Import necessary libraries

In [2]:
```
import tensorflow as tf
import numpy as np
from tensorflow import keras
import matplotlib.pyplot as plt
import random
import os
import itertools
import datetime
from tensorflow.keras.layers.experimental.preprocessing import Rescaling
from tensorflow.keras import layers
from sklearn.metrics import precision_score, accuracy_score, recall_score, confusion_mat
```

Step 1: Data Preparation

Define directories for training and testing data

In [3]:
```
train_dir = 'New Plant Diseases Dataset(Augmented)/train'
test_dir = 'New Plant Diseases Dataset(Augmented)/valid'
```

Create image datasets for training and testing

In [4]:
```
train_data = keras.utils.image_dataset_from_directory(train_dir,
                                                      image_size=(224, 224),
                                                      label_mode='categorical',
                                                      batch_size=32)
```

```
Found 70295 files belonging to 38 classes.
```

In [5]:
```
test_data = keras.utils.image_dataset_from_directory(test_dir,
                                                     image_size=(224, 224),
                                                     label_mode='categorical',
                                                     batch_size=32)
```

```
Found 17572 files belonging to 38 classes.
```

Define class names based on the directory structure

In [6]:
```
class_names = train_data.class_names
class_names
```

Out[6]:
```
['Apple___Apple_scab',
 'Apple___Black_rot',
 'Apple___Cedar_apple_rust',
 'Apple___healthy',
 'Blueberry___healthy',
 'Cherry_(including_sour)___Powdery_mildew',
 'Cherry_(including_sour)___healthy',
 'Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot',
 'Corn_(maize)___Common_rust_',
 'Corn_(maize)___Northern_Leaf_Blight',
 'Corn_(maize)___healthy',
 'Grape___Black_rot',
 'Grape___Esca_(Black_Measles)',
 'Grape___Leaf_blight_(Isariopsis_Leaf_Spot)',
 'Grape___healthy',
 'Orange___Haunglongbing_(Citrus_greening)',
 'Peach___Bacterial_spot',
 'Peach___healthy',
```

```
 'Pepper,_bell___Bacterial_spot',
 'Pepper,_bell___healthy',
 'Potato___Early_blight',
 'Potato___Late_blight',
 'Potato___healthy',
 'Raspberry___healthy',
 'Soybean___healthy',
 'Squash___Powdery_mildew',
 'Strawberry___Leaf_scorch',
 'Strawberry___healthy',
 'Tomato___Bacterial_spot',
 'Tomato___Early_blight',
 'Tomato___Late_blight',
 'Tomato___Leaf_Mold',
 'Tomato___Septoria_leaf_spot',
 'Tomato___Spider_mites Two-spotted_spider_mite',
 'Tomato___Target_Spot',
 'Tomato___Tomato_Yellow_Leaf_Curl_Virus',
 'Tomato___Tomato_mosaic_virus',
 'Tomato___healthy']
```

Step 2: Model Creation

Define the input image shape

In [7]:
```
image_shape = (224, 224, 3)
```

Create a base model (EfficientNetB0) for feature extraction

In [8]:
```
base_model = tf.keras.applications.EfficientNetB0(include_top=False, weights='imagenet')
base_model.trainable = False
```

Create the main model by adding layers on top of the base model

In [9]:
```
inputs = layers.Input(shape=image_shape, name='input_layer')
x = base_model(inputs, training=False)
x = layers.GlobalAveragePooling2D(name='GlobalAveragePooling2D_layer')(x)
outputs = layers.Dense(len(class_names), activation='softmax', name='output_layer')(x)
feature_model = tf.keras.Model(inputs, outputs, name='Crop_Diseases_Detection_Model')
```

Set some layers in the base model as trainable

In [10]:
```
base_model.trainable = True
for layer in base_model.layers[:-20]:
    layer.trainable = False
```

Compile the model

In [11]:
```
feature_model.compile(
    loss='categorical_crossentropy',
    optimizer=tf.keras.optimizers.Adam(learning_rate=0.0001),
    metrics=['accuracy']
)
```

