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PRACTICAL 3: To analyze crop production trends over time using time series analysis techniques, identifying patterns, seasonality, and forecasting future yields

```
import pandas as pd

data = pd.read_csv('/content/CROP DATA.csv')

data.tail()
```


```
{"summary":"{\n  \"name\": \"data\",\n  \"rows\": 5,\n  \"fields\": [\n    {\n      \"column\": \"Year\",\n      \"properties\": {\n        \"dtype\": \"number\",\n        \"std\": 0,\n        \"min\": 2022,\n        \"max\": 2023,\n        \"num_unique_values\": 2,\n        \"samples\": [\n          2023,\n          2022\n        ],\n        \"semantic_type\": \"\",\n        \"description\": \"\"\n      }\n    },\n    {\n      \"column\": \"Quarter\",\n      \"properties\": {\n        \"dtype\": \"number\",\n        \"std\": 1,\n        \"min\": 1,\n        \"max\": 4,\n        \"num_unique_values\": 4,\n        \"samples\": [\n          1,\n          3\n        ],\n        \"semantic_type\": \"\",\n        \"description\": \"\"\n      }\n    },\n    {\n      \"column\": \"CROPYIELD\",\n      \"properties\": {\n        \"dtype\": \"number\",\n        \"std\": 278.11276890552864,\n        \"min\": 21989.981,\n        \"max\": 22668.986,\n        \"num_unique_values\": 5,\n        \"samples\": [\n          22112.329,\n          22668.986\n        ],\n        \"semantic_type\": \"\",\n        \"description\": \"\"\n      }\n    }\n  ]\n}","type":"dataframe"}
```


```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 308 entries, 0 to 307
Data columns (total 3 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Year       308 non-null    int64  
 1   Quarter    308 non-null    int64  
 2   CROPYIELD  308 non-null    float64
dtypes: float64(1), int64(2)
memory usage: 7.3 KB
```

```
rng = pd.date_range(start='1947', end='2024', freq='Y')
```

```
<ipython-input-25-741d5901ddbf>:1: FutureWarning: 'Y' is deprecated and will be removed in a future version, please use 'YE' instead.
  rng = pd.date_range(start='1947', end='2024', freq='Y')
```

```
rng
```

```
DatetimeIndex(['1947-12-31', '1948-12-31', '1949-12-31', '1950-12-31',
               '1951-12-31', '1952-12-31', '1953-12-31', '1954-12-31',
               '1955-12-31', '1956-12-31', '1957-12-31', '1958-12-31',
               '1959-12-31', '1960-12-31', '1961-12-31', '1962-12-31',
               '1963-12-31', '1964-12-31', '1965-12-31', '1966-12-31',
               '1967-12-31', '1968-12-31', '1969-12-31', '1970-12-31',
               '1971-12-31', '1972-12-31', '1973-12-31', '1974-12-31',
               '1975-12-31', '1976-12-31', '1977-12-31', '1978-12-31',
               '1979-12-31', '1980-12-31', '1981-12-31', '1982-12-31',
               '1983-12-31', '1984-12-31', '1985-12-31', '1986-12-31',
               '1987-12-31', '1988-12-31', '1989-12-31', '1990-12-31',
               '1991-12-31', '1992-12-31', '1993-12-31', '1994-12-31',
               '1995-12-31', '1996-12-31', '1997-12-31', '1998-12-31',
               '1999-12-31', '2000-12-31', '2001-12-31', '2002-12-31',
               '2003-12-31', '2004-12-31', '2005-12-31', '2006-12-31',
               '2007-12-31', '2008-12-31', '2009-12-31', '2010-12-31',
               '2011-12-31', '2012-12-31', '2013-12-31', '2014-12-31',
               '2015-12-31', '2016-12-31', '2017-12-31', '2018-12-31',
               '2019-12-31', '2020-12-31', '2021-12-31', '2022-12-31',
               '2023-12-31'],
              dtype='datetime64[ns]', freq='YE-DEC')
```

```
yearly_data = data.groupby('Year')['CROPYIELD'].sum()
```

```
yearly_data
```

```
Year
1947     8738.457
1948     9098.506
1949     9047.711
1950     9834.127
1951    10625.280
          ...
