	7.	-0.51201035	-0.58540771	-0.41809004]
[2.	8.	-0.77195406	0.62741006	0.9988962]
[3.	9.	0.2678208	-0.58540771	0.40227042]
[0.	8.	1.39424356	-0.58540771	-1.38760694]
[4.	0.	-0.77195406	-0.58540771	1.22263087]
[2.	10.	-0.94524987	0.80066974	0.70058331]
[0.	5.	-0.59865825	-0.58540771	-0.79098116]
[1.	6.	0.44111661	-0.58540771	-0.04519892]
[3.	2.	1.914131	-0.58540771	-1.38760694]
[4.	3.	-1.20519359	0.97392942	0.77516153]
[3.	9.	0.3544687	-0.58540771	0.17853575]
[0.	5.	-0.51201035	-0.58540771	-0.34351182]
[1.	7.	1.82748309	-0.58540771	-1.38760694]
[4.	0.	-0.59865825	-0.58540771	1.74467843]
[3.	1.	-0.68530616	1.49370846	-0.26893359]
[0.	4.	0.3544687	-0.58540771	0.40227042]
[2.	10.	1.65418728	-0.58540771	-1.38760694]
[4.	4.	-0.94524987	-0.58540771	-0.26893359]
[2.	8.	-0.68530616	1.66696814	-0.26893359]
[3.	2.	-0.33871454	-0.58540771	1.37178732]
[1.	6.	1.48089147	-0.58540771	-1.38760694]
[2.	10.	-0.51201035	-0.58540771	-0.71640293]
[0.	1.	0.44111661	-0.58540771	0.10395752]
[4.	0.	-1.20519359	2.53326654	-0.26893359]
[0.	5.	1.56753938	-0.58540771	-1.38760694]
[3.	1.	-0.33871454	-0.58540771	1.59552199]
[0.	8.	-0.85860197	-0.58540771	-0.41809004]
[2.	8.	-0.94524987	0.80066974	1.07347442]
[1.	7.	-1.11854568	2.6632113	-0.19435537]
[4.	4.	-0.77195406	-0.58540771	-0.34351182]
[1.	7.	0.18117289	-0.58540771	0.32769219]
[3.	9.	1.74083519	-0.58540771	-1.38760694]
[2.	10.	0.3544687	-0.58540771	0.0293793]
[0.	5.	2.0007789	-0.58540771	-1.38760694]
[3.	2.	-0.51201035	-0.58540771	1.52094376]
[1.	6.	-0.85860197	1.1471891	0.25311397]

```
[ 4.      3.      0.2678208 -0.58540771  0.17853575]
[ 2.      8.     -0.77195406 -0.58540771 -0.26893359]
[ 1.      7.     -1.03189778  2.18674718  0.10395752]
[ 3.      1.     -0.42536244 -0.58540771  1.44636554]
[ 1.      6.     -0.77195406  0.80066974  0.77516153]
[ 4.      4.      1.914131   -0.58540771 -1.38760694]
[ 0.      1.     -0.42536244 -0.58540771  1.22263087]
[ 2.      8.     -0.68530616 -0.58540771 -0.71640293]
[ 4.      0.      0.18117289 -0.58540771  0.70058331]
[ 1.      7.     -0.94524987  0.62741006  0.92431798]
[ 3.      9.     -0.51201035  2.36000686 -0.19435537]
[ 0.      4.      1.39424356 -0.58540771 -1.38760694]
[ 2.     10.     -0.59865825  2.53326654  0.0293793 ]
[ 2.      1.     -0.68530616 -0.58540771  1.44636554]
[ 0.      5.     -0.94524987  0.97392942  0.84973976]
[ 1.      6.     -1.11854568  2.6632113   0.17853575]
[ 3.      2.      1.914131   -0.58540771 -1.38760694]
[ 4.      3.     -0.85860197  1.1471891   0.84973976]
[ 1.      7.      0.44111661 -0.58540771  0.0293793 ]
[ 3.      9.     -1.29184149  2.36000686 -0.11977715]
[ 2.     10.      1.74083519 -0.58540771 -1.38760694]
[ 4.      4.     -0.33871454 -0.58540771  1.67010021]
[ 0.      8.     -0.59865825 -0.58540771 -0.64182471]]
```

```
print(dataset3_x)
```

	State_Name	District_Name	Season	Crop_Year
0	0	15	1	0.0
1	0	15	1	0.0
2	0	15	1	0.0
3	0	15	1	0.0
4	0	15	1	0.0
...
10968	21	321	3	0.0
10969	21	321	3	0.0
10970	21	321	4	0.0
10971	21	321	5	0.0
10972	21	321	5	0.0

```
[10973 rows x 4 columns]
```

```
print(dataset4_x)
```

```
[[-4.30908406e-01  3.46099464e-01]
 [-9.04806530e-01  5.75996666e-01]
 [-6.86009163e-01  3.03039164e-01]
 [-3.51667257e-01  2.06750592e+00]
 [-2.72158331e-01  1.17669035e+00]
 [ 2.95715217e-01  9.41396918e-01]
 [ 1.57757402e+00  4.08036604e-01]
 [ 1.13812148e+00  9.12046221e-01]]
```

```

[ 9.43709238e-01  5.82766841e-01]
[ 1.08467165e+00  5.31084524e-01]
[-1.18834888e+00  9.73055103e-02]
[-8.79874999e-01 -4.18016617e-02]
[-5.36449646e-01  2.87487675e-01]
[-7.49159056e-01  6.80755159e-01]
[-1.64191171e-01 -3.47328031e-02]
[-8.47956646e-01  1.88179406e+00]
[ 1.01597526e-01  9.56769197e-01]
[ 9.86338809e-02  7.60722866e-01]
[ 7.84268126e-02  3.23568722e-01]
[ 2.64351960e-01  1.60634752e+00]
[-6.63877716e-01 -1.18427855e+00]
[-6.04978248e-01 -1.00779603e+00]
[-6.67308886e-01 -9.31054115e-01]
[-5.77942130e-01 -2.05659795e-01]
[ 6.34781587e-01 -7.50041555e-01]
[-1.50272471e+00  1.01573941e+00]
[-1.43769025e+00  4.72661901e-01]
[-1.53155349e+00  2.86693906e+00]
[-1.14503623e+00  6.32258807e-01]
[-9.88557920e-01  6.64387267e-01]
[-6.41429883e-02 -8.57528030e-01]
[-2.25927633e-01 -8.75030922e-01]
[ 2.90598496e-01 -8.58892021e-01]
[ 1.17680592e+00 -9.20012757e-01]
[ 1.26068252e+00 -8.00499267e-01]
[-8.19606247e-01 -3.12947147e-01]
[-7.07146215e-01 -2.51527727e-01]
[-4.68284353e-01  1.62701596e-03]
[-7.19904727e-01  1.64019260e-02]
[-1.10241245e-01 -3.41302231e-01]
[ 1.17306210e+00 -1.49370539e+00]
[ 2.21735306e+00 -1.50078421e+00]
[ 2.21735306e+00 -1.46773978e+00]
[ 2.21735306e+00 -1.47984645e+00]
[ 2.21735306e+00 -1.50152096e+00]
[-4.73390219e-01 -7.80238524e-01]
[ 4.62653494e-01 -7.85664620e-01]
[ 2.07849463e-01 -8.20471281e-01]
[ 6.11956931e-02 -9.06352935e-01]]

```

```
print(dataset1_y)
```

```

      label
0         0
1         0
2         0
3         0
4         0
...      ...