In [12]:
```
base_model.summary()
```

```
Model: "efficientnetb0"
_____
_____
```

```
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, None, None,  0           []
                                 3)]

 rescaling (Rescaling)          (None, None, None,   0           ['input_1[0][0]']
                                3)

 normalization (Normalization)  (None, None, None,   7           ['rescaling[0][0]']
                                3)

 rescaling_1 (Rescaling)        (None, None, None,   0           ['normalization[0][0]']
                                3)

 stem_conv_pad (ZeroPadding2D)  (None, None, None,   0           ['rescaling_1[0][0]']
                                3)

 stem_conv (Conv2D)             (None, None, None,   864         ['stem_conv_pad[0][0]']
                                32)

 stem_bn (BatchNormalization)   (None, None, None,   128         ['stem_conv[0][0]']
                                32)

 stem_activation (Activation)   (None, None, None,   0           ['stem_bn[0][0]']
                                32)

 block1a_dwconv (DepthwiseConv2  (None, None, None,   288        ['stem_activation[0]
[0]']
 D)                             32)

 block1a_bn (BatchNormalization  (None, None, None,   128        ['block1a_dwconv[0]
[0]']
 )                              32)

 block1a_activation (Activation  (None, None, None,   0          ['block1a_bn[0][0]']
```

```
 )                              32)

 block1a_se_squeeze (GlobalAver  (None, 32)          0           ['block1a_activation[0]
[0]']
 agePooling2D)

 block1a_se_reshape (Reshape)   (None, 1, 1, 32)     0           ['block1a_se_squeeze[0]
[0]']

 block1a_se_reduce (Conv2D)     (None, 1, 1, 8)      264         ['block1a_se_reshape[0]
[0]']

 block1a_se_expand (Conv2D)     (None, 1, 1, 32)     288         ['block1a_se_reduce[0]
[0]']

 block1a_se_excite (Multiply)   (None, None, None,   0           ['block1a_activation[0]
[0]',
                                32)                              'block1a_se_expand[0]
[0]']

 block1a_project_conv (Conv2D)  (None, None, None,   512         ['block1a_se_excite[0]
[0]']
                                16)

 block1a_project_bn (BatchNorma  (None, None, None,   64         ['block1a_project_conv
[0][0]']
 lization)                      16)

 block2a_expand_conv (Conv2D)   (None, None, None,   1536        ['block1a_project_bn[0]
[0]']
                                96)

 block2a_expand_bn (BatchNormal  (None, None, None,   384        ['block2a_expand_conv
[0][0]']
 ization)                       96)

 block2a_expand_activation (Act  (None, None, None,   0          ['block2a_expand_bn[0]
[0]']
 ivation)                       96)

 block2a_dwconv_pad (ZeroPaddin  (None, None, None,   0          ['block2a_expand_activa
tion[0][0]
 g2D)                           96)                              ']

 block2a_dwconv (DepthwiseConv2  (None, None, None,   864        ['block2a_dwconv_pad[0]
[0]']
```

```
 D)                             96)

 block2a_bn (BatchNormalization  (None, None, None,   384         ['block2a_dwconv[0]
[0]']
 )                              96)

 block2a_activation (Activation  (None, None, None,   0           ['block2a_bn[0][0]']

 )                              96)

 block2a_se_squeeze (GlobalAver  (None, 96)           0           ['block2a_activation[0]
[0]']
 agePooling2D)

 block2a_se_reshape (Reshape)   (None, 1, 1, 96)     0           ['block2a_se_squeeze[0]
[0]']

 block2a_se_reduce (Conv2D)     (None, 1, 1, 4)      388         ['block2a_se_reshape[0]
[0]']

 block2a_se_expand (Conv2D)     (None, 1, 1, 96)     480         ['block2a_se_reduce[0]
[0]']

 block2a_se_excite (Multiply)   (None, None, None,   0           ['block2a_activation[0]
[0]',
                                96)                               'block2a_se_expand[0]
[0]']

 block2a_project_conv (Conv2D)  (None, None, None,   2304        ['block2a_se_excite[0]
[0]']
                                24)

 block2a_project_bn (BatchNorma  (None, None, None,   96         ['block2a_project_conv
[0][0]']
 lization)                      24)

 block2b_expand_conv (Conv2D)   (None, None, None,   3456        ['block2a_project_bn[0]
[0]']
                                144)

 block2b_expand_bn (BatchNormal  (None, None, None,   576        ['block2b_expand_conv
[0][0]']
 ization)                       144)