2019    82768.347
2020    80936.296
2021    85630.770
2022    87288.146
2023    89497.357
Name: CROPYIELD, Length: 77, dtype: float64
```

```
rng = pd.date_range(start='1947', end='2024', freq='Y')
s = yearly_data.values
Crop = pd.Series(s,rng)
```

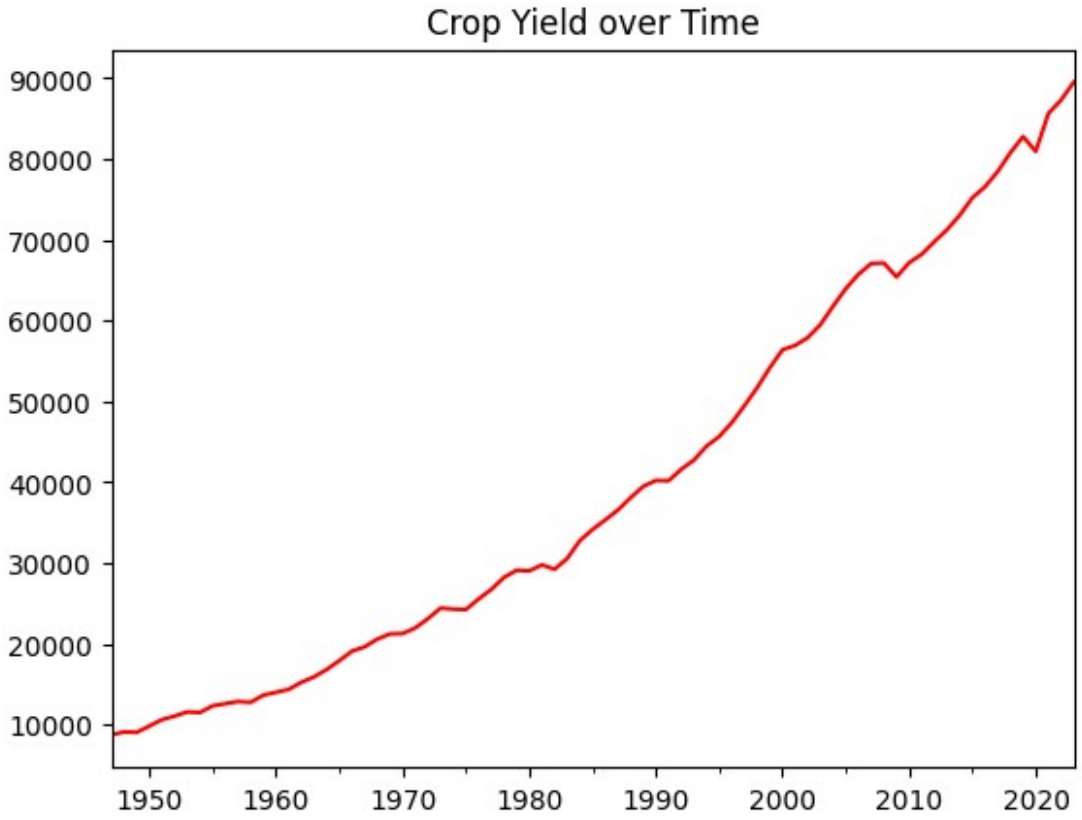
```
<ipython-input-29-a7621b9330fe>:1: FutureWarning: 'Y' is deprecated
and will be removed in a future version, please use 'YE' instead.