```

```
2195    21
2196    21
2197    21
2198    21
2199    21
```

```
[2200 rows x 1 columns]
```

```
print(dataset2_y)
```

```
      Fertilizer Name
0                6
1                5
2                1
3                4
4                6
..            ...
94                4
95                0
96                6
97                5
98                3
```

```
[99 rows x 1 columns]
```

```
print(dataset3_y)
```

```
      Crop Type
0            1
1            2
2            8
3            9
4           11
...      ...
10968       58
10969       62
10970       65
10971       58
10972       62
```

```
[10973 rows x 1 columns]
```

```
print(dataset4_y)
```

```
      Crop
0        0
1        0
2        0
3        0
4        0
5        1
```

6	1
7	1
8	1
9	1
10	2
11	2
12	2
13	2
14	2
15	3
16	3
17	3
18	3
19	3
20	4
21	4
22	4
23	4
24	4
25	5
26	5
27	5
28	5
29	5
30	6
31	6
32	6
33	6
34	6
35	7
36	7
37	7
38	7
39	7
40	8
41	8
42	8
43	8
44	8
45	9
46	9
47	9
48	9

```
X_train_1, X_test_1, y_train_1, y_test_1 =  
train_test_split(dataset1_x, dataset1_y, test_size=0.3,  
random_state=2)  
X_train_2, X_test_2, y_train_2, y_test_2 =  
train_test_split(dataset2_x, dataset2_y, test_size=0.3,  
random_state=2)
```

```

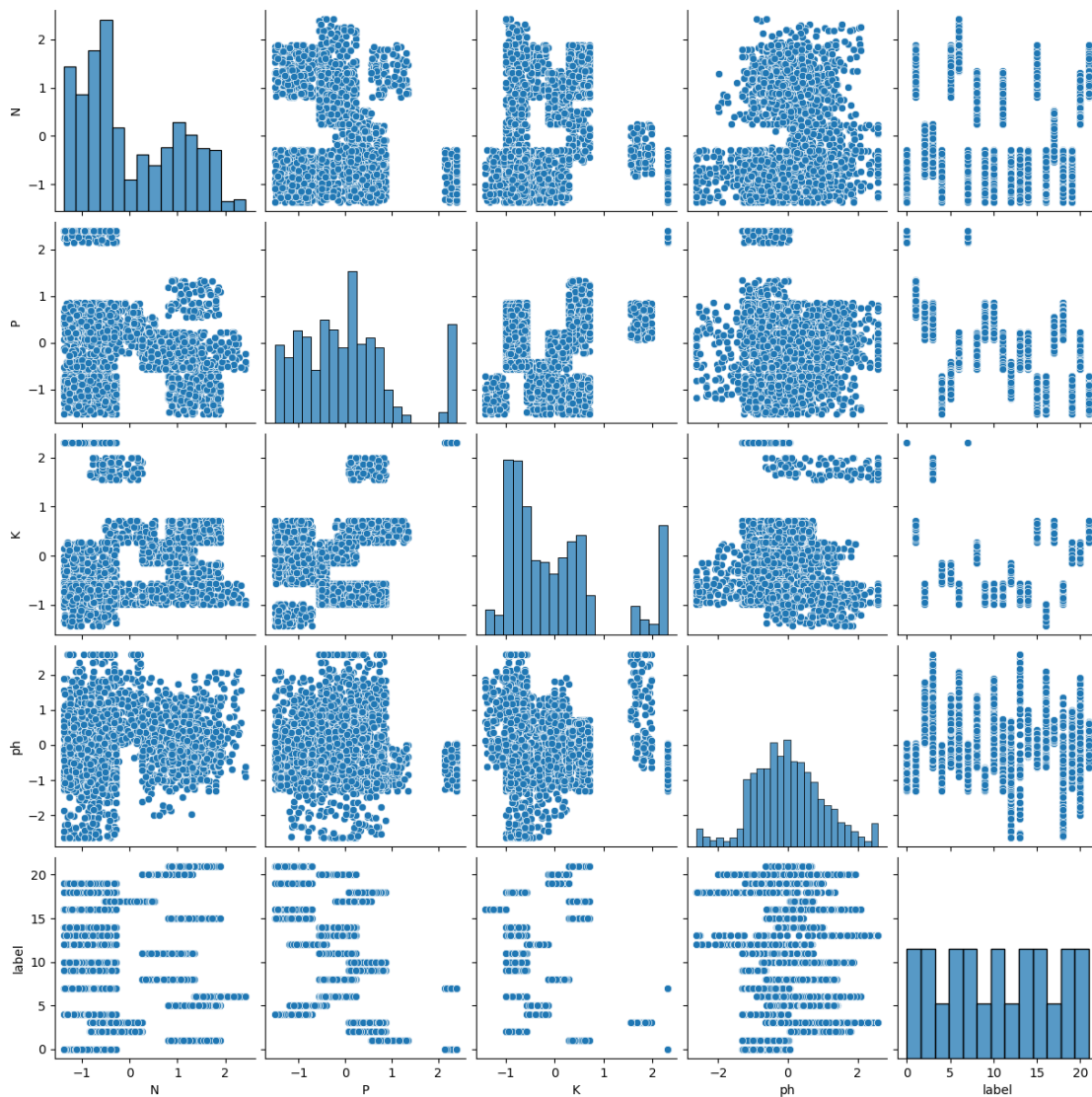
X_train_3, X_test_3, y_train_3, y_test_3 =
train_test_split(dataset3_x, dataset3_y, test_size=0.3,
random_state=2)
X_train_4, X_test_4, y_train_4, y_test_4 =
train_test_split(dataset4_x, dataset4_y, test_size=0.3,
random_state=2)

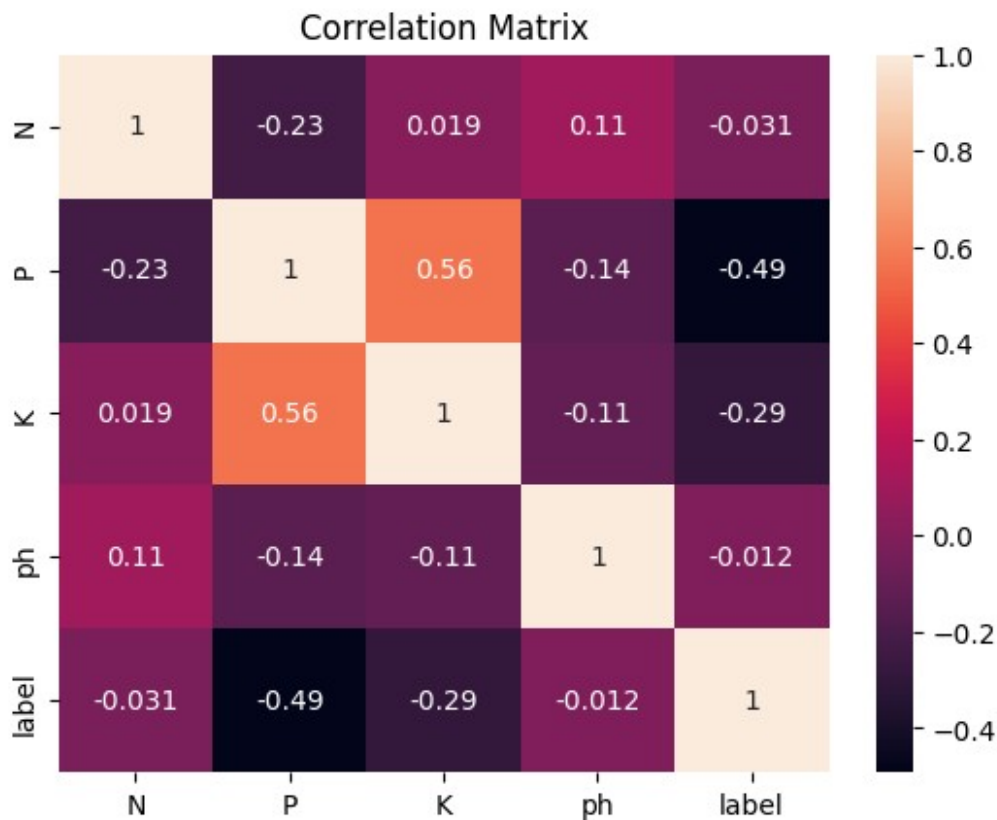
sns.pairplot(preprocessed_dataset1.select_dtypes(include=['float',
'int']))
plt.show()

corr_matrix = preprocessed_dataset1.corr()
sns.heatmap(corr_matrix, annot=True)
plt.title('Correlation Matrix')
plt.show()

plt.show()