 block2b_expand_activation (Act  (None, None, None,   0          ['block2b_expand_bn[0]
[0]']
```

```
 ivation)                       144)

 block2b_dwconv (DepthwiseConv2  (None, None, None,   1296       ['block2b_expand_activa
tion[0][0]
 D)                             144)                              ']

 block2b_bn (BatchNormalization  (None, None, None,   576        ['block2b_dwconv[0]
[0]']
 )                              144)

 block2b_activation (Activation  (None, None, None,   0          ['block2b_bn[0][0]']

 )                              144)

 block2b_se_squeeze (GlobalAver  (None, 144)         0           ['block2b_activation[0]
[0]']
 agePooling2D)

 block2b_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block2b_se_squeeze[0]
[0]']

 block2b_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block2b_se_reshape[0]
[0]']

 block2b_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block2b_se_reduce[0]
[0]']

 block2b_se_excite (Multiply)   (None, None, None,   0           ['block2b_activation[0]
[0]',
                                144)                              'block2b_se_expand[0]
[0]']

 block2b_project_conv (Conv2D)  (None, None, None,   3456        ['block2b_se_excite[0]
[0]']
                                24)

 block2b_project_bn (BatchNorma  (None, None, None,   96         ['block2b_project_conv
[0][0]']
 lization)                      24)

 block2b_drop (Dropout)         (None, None, None,   0          ['block2b_project_bn[0]
[0]']
                                24)

 block2b_add (Add)              (None, None, None,   0          ['block2b_drop[0][0]',
```

```
                                24)                                'block2a_project_bn[0]
[0]']

 block3a_expand_conv (Conv2D)   (None, None, None,   3456        ['block2b_add[0][0]']
                                144)

 block3a_expand_bn (BatchNormal  (None, None, None,   576        ['block3a_expand_conv
[0][0]']
 ization)                       144)

 block3a_expand_activation (Act  (None, None, None,   0          ['block3a_expand_bn[0]
[0]']
 ivation)                       144)

 block3a_dwconv_pad (ZeroPaddin  (None, None, None,   0          ['block3a_expand_activa
tion[0][0]
 g2D)                           144)                             ']

 block3a_dwconv (DepthwiseConv2  (None, None, None,   3600       ['block3a_dwconv_pad[0]
[0]']
 D)                             144)

 block3a_bn (BatchNormalization  (None, None, None,   576        ['block3a_dwconv[0]
[0]']
 )                              144)

 block3a_activation (Activation  (None, None, None,   0          ['block3a_bn[0][0]']

 )                              144)

 block3a_se_squeeze (GlobalAver  (None, 144)         0           ['block3a_activation[0]
[0]']
 agePooling2D)

 block3a_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block3a_se_squeeze[0]
[0]']

 block3a_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block3a_se_reshape[0]
[0]']

 block3a_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block3a_se_reduce[0]
[0]']

 block3a_se_excite (Multiply)   (None, None, None,   0           ['block3a_activation[0]
[0]',
```

```
                                144)                                'block3a_se_expand[0]
[0]']

 block3a_project_conv (Conv2D)  (None, None, None,   5760        ['block3a_se_excite[0]
[0]']
                                40)

 block3a_project_bn (BatchNorma  (None, None, None,   160        ['block3a_project_conv
[0][0]']
 lization)                      40)

 block3b_expand_conv (Conv2D)   (None, None, None,   9600        ['block3a_project_bn[0]
[0]']
                                240)

 block3b_expand_bn (BatchNormal  (None, None, None,   960        ['block3b_expand_conv
[0][0]']
 ization)                       240)

 block3b_expand_activation (Act  (None, None, None,   0          ['block3b_expand_bn[0]
[0]']
 ivation)                       240)

 block3b_dwconv (DepthwiseConv2  (None, None, None,   6000       ['block3b_expand_activa
tion[0][0]
 D)                             240)                             ']

 block3b_bn (BatchNormalization  (None, None, None,   960        ['block3b_dwconv[0]
[0]']
 )                              240)

 block3b_activation (Activation  (None, None, None,   0          ['block3b_bn[0][0]']

 )                              240)

 block3b_se_squeeze (GlobalAver  (None, 240)         0          ['block3b_activation[0]
[0]']
 agePooling2D)