  rng = pd.date_range(start='1947', end='2024', freq='Y')
```

```
Crop
```

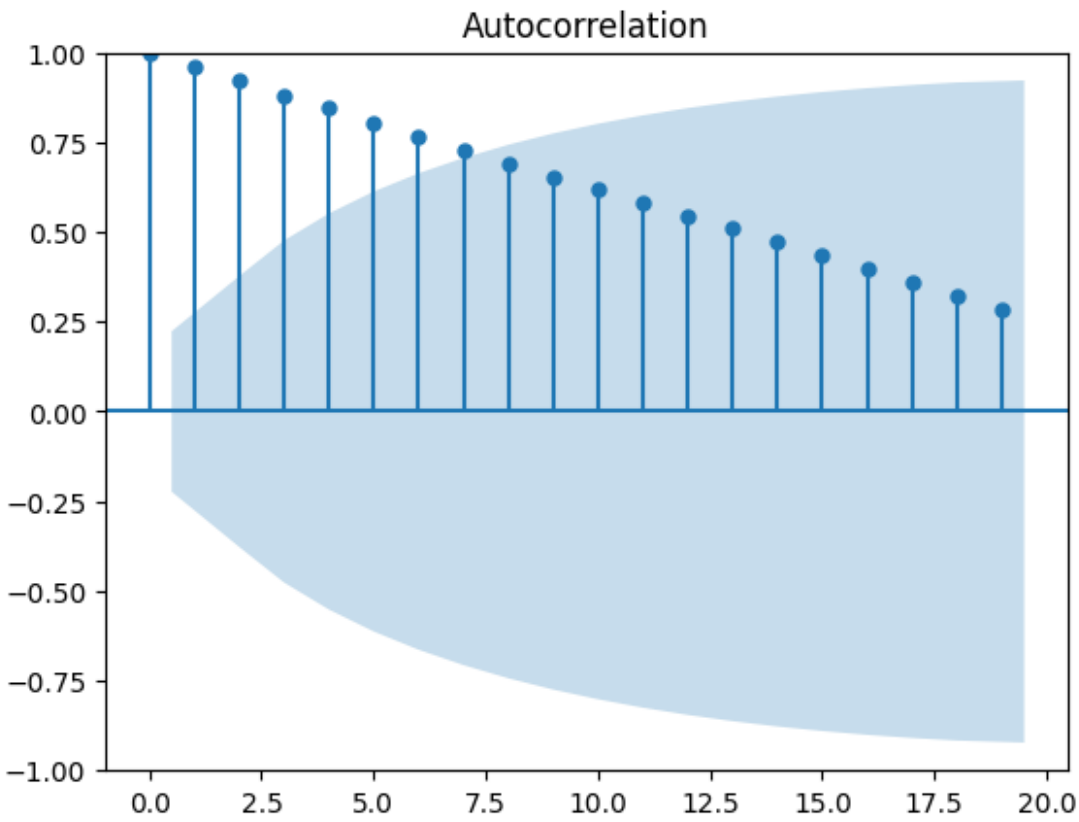
```
1947-12-31     8738.457
1948-12-31     9098.506
1949-12-31     9047.711
1950-12-31     9834.127
1951-12-31    10625.280
                 ...
2019-12-31    82768.347
2020-12-31    80936.296
2021-12-31    85630.770
2022-12-31    87288.146
2023-12-31    89497.357
Freq: YE-DEC, Length: 77, dtype: float64
```

```
Crop.plot(color='red',title = 'Crop Yield over Time')
```

```
<Axes: title={'center': 'Crop Yield over Time'}>
```

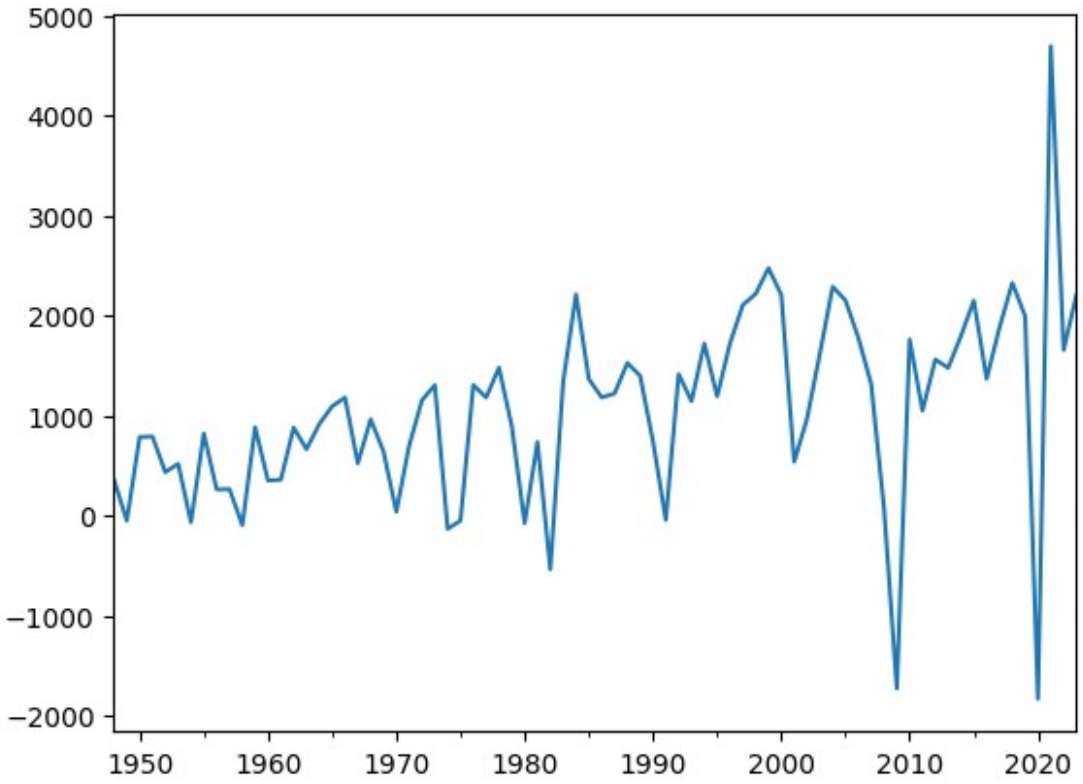



```
import matplotlib.pyplot as plt
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plot_acf(Crop)
plt.show()
```

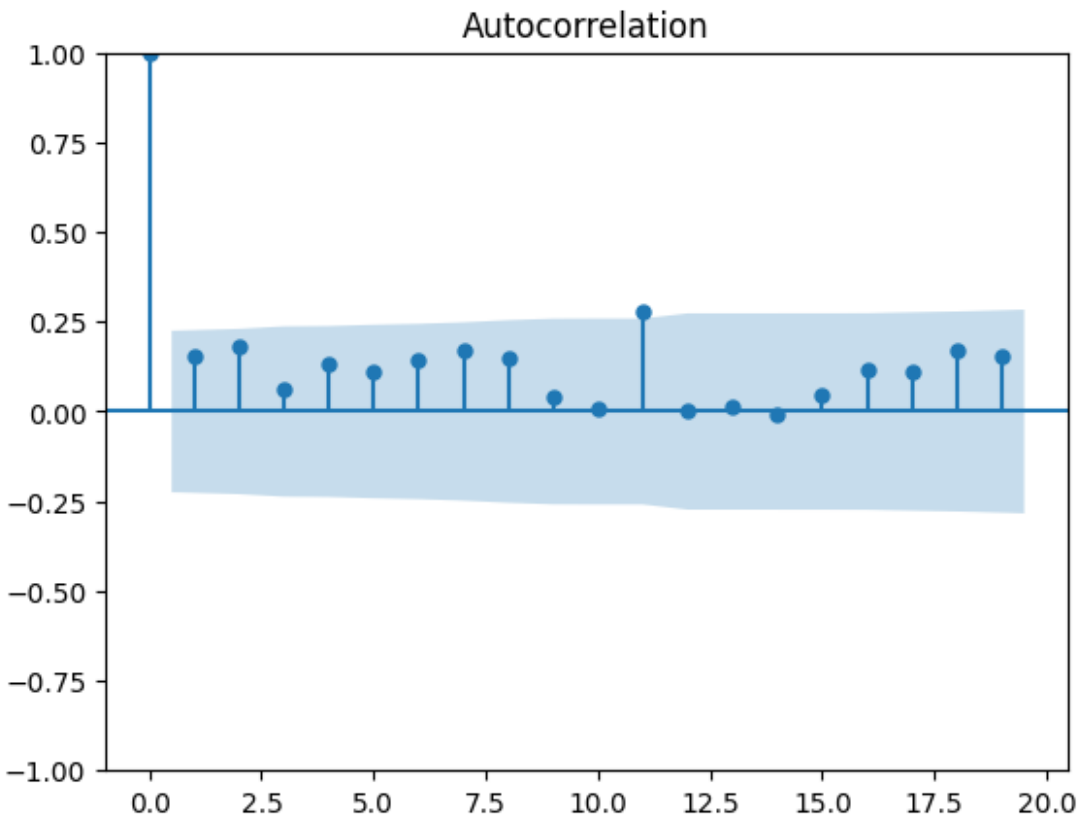



```
from statsmodels.tsa.statespace.tools import diff
Cropdiff = diff(Crop)
Cropdiff.plot()
Cropdiff.head()
```

```
1948-12-31    360.049
1949-12-31    -50.795
1950-12-31    786.416
1951-12-31    791.153
1952-12-31    433.932
Freq: YE-DEC, dtype: float64
```

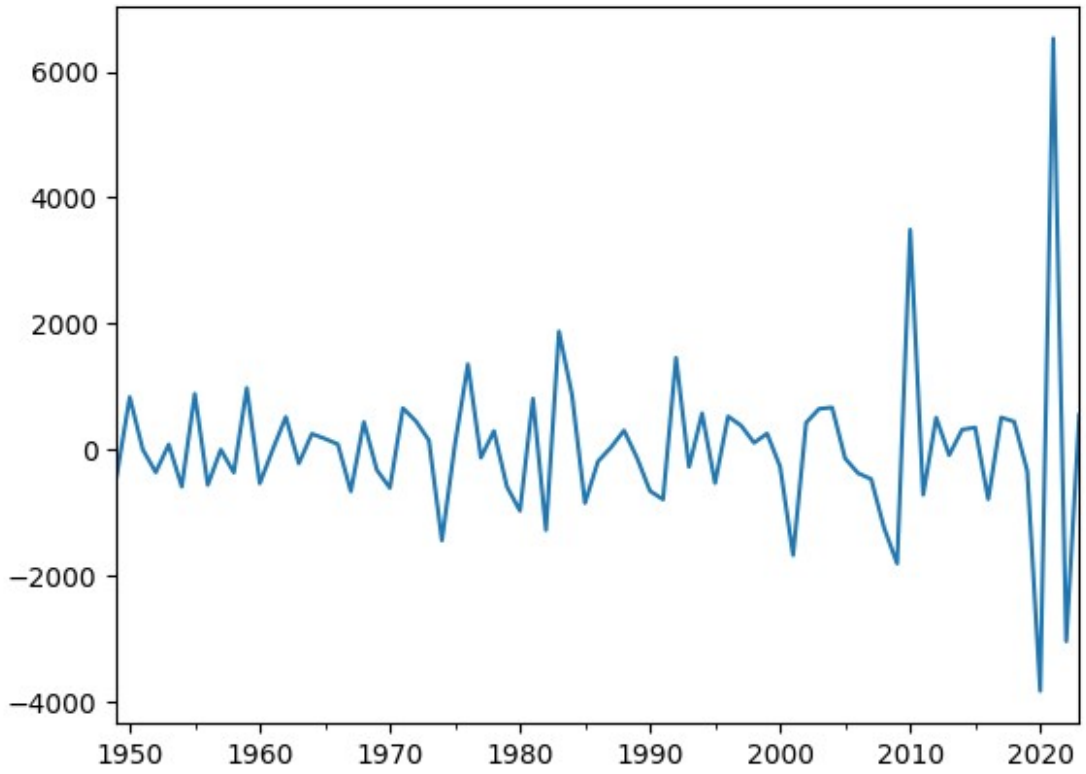



```
plot_acf(Cropdiff)
plt.show()
```




```
from statsmodels.tsa.statespace.tools import diff
Cropdiff1 = diff(Cropdiff)
Cropdiff1.plot()
Cropdiff1.head()
```

```
1949-12-31   -410.844
1950-12-31    837.211
1951-12-31      4.737
1952-12-31   -357.221
1953-12-31     84.503
Freq: YE-DEC, dtype: float64
```




```
!pip install arch
```

```
Collecting arch
  Downloading arch-7.2.0-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (13 kB)
Requirement already satisfied: numpy>=1.22.3 in
/usr/local/lib/python3.10/dist-packages (from arch) (1.26.4)
Requirement already satisfied: scipy>=1.8 in
/usr/local/lib/python3.10/dist-packages (from arch) (1.13.1)
Requirement already satisfied: pandas>=1.4 in
/usr/local/lib/python3.10/dist-packages (from arch) (2.2.2)