```

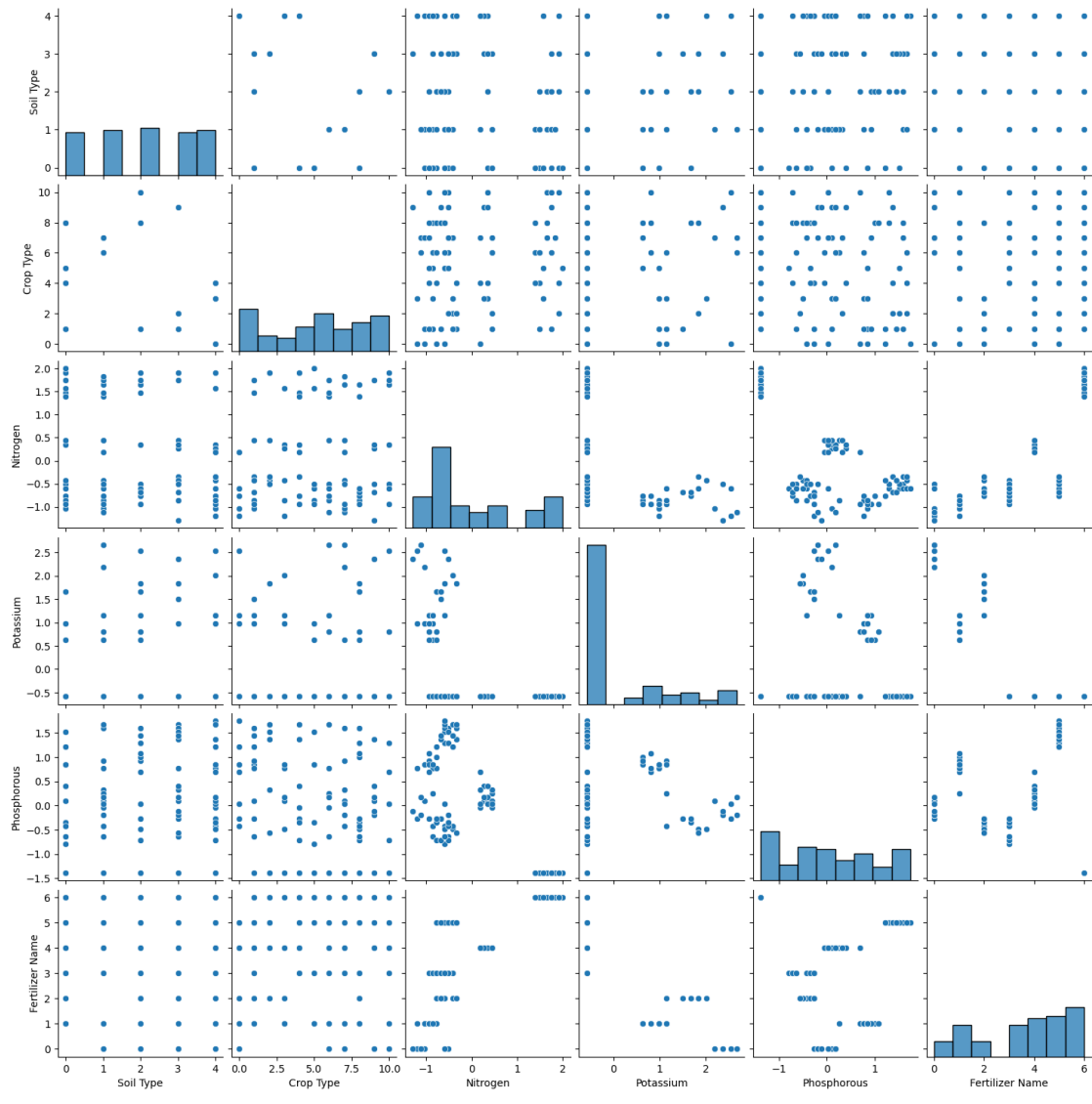


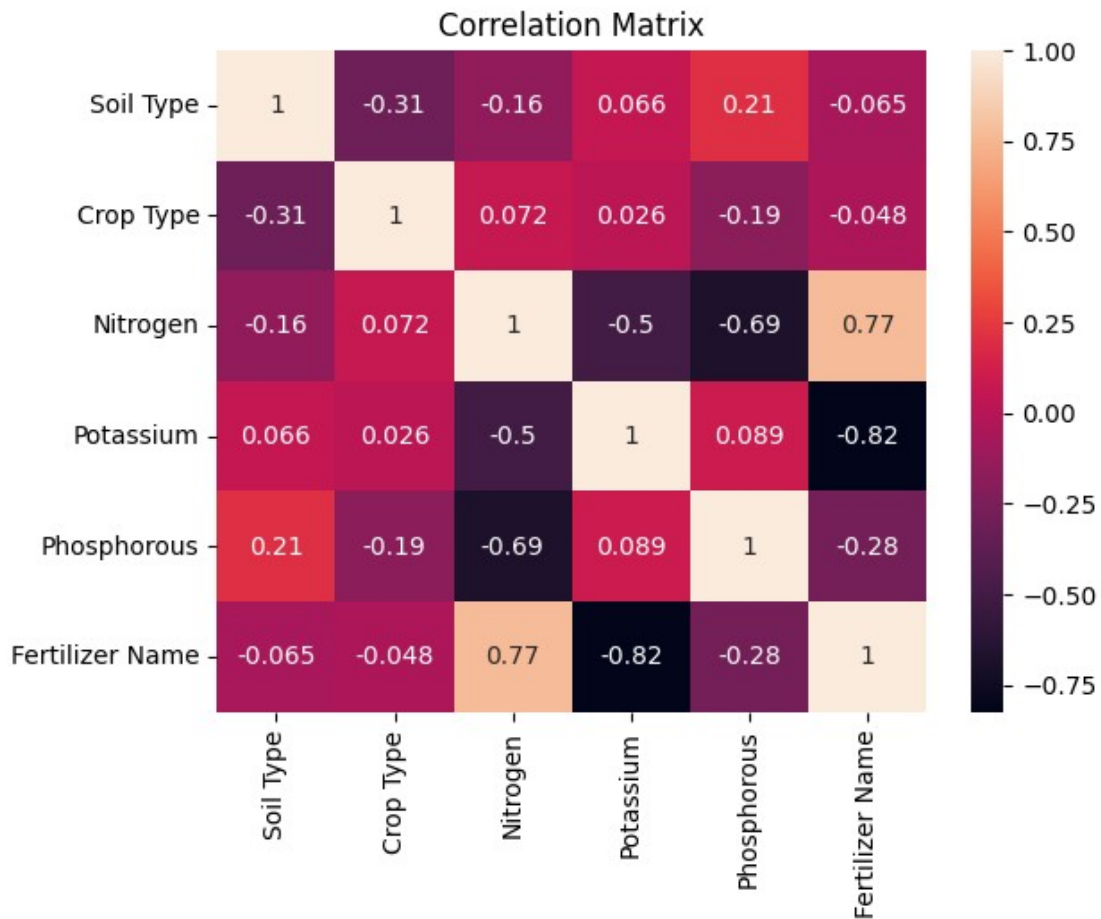


```
sns.pairplot(preprocessed_dataset2.select_dtypes(include=['float',
'int']))
plt.show()
```

```
corr_matrix = preprocessed_dataset2.corr()
sns.heatmap(corr_matrix, annot=True)
plt.title('Correlation Matrix')
plt.show()
```

```
plt.show()
```