 block3b_se_reshape (Reshape)   (None, 1, 1, 240)    0          ['block3b_se_squeeze[0]
[0]']

 block3b_se_reduce (Conv2D)     (None, 1, 1, 10)     2410       ['block3b_se_reshape[0]
[0]']
```

```
 block3b_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block3b_se_reduce[0]
[0]']

 block3b_se_excite (Multiply)   (None, None, None,   0           ['block3b_activation[0]
[0]',
                                240)                              'block3b_se_expand[0]
[0]']

 block3b_project_conv (Conv2D)  (None, None, None,   9600        ['block3b_se_excite[0]
[0]']
                                40)

 block3b_project_bn (BatchNorma  (None, None, None,   160        ['block3b_project_conv
[0][0]']
 lization)                      40)

 block3b_drop (Dropout)         (None, None, None,   0           ['block3b_project_bn[0]
[0]']
                                40)

 block3b_add (Add)              (None, None, None,   0           ['block3b_drop[0][0]',

                                40)                               'block3a_project_bn[0]
[0]']

 block4a_expand_conv (Conv2D)   (None, None, None,   9600        ['block3b_add[0][0]']

                                240)

 block4a_expand_bn (BatchNormal  (None, None, None,   960        ['block4a_expand_conv
[0][0]']
 ization)                       240)

 block4a_expand_activation (Act  (None, None, None,   0          ['block4a_expand_bn[0]
[0]']
 ivation)                       240)

 block4a_dwconv_pad (ZeroPaddin  (None, None, None,   0          ['block4a_expand_activa
tion[0][0]
 g2D)                           240)                             ']

 block4a_dwconv (DepthwiseConv2  (None, None, None,   2160       ['block4a_dwconv_pad[0]
[0]']
 D)                             240)

 block4a_bn (BatchNormalization  (None, None, None,   960        ['block4a_dwconv[0]
[0]']
```

```
 )                              240)

 block4a_activation (Activation  (None, None, None,   0          ['block4a_bn[0][0]']
 )                              240)

 block4a_se_squeeze (GlobalAver  (None, 240)         0           ['block4a_activation[0]
[0]']
 agePooling2D)

 block4a_se_reshape (Reshape)   (None, 1, 1, 240)    0           ['block4a_se_squeeze[0]
[0]']

 block4a_se_reduce (Conv2D)     (None, 1, 1, 10)     2410        ['block4a_se_reshape[0]
[0]']

 block4a_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block4a_se_reduce[0]
[0]']

 block4a_se_excite (Multiply)   (None, None, None,   0           ['block4a_activation[0]
[0]',
                                240)                             'block4a_se_expand[0]
[0]']

 block4a_project_conv (Conv2D)  (None, None, None,   19200       ['block4a_se_excite[0]
[0]']
                                80)

 block4a_project_bn (BatchNorma  (None, None, None,   320        ['block4a_project_conv
[0][0]']
 lization)                      80)

 block4b_expand_conv (Conv2D)   (None, None, None,   38400       ['block4a_project_bn[0]
[0]']
                                480)

 block4b_expand_bn (BatchNormal  (None, None, None,   1920       ['block4b_expand_conv
[0][0]']
 ization)                       480)

 block4b_expand_activation (Act  (None, None, None,   0          ['block4b_expand_bn[0]
[0]']
 ivation)                       480)

 block4b_dwconv (DepthwiseConv2  (None, None, None,   4320       ['block4b_expand_activa
tion[0][0]
```

```
 D)                             480)                                  ']

 block4b_bn (BatchNormalization  (None, None, None,   1920        ['block4b_dwconv[0]
[0]']
 )                              480)

 block4b_activation (Activation  (None, None, None,   0           ['block4b_bn[0][0]']

 )                              480)

 block4b_se_squeeze (GlobalAver  (None, 480)         0           ['block4b_activation[0]
[0]']
 agePooling2D)

 block4b_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4b_se_squeeze[0]
[0]']

 block4b_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4b_se_reshape[0]
[0]']

 block4b_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4b_se_reduce[0]
[0]']

 block4b_se_excite (Multiply)   (None, None, None,   0           ['block4b_activation[0]
[0]',
                                480)                                 'block4b_se_expand[0]
[0]']

 block4b_project_conv (Conv2D)  (None, None, None,   38400       ['block4b_se_excite[0]
[0]']
                                80)

 block4b_project_bn (BatchNorma  (None, None, None,   320        ['block4b_project_conv