Requirement already satisfied: statsmodels>=0.12 in
/usr/local/lib/python3.10/dist-packages (from arch) (0.14.4)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.10/dist-packages (from pandas>=1.4->arch)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.10/dist-packages (from pandas>=1.4->arch)
(2024.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.10/dist-packages (from pandas>=1.4->arch)
(2024.2)
Requirement already satisfied: patsy>=0.5.6 in
/usr/local/lib/python3.10/dist-packages (from statsmodels>=0.12->arch)
(1.0.1)
```

```
Requirement already satisfied: packaging>=21.3 in
/usr/local/lib/python3.10/dist-packages (from statsmodels>=0.12->arch)
(24.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2-
>pandas>=1.4->arch) (1.17.0)
Downloading arch-7.2.0-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (985 kB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0.0/985.1 kB ? eta -:--:--
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 985.1/985.1 kB 31.5 MB/s eta
0:00:00
```

```
from arch.unitroot import ADF
adf = ADF(Crop,lags=0)
adf.summary()
```

```
<class 'statsmodels.iolib.summary.Summary'>
"""
   Augmented Dickey-Fuller Results
====================================
Test Statistic                  4.038
P-value                         1.000
Lags                                0
------------------------------------

Trend: Constant
Critical Values: -3.52 (1%), -2.90 (5%), -2.59 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
"""
```

```
from arch.unitroot import ADF
adf = ADF(Cropdiff,lags=0)
adf.summary()
```

```
<class 'statsmodels.iolib.summary.Summary'>
"""
   Augmented Dickey-Fuller Results
====================================
Test Statistic                 -7.241
P-value                         0.000
Lags                                0