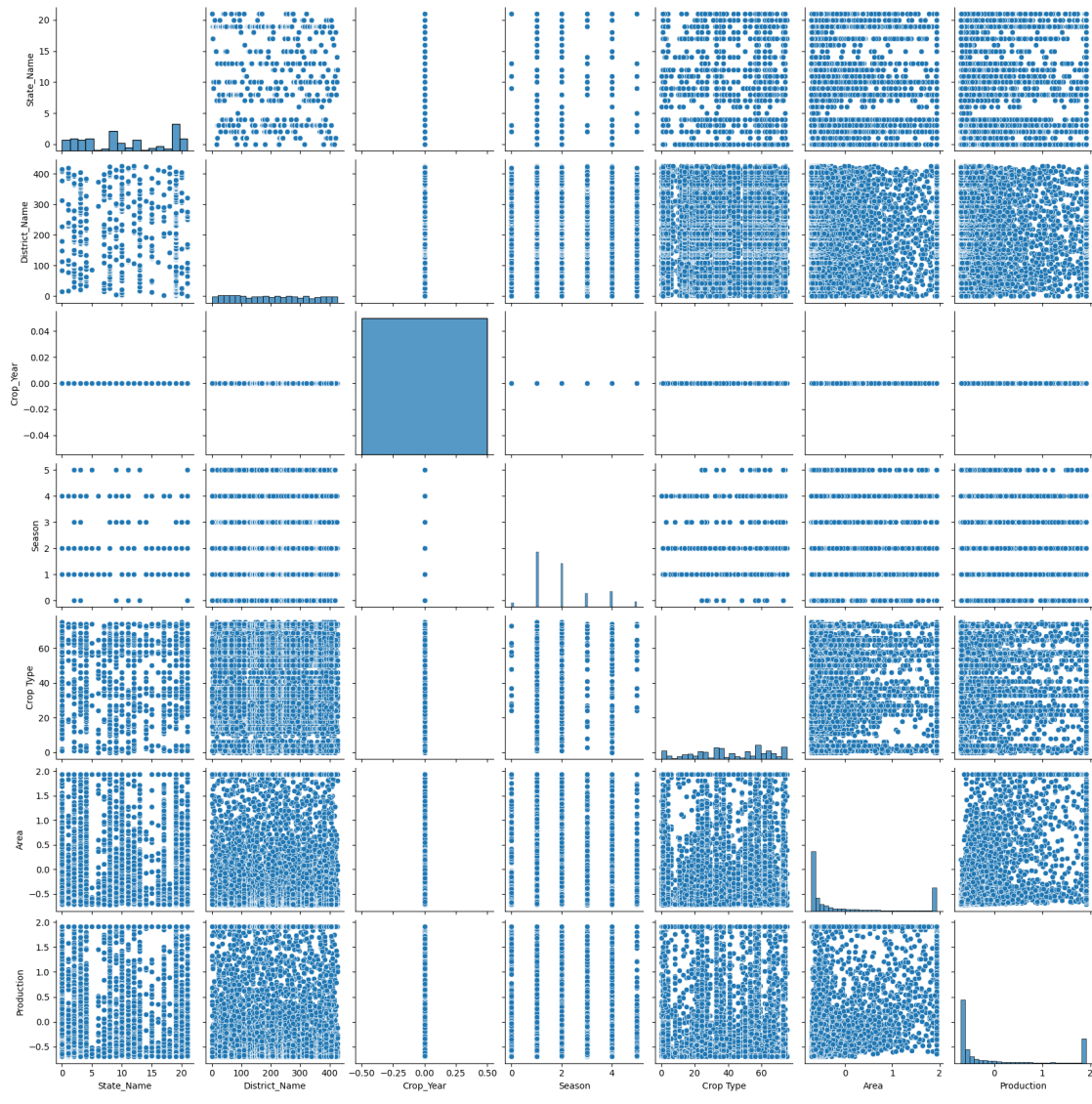


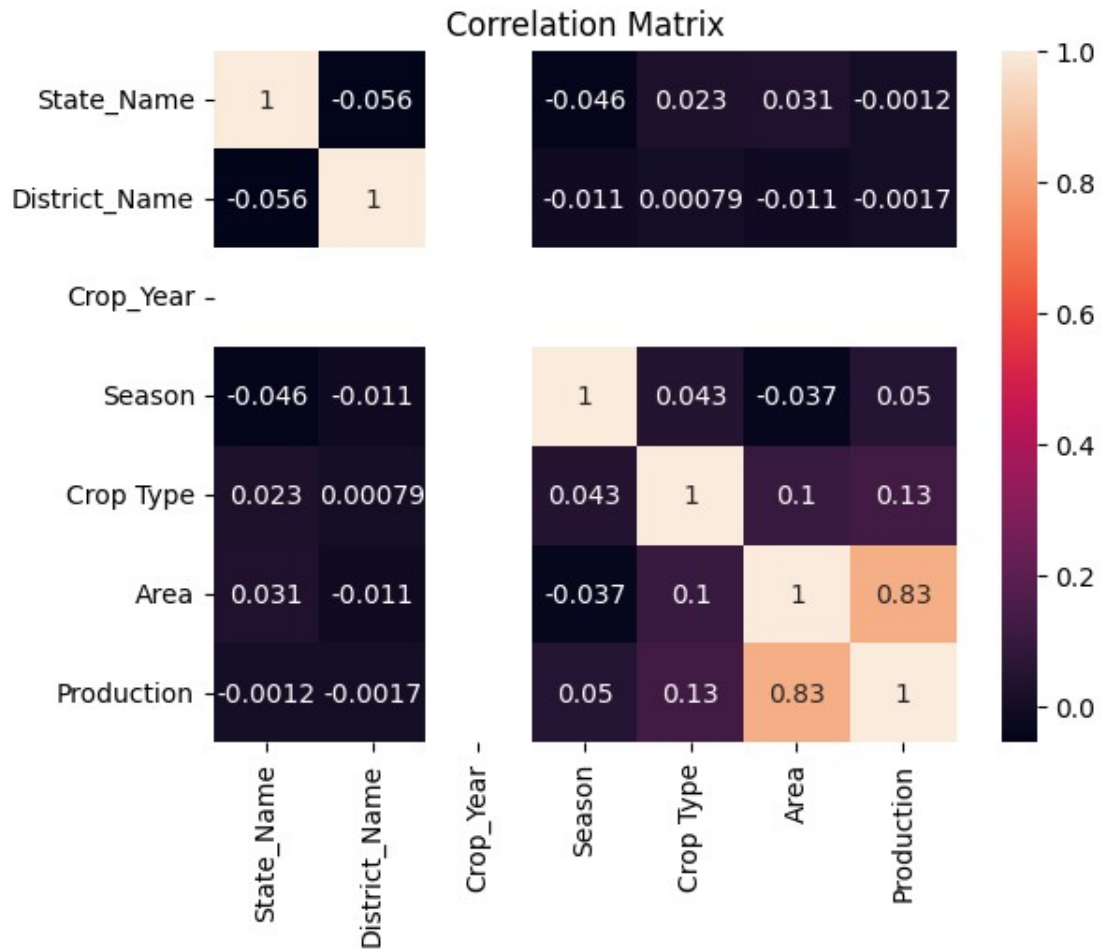


```
sns.pairplot(preprocessed_dataset3.select_dtypes(include=['float',
'int']))
plt.show()

corr_matrix = preprocessed_dataset3.corr()
sns.heatmap(corr_matrix, annot=True)
plt.title('Correlation Matrix')
plt.show()

plt.show()
```