------------------------------------

Trend: Constant
Critical Values: -3.52 (1%), -2.90 (5%), -2.59 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
"""
```

```
!pip install pmdarima
```

```
Collecting pmdarima
  Downloading pmdarima-2.0.4-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl.m
etadata (7.8 kB)
Requirement already satisfied: joblib>=0.11 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (1.4.2)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (3.0.11)
Requirement already satisfied: numpy>=1.21.2 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (1.26.4)
Requirement already satisfied: pandas>=0.19 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (2.2.2)
Requirement already satisfied: scikit-learn>=0.22 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (1.6.0)
Requirement already satisfied: scipy>=1.3.2 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (1.13.1)
Requirement already satisfied: statsmodels>=0.13.2 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (0.14.4)
Requirement already satisfied: urllib3 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (2.2.3)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (75.1.0)
Requirement already satisfied: packaging>=17.1 in
/usr/local/lib/python3.10/dist-packages (from pmdarima) (24.2)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima)
(2024.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima)
(2024.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/usr/local/lib/python3.10/dist-packages (from scikit-learn>=0.22-
>pmdarima) (3.5.0)
Requirement already satisfied: patsy>=0.5.6 in
/usr/local/lib/python3.10/dist-packages (from statsmodels>=0.13.2-
>pmdarima) (1.0.1)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2-
>pandas>=0.19->pmdarima) (1.17.0)
Downloading pmdarima-2.0.4-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl
(2.1 MB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.1/2.1 MB 33.8 MB/s eta
0:00:00
darima
Successfully installed pmdarima-2.0.4
```

```python
import pmdarima
pmdarima.arima.ndiffs(Crop)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
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/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
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51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
```

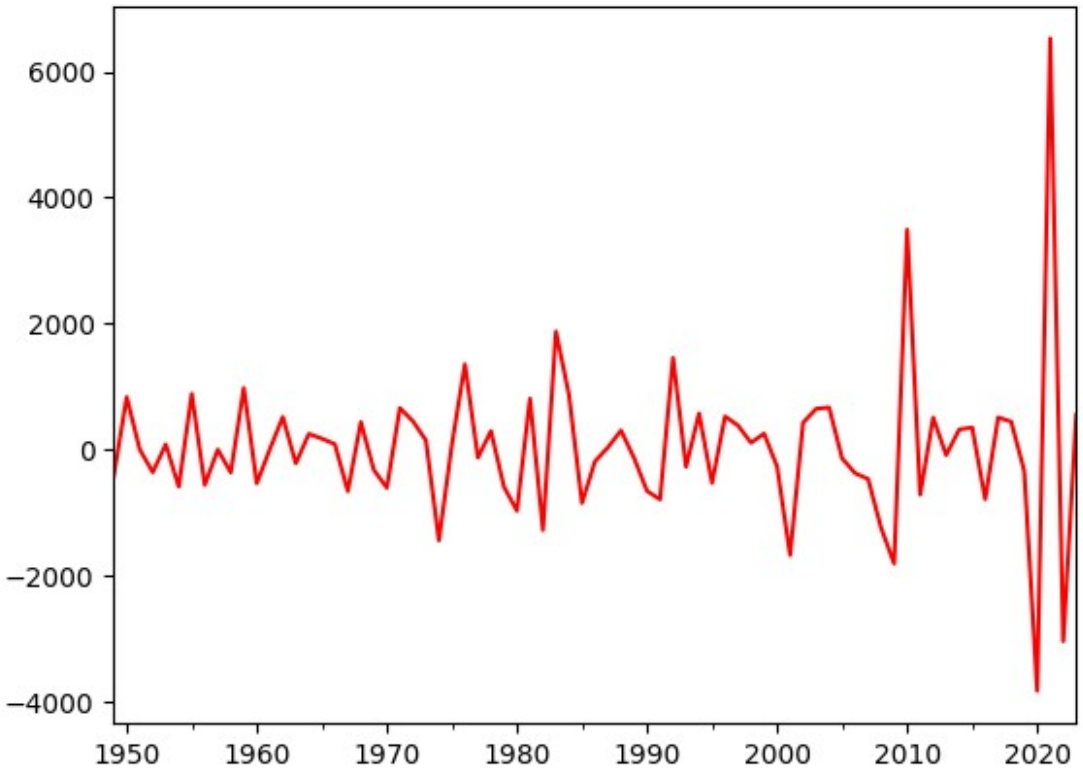
```
2
```

```
!pip install statsmodels.tsa.stattools
```

```
ERROR: Could not find a version that satisfies the requirement
statsmodels.tsa.stattools (from versions: none)
ERROR: No matching distribution found for statsmodels.tsa.stattools

from statsmodels.tsa.statespace.tools import diff
Cropdiff = diff(Crop)
Cropdiff = diff(Cropdiff)
Cropdiff1.plot(color='red')

<Axes: >
```




```
import pmdarima as pm
model = pm.auto_arima(Crop,max_p=2, max_q=2,
seasonal=False,trace=True)
model

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
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  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
```

```
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  warnings.warn(
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  warnings.warn(
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  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

Performing stepwise search to minimize aic
 ARIMA(2,2,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.31 sec
 ARIMA(0,2,0)(0,0,0)[0] intercept   : AIC=1283.929, Time=0.02 sec
 ARIMA(1,2,0)(0,0,0)[0] intercept   : AIC=1267.411, Time=0.03 sec
 ARIMA(0,2,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.09 sec
 ARIMA(0,2,0)(0,0,0)[0]             : AIC=1281.960, Time=0.02 sec