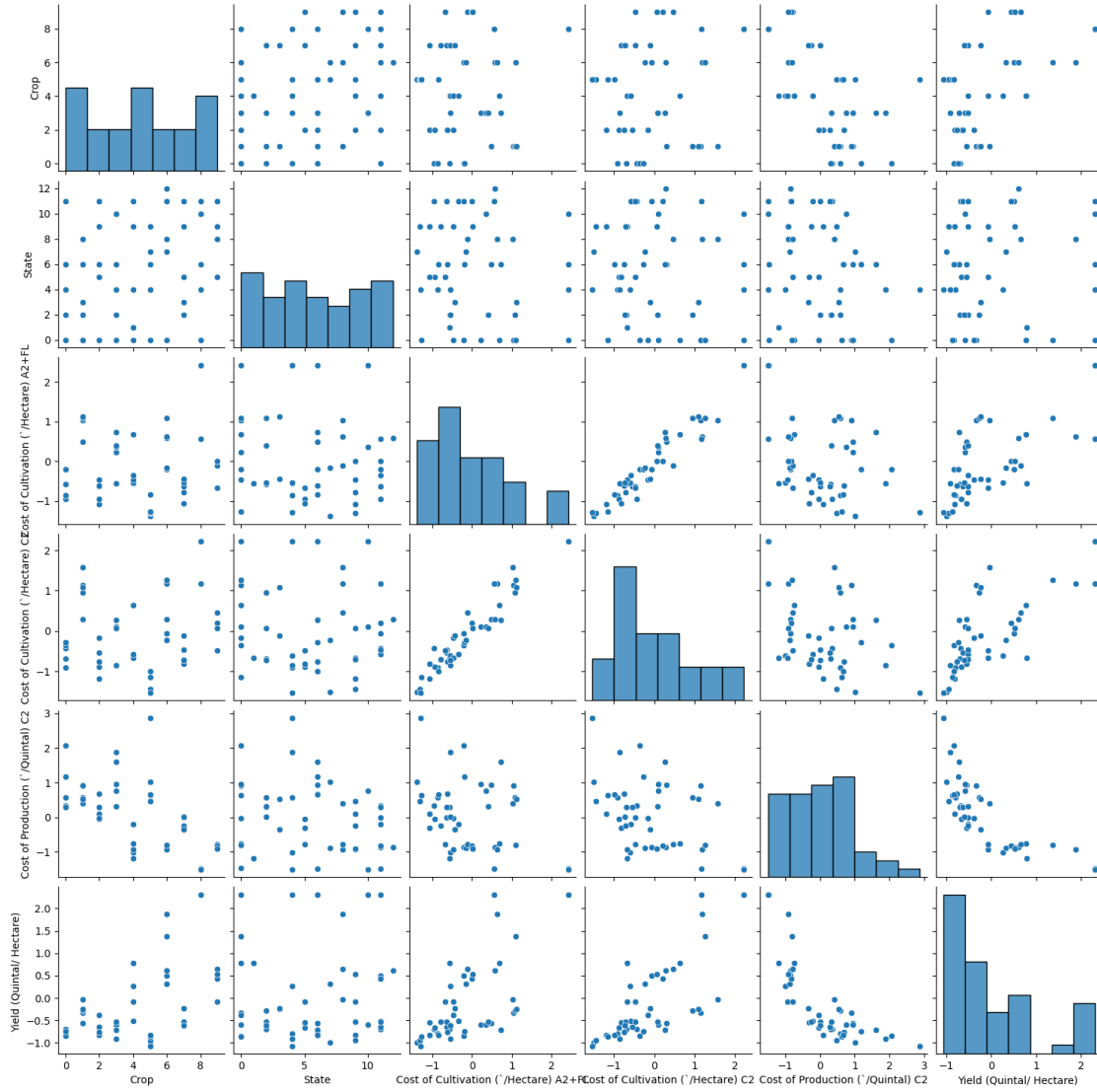


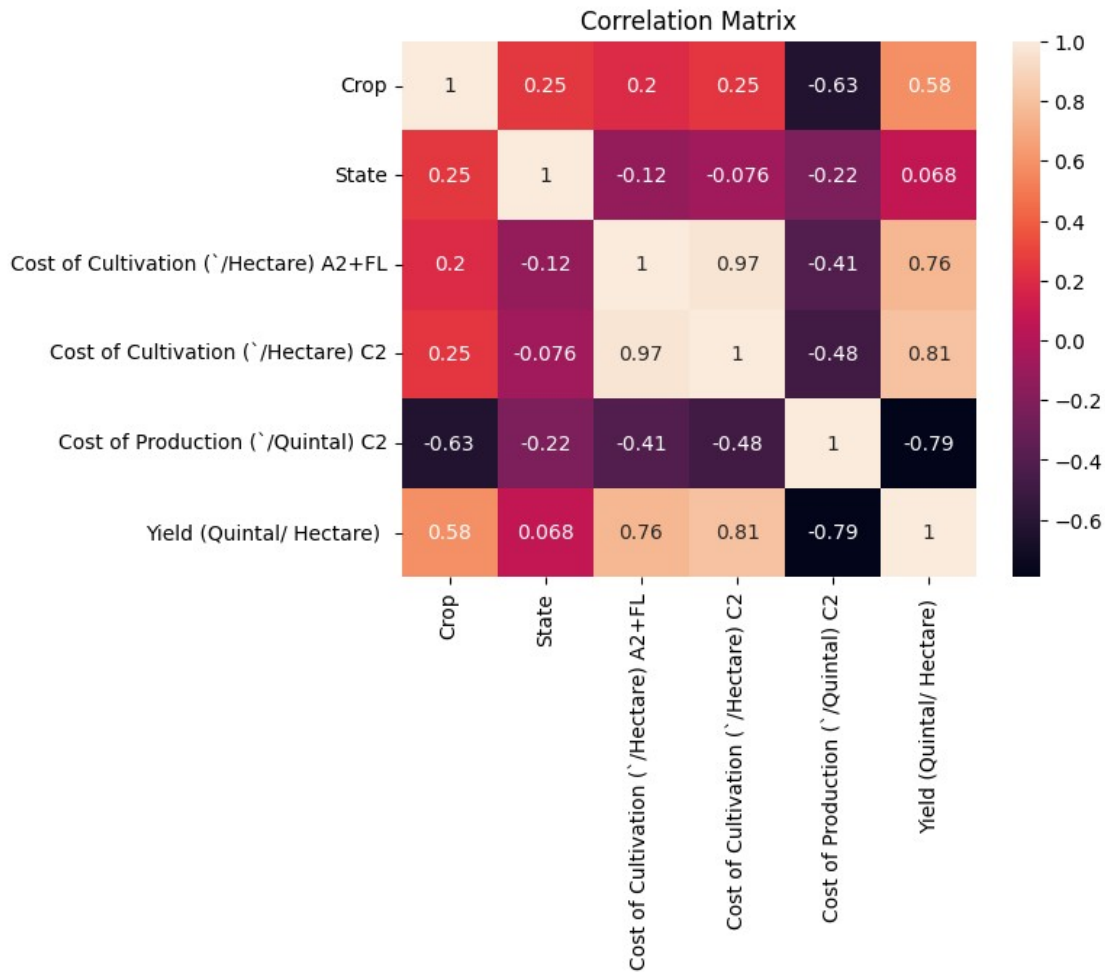


```
sns.pairplot(preprocessed_dataset4.select_dtypes(include=['float',
'int']))
plt.show()
```

```
corr_matrix = preprocessed_dataset4.corr()
sns.heatmap(corr_matrix, annot=True)
plt.title('Correlation Matrix')
plt.show()
```

```
plt.show()
```





```

clf = DecisionTreeClassifier()
clf.fit(X_train_1, y_train_1)
y_train_pred = clf.predict(X_train_1)
y_test_pred = clf.predict(X_test_1)

accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)

1.0
0.7560606060606061

clf = DecisionTreeClassifier()
clf.fit(X_train_2, y_train_2)
y_train_pred = clf.predict(X_train_2)
y_test_pred = clf.predict(X_test_2)

accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)

```

```

accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)

1.0
0.9333333333333333

clf = DecisionTreeClassifier()
clf.fit(X_train_3, y_train_3)
y_train_pred = clf.predict(X_train_3)
y_test_pred = clf.predict(X_test_3)

accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)

0.1895586512172894
0.028857837181044958

clf = DecisionTreeClassifier()
clf.fit(X_train_4, y_train_4)
y_train_pred = clf.predict(X_train_4)
y_test_pred = clf.predict(X_test_4)

accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_4)
print(accuracy_test)

1.0
0.6

rf = RandomForestClassifier(n_estimators=100, random_state=42)
rf.fit(X_train_1, y_train_1)
y_train_pred = rf.predict(X_train_1)
y_test_pred = rf.predict(X_test_1)

<ipython-input-45-29bfd04d51a0>:2: DataConversionWarning: A column-
vector y was passed when a 1d array was expected. Please change the
shape of y to (n_samples,), for example using ravel().
    rf.fit(X_train_1, y_train_1)

accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)

1.0
0.8030303030303030

rf = RandomForestClassifier(n_estimators=100, random_state=42)
rf.fit(X_train_2, y_train_2)