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
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  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
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/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(2,2,0)(0,0,0)[0] intercept   : AIC=1261.666, Time=0.09 sec

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(2,2,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.24 sec
 ARIMA(1,2,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.15 sec
 ARIMA(2,2,0)(0,0,0)[0]             : AIC=1259.699, Time=0.03 sec

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(1,2,0)(0,0,0)[0]             : AIC=1265.363, Time=0.03 sec
 ARIMA(2,2,1)(0,0,0)[0]             : AIC=1247.884, Time=0.11 sec

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
```
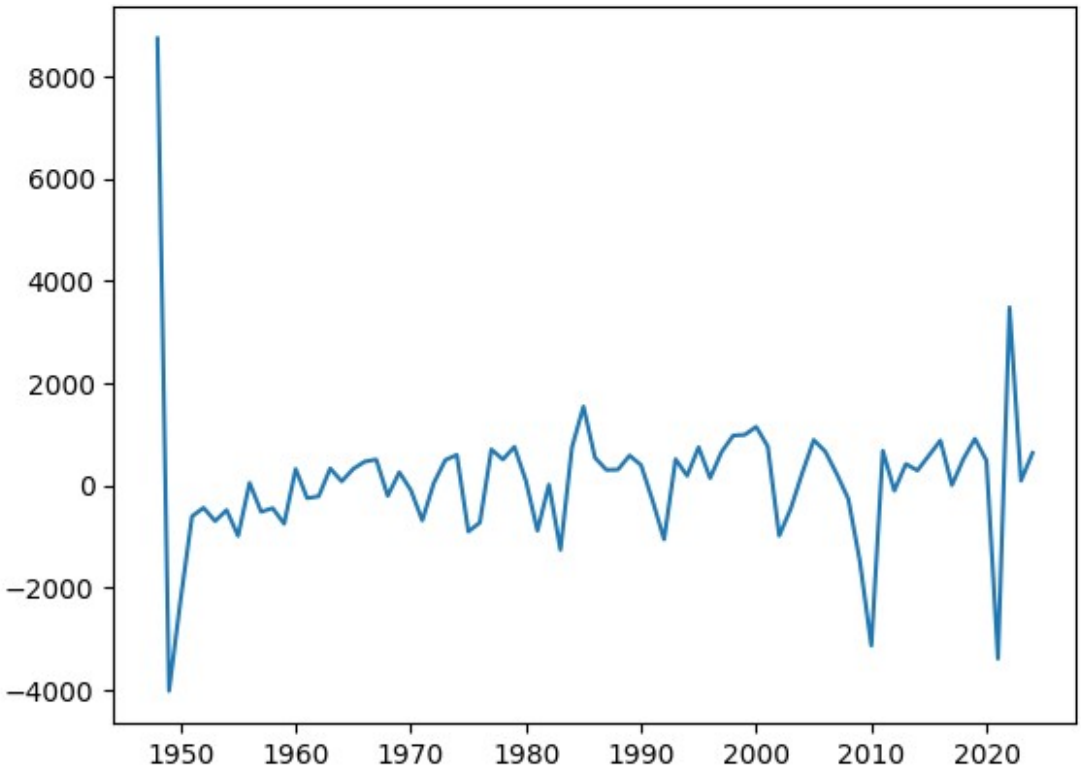

```
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(1,2,1)(0,0,0)[0]             : AIC=1245.917, Time=0.12 sec
 ARIMA(0,2,1)(0,0,0)[0]             : AIC=1244.431, Time=0.04 sec
 ARIMA(0,2,2)(0,0,0)[0]             : AIC=1245.903, Time=0.09 sec

/usr/local/lib/python3.10/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(1,2,2)(0,0,0)[0]             : AIC=1248.282, Time=0.11 sec

Best model:  ARIMA(0,2,1)(0,0,0)[0]
Total fit time: 1.510 seconds

ARIMA(order=(0, 2, 1), scoring_args={}, suppress_warnings=True,
      with_intercept=False)

from statsmodels.tsa.arima.model  import ARIMA
model = ARIMA(Crop, order=(0,2,1)).fit()
model.params
print(model.params)
model.aic
print(model.aic)

ma.L1         -0.898574
sigma2    822606.170846
dtype: float64
1244.4313001285873

resi = model.resid
from statsmodels.stats.diagnostic import acorr_ljungbox
acorr_ljungbox(resi,lags=8,boxpierce=True)

{"summary":"{\n  \"name\":
\"acorr_ljungbox(resi,lags=8,boxpierce=True)\",\n  \"rows\": 8,\n
\"fields\": [\n    {\n      \"column\": \"lb_stat\",\n
\"properties\": {\n        \"dtype\": \"number\",\n        \"std\":
0.29111141090819614,\n        \"min\": 1.9524470560493912,\n
\"max\": 2.8920102110465598,\n        \"num_unique_values\": 8,\n
\"samples\": [\n          2.5444527289573586,\n
```

```
2.749660143875047,\n          1.9524470560493912\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"lb_pvalue\",\n
\"properties\": {\n        \"dtype\": \"number\",\n        \"std\":
0.2928440373240872,\n        \"min\": 0.16232340100637732,\n
\"max\": 0.9409504809955623,\n        \"num_unique_values\": 8,\n
\"samples\": [\n          0.28020708371381436,\n
0.8395470837959395,\n          0.16232340100637732\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"bp_stat\",\n      \"properties\":
{\n        \"dtype\": \"number\",\n        \"std\":
0.2731689137022754,\n        \"min\": 1.8783034969589079,\n
\"max\": 2.7552874938213296,\n        \"num_unique_values\": 8,\n
\"samples\": [\n          2.440334199086725,\n
2.630364830956817,\n          1.8783034969589079\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"bp_pvalue\",\n
\"properties\": {\n        \"dtype\": \"number\",\n        \"std\":
0.29232829351084194,\n        \"min\": 0.1705270917041129,\n
\"max\": 0.9487637665010837,\n        \"num_unique_values\": 8,\n
\"samples\": [\n          0.2951808382194512,\n
0.8536019686669327,\n          0.1705270917041129\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    }\n  ]\n}","type":"dataframe"}
```


```
plt.plot(resi)
```

```
[<matplotlib.lines.Line2D at 0x789bd87ce800>]
```




```
model.forecast(steps=3)

2024-12-31    91138.301869
2025-12-31    92779.246738
2026-12-31    94420.191607
Freq: YE-DEC, Name: predicted_mean, dtype: float64
```