```



```
y_train_pred = rf.predict(X_train_2)
y_test_pred = rf.predict(X_test_2)
```

<ipython-input-47-16b45080ecaa>:2: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().

```
rf.fit(X_train_2, y_train_2)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)
```

```
1.0
```

```
1.0
```

```
rf = RandomForestClassifier(n_estimators=100, random_state=42)
```

```
rf.fit(X_train_3, y_train_3)
```

```
y_train_pred = rf.predict(X_train_3)
```

```
y_test_pred = rf.predict(X_test_3)
```

<ipython-input-49-a9e49080da34>:2: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().

```
rf.fit(X_train_3, y_train_3)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)
```

```
0.1895586512172894
```

```
0.028857837181044958
```

```
rf = RandomForestClassifier(n_estimators=100, random_state=42)
```

```
rf.fit(X_train_4, y_train_4)
```

```
y_train_pred = rf.predict(X_train_4)
```

```
y_test_pred = rf.predict(X_test_4)
```

<ipython-input-51-c75619a734c1>:2: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().

```
rf.fit(X_train_4, y_train_4)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_4)
print(accuracy_test)
```

```
1.0
```

```
0.4666666666666667
```

```
clf = xgb.XGBClassifier(objective='binary:logistic')
clf.fit(X_train_1, y_train_1)
y_train_pred = clf.predict(X_train_1)
y_test_pred = clf.predict(X_test_1)
modell_y_test_pred_ds_1 = clf.predict(X_test_1)

accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)
```

```
1.0
0.7803030303030303
```

```
clf = xgb.XGBClassifier(objective='binary:logistic')
clf.fit(X_train_2, y_train_2)
y_train_pred = clf.predict(X_train_2)
y_test_pred = clf.predict(X_test_2)
modell_y_test_pred_ds_2 = clf.predict(X_test_2)

accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)
```

```
1.0
0.9666666666666667
```

```
clf = xgb.XGBClassifier(objective='binary:logistic')
clf.fit(X_train_3, y_train_3)
y_train_pred = clf.predict(X_train_3)
y_test_pred = clf.predict(X_test_3)
modell_y_test_pred_ds_3 = clf.predict(X_test_3)

accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)
```

```
0.1883869287853144
0.02976913730255164
```

```
clf = xgb.XGBClassifier(objective='binary:logistic')
clf.fit(X_train_4, y_train_4)
y_train_pred = clf.predict(X_train_4)
y_test_pred = clf.predict(X_test_4)
modell_y_test_pred_ds_4 = clf.predict(X_test_4)

accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_4)
print(accuracy_test)
```

```
1.0
0.5333333333333333
```

```
nb = GaussianNB()
nb.fit(X_train_1, y_train_1)
y_train_pred = nb.predict(X_train_1)
y_test_pred = nb.predict(X_test_1)
model2_y_test_pred_ds_1 = nb.predict(X_test_1)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)

accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)
```

```
0.7967532467532468
0.7772727272727272
```

```
nb = GaussianNB()
nb.fit(X_train_2, y_train_2)
y_train_pred = nb.predict(X_train_2)
y_test_pred = nb.predict(X_test_2)
model2_y_test_pred_ds_2 = nb.predict(X_test_2)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)

accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)
```

```
1.0
1.0
```

```
nb = GaussianNB()
nb.fit(X_train_3, y_train_3)
y_train_pred = nb.predict(X_train_3)
y_test_pred = nb.predict(X_test_3)
model2_y_test_pred_ds_3 = nb.predict(X_test_3)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
```

```
(n_samples, ), for example using ravel().
y = column_or_1d(y, warn=True)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)
```

```
0.09425856008332248
0.08262454434993925
```

```
nb = GaussianNB()
nb.fit(X_train_4, y_train_4)
y_train_pred = nb.predict(X_train_4)
y_test_pred = nb.predict(X_test_4)
model2_y_test_pred_ds_4 = nb.predict(X_test_4)
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
y = column_or_1d(y, warn=True)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_4)
print(accuracy_test)
```

```
0.8529411764705882
0.6666666666666666
```

```
model = SVC(kernel='linear', C=1, random_state=42)
model.fit(X_train_1, y_train_1)
y_train_pred = model.predict(X_train_1)
y_test_pred = model.predict(X_test_1)
model3_y_test_pred_ds_1 = model.predict(X_test_1)
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
y = column_or_1d(y, warn=True)
```

```
accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)
```

```
0.7383116883116884
0.7075757575757575
```

```
model = SVC(kernel='linear', C=1, random_state=42)
model.fit(X_train_2, y_train_2)
```

```

y_train_pred = model.predict(X_train_2)
y_test_pred = model.predict(X_test_2)
model3_y_test_pred_ds_2 = model.predict(X_test_2)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
    y = column_or_1d(y, warn=True)

accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)

1.0
1.0

model = SVC(kernel='linear', C=1, random_state=42)
model.fit(X_train_3, y_train_3)
y_train_pred = model.predict(X_train_3)
y_test_pred = model.predict(X_test_3)
model3_y_test_pred_ds_3 = model.predict(X_test_3)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
    y = column_or_1d(y, warn=True)

accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)

0.08501497200885301
0.07229647630619684

model = SVC(kernel='linear', C=1, random_state=42)
model.fit(X_train_4, y_train_4)
y_train_pred = model.predict(X_train_4)
y_test_pred = model.predict(X_test_4)
model3_y_test_pred_ds_4 = model.predict(X_test_4)

/usr/local/lib/python3.9/dist-packages/sklearn/utils/
validation.py:1143: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
    y = column_or_1d(y, warn=True)

accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)

```

```
accuracy_test = accuracy_score(y_test_pred, y_test_4)
print(accuracy_test)
```

```
0.6470588235294118
0.3333333333333333
```

```
knn = KNeighborsClassifier()
```

```
param_grid = {'n_neighbors': [i for i in range(2, 100)]}
```

```
grid_search = GridSearchCV(knn, param_grid=param_grid, cv=5)
grid_search.fit(X_train_1, y_train_1)
```

```
print("Best parameter value:", grid_search.best_params_)
print("Best accuracy score:", grid_search.best_score_)
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/neighbors/_classification.py:215: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
    return self._fit(X, y)
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Best parameter value: {'n_neighbors': 8}
Best accuracy score: 0.7487012987012986

```

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knn = KNeighborsClassifier(n_neighbors=8)
knn.fit(X_train_1, y_train_1)
y_train_pred = knn.predict(X_train_1)
y_test_pred = knn.predict(X_test_1)
model4_y_test_pred_ds_1 = knn.predict(X_test_1)

accuracy_train = accuracy_score(y_train_pred, y_train_1)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_1)
print(accuracy_test)

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0.8175324675324676
0.7636363636363637

knn = KNeighborsClassifier()

param_grid = {'n_neighbors': [i for i in range(2, 20)]}

grid_search = GridSearchCV(knn, param_grid=param_grid, cv=5)
grid_search.fit(X_train_2, y_train_2)

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Best parameter value: {'n_neighbors': 3}

Best accuracy score: 0.6098901098901098

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knn = KNeighborsClassifier(n_neighbors=3)
knn.fit(X_train_2, y_train_2)
y_train_pred = knn.predict(X_train_2)
y_test_pred = knn.predict(X_test_2)
model4_y_test_pred_ds_2 = knn.predict(X_test_2)

accuracy_train = accuracy_score(y_train_pred, y_train_2)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_2)
print(accuracy_test)

0.9130434782608695
0.6333333333333333

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knn = KNeighborsClassifier()

param_grid = {'n_neighbors': [i for i in range(2, 20)]}

grid_search = GridSearchCV(knn, param_grid=param_grid, cv=5)
grid_search.fit(X_train_3, y_train_3)

print("Best parameter value:", grid_search.best_params_)
print("Best accuracy score:", grid_search.best_score_)

/usr/local/lib/python3.9/dist-packages/sklearn/model_selection/
_split.py:700: UserWarning: The least populated class in y has only 1
members, which is less than n_splits=5.
    warnings.warn(

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    return self._fit(X, y)

```

```

Best parameter value: {'n_neighbors': 19}
Best accuracy score: 0.02304382522771633

```

```

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knn = KNeighborsClassifier(n_neighbors=19)
knn.fit(X_train_3, y_train_3)
y_train_pred = knn.predict(X_train_3)
y_test_pred = knn.predict(X_test_3)
model4_y_test_pred_ds_3 = knn.predict(X_test_3)

accuracy_train = accuracy_score(y_train_pred, y_train_3)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_3)
print(accuracy_test)

/usr/local/lib/python3.9/dist-packages/sklearn/neighbors/
_classification.py:215: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
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0.12003645358677256
0.015795868772782502

nn = KNeighborsClassifier()

param_grid = {'n_neighbors': [i for i in range(3, 10)]}

grid_search = GridSearchCV(knn, param_grid=param_grid, cv=2)
grid_search.fit(X_train_4, y_train_4)

print("Best parameter value:", grid_search.best_params_)
print("Best accuracy score:", grid_search.best_score_)

/usr/local/lib/python3.9/dist-packages/sklearn/neighbors/
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1d array was expected. Please change the shape of y to (n_samples,),
for example using ravel().
    return self._fit(X, y)

```

Best parameter value: {'n_neighbors': 4}

Best accuracy score: 0.4117647058823529

```

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```

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1d array was expected. Please change the shape of y to (n_samples,),
for example using ravel().
    return self._fit(X, y)

```

```

knn = KNeighborsClassifier(n_neighbors=4)
knn.fit(X_train_4, y_train_4)
y_train_pred = knn.predict(X_train_4)
y_test_pred = knn.predict(X_test_4)
model4_y_test_pred_ds_4 = knn.predict(X_test_4)

```

```

accuracy_train = accuracy_score(y_train_pred, y_train_4)
print(accuracy_train)
accuracy_test = accuracy_score(y_test_pred, y_test_4)
v
kprint(accuracy_test)

```

```

0.6470588235294118
0.6

```

```

/usr/local/lib/python3.9/dist-packages/sklearn/neighbors/
_classification.py:215: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to
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```

```

def merge_preds_ds1(model1_y_test_pred_ds_1, model2_y_test_pred_ds_1,
model3_y_test_pred_ds_1, model4_y_test_pred_ds_1):
    stacked_preds = np.stack((model1_y_test_pred_ds_1,
model2_y_test_pred_ds_1, model3_y_test_pred_ds_1,
model4_y_test_pred_ds_1), axis=1)
    ensemble_preds = np.apply_along_axis(lambda x:
np.argmax(np.bincount(x)), axis=1, arr=stacked_preds)
    return ensemble_preds

```

```

merged_preds_ds1 = merge_preds_ds1(model1_y_test_pred_ds_1,
model2_y_test_pred_ds_1, model3_y_test_pred_ds_1,
model4_y_test_pred_ds_1)

```

```

from sklearn.metrics import accuracy_score
accuracy = accuracy_score(y_test_1, merged_preds_ds1)
print('Merged model accuracy:', accuracy)

```

Merged model accuracy: 0.7833333333333333

```

def merge_preds_ds2(model1_y_test_pred_ds_2, model2_y_test_pred_ds_2,
model3_y_test_pred_ds_2, model4_y_test_pred_ds_2):
    stacked_preds = np.stack((model1_y_test_pred_ds_2,
model2_y_test_pred_ds_2, model3_y_test_pred_ds_2,
model4_y_test_pred_ds_2), axis=1)
    ensemble_preds = np.apply_along_axis(lambda x:
np.argmax(np.bincount(x)), axis=1, arr=stacked_preds)
    return ensemble_preds

```

```

merged_preds_ds2 = merge_preds_ds1(model1_y_test_pred_ds_2,
model2_y_test_pred_ds_2, model3_y_test_pred_ds_2,
model4_y_test_pred_ds_2)

```

```

from sklearn.metrics import accuracy_score
accuracy = accuracy_score(y_test_2, merged_preds_ds2)
print('Merged model accuracy:', accuracy)

```

Merged model accuracy: 1.0

```

def merge_preds_ds3(model1_y_test_pred_ds_3, model2_y_test_pred_ds_3,
model3_y_test_pred_ds_3, model4_y_test_pred_ds_3):
    stacked_preds = np.stack((model1_y_test_pred_ds_3,
model2_y_test_pred_ds_3, model3_y_test_pred_ds_3,
model4_y_test_pred_ds_3), axis=1)
    ensemble_preds = np.apply_along_axis(lambda x:
np.argmax(np.bincount(x)), axis=1, arr=stacked_preds)
    return ensemble_preds

```

```

merged_preds_ds2 = merge_preds_ds1(model1_y_test_pred_ds_2,
model2_y_test_pred_ds_2, model3_y_test
                                _pred_ds_2,
model4_y_test_pred_ds_2)

```

```

from sklearn.metrics import accuracy_score
accuracy = accuracy_score(y_test_2, merged_preds_ds2)
print('Merged model accuracy:', accuracy)

```