[0][0]']
 lization)                      80)

 block4b_drop (Dropout)         (None, None, None,   0           ['block4b_project_bn[0]
[0]']
                                80)

 block4b_add (Add)              (None, None, None,   0           ['block4b_drop[0][0]',

                                80)                                  'block4a_project_bn[0]
[0]']

 block4c_expand_conv (Conv2D)   (None, None, None,   38400       ['block4b_add[0][0]']
```

```
                                480)

 block4c_expand_bn (BatchNormal  (None, None, None,   1920        ['block4c_expand_conv
[0][0]']
 ization)                       480)

 block4c_expand_activation (Act  (None, None, None,   0           ['block4c_expand_bn[0]
[0]']
 ivation)                       480)

 block4c_dwconv (DepthwiseConv2  (None, None, None,   4320        ['block4c_expand_activa
tion[0][0]
 D)                             480)                              ']

 block4c_bn (BatchNormalization  (None, None, None,   1920        ['block4c_dwconv[0]
[0]']
 )                              480)

 block4c_activation (Activation  (None, None, None,   0           ['block4c_bn[0][0]']

 )                              480)

 block4c_se_squeeze (GlobalAver  (None, 480)         0           ['block4c_activation[0]
[0]']
 agePooling2D)

 block4c_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4c_se_squeeze[0]
[0]']

 block4c_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4c_se_reshape[0]
[0]']

 block4c_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4c_se_reduce[0]
[0]']

 block4c_se_excite (Multiply)   (None, None, None,   0           ['block4c_activation[0]
[0]',
                                480)                              'block4c_se_expand[0]
[0]']

 block4c_project_conv (Conv2D)  (None, None, None,   38400       ['block4c_se_excite[0]
[0]']
                                80)

 block4c_project_bn (BatchNorma  (None, None, None,   320         ['block4c_project_conv
[0][0]']
```

```
 lization)                      80)

 block4c_drop (Dropout)         (None, None, None,   0           ['block4c_project_bn[0]
[0]']
                                80)

 block4c_add (Add)              (None, None, None,   0           ['block4c_drop[0][0]',
                                80)                               'block4b_add[0][0]']

 block5a_expand_conv (Conv2D)   (None, None, None,   38400       ['block4c_add[0][0]']
                                480)

 block5a_expand_bn (BatchNormal  (None, None, None,   1920       ['block5a_expand_conv
[0][0]']
 ization)                       480)

 block5a_expand_activation (Act  (None, None, None,   0          ['block5a_expand_bn[0]
[0]']
 ivation)                       480)

 block5a_dwconv (DepthwiseConv2  (None, None, None,   12000      ['block5a_expand_activa
tion[0][0]
 D)                             480)                              ']

 block5a_bn (BatchNormalization  (None, None, None,   1920       ['block5a_dwconv[0]
[0]']
 )                              480)

 block5a_activation (Activation  (None, None, None,   0          ['block5a_bn[0][0]']

 )                              480)

 block5a_se_squeeze (GlobalAver  (None, 480)         0           ['block5a_activation[0]
[0]']
 agePooling2D)

 block5a_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block5a_se_squeeze[0]
[0]']

 block5a_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block5a_se_reshape[0]
[0]']
```

```
 block5a_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block5a_se_reduce[0]
[0]']

 block5a_se_excite (Multiply)   (None, None, None,   0           ['block5a_activation[0]
[0]',
                                480)                              'block5a_se_expand[0]
[0]']

 block5a_project_conv (Conv2D)  (None, None, None,   53760       ['block5a_se_excite[0]
[0]']
                                112)

 block5a_project_bn (BatchNorma  (None, None, None,   448        ['block5a_project_conv
[0][0]']
 lization)                      112)

 block5b_expand_conv (Conv2D)   (None, None, None,   75264       ['block5a_project_bn[0]
[0]']
                                672)

 block5b_expand_bn (BatchNormal  (None, None, None,   2688       ['block5b_expand_conv
[0][0]']
 ization)                       672)

 block5b_expand_activation (Act  (None, None, None,   0          ['block5b_expand_bn[0]
[0]']
 ivation)                       672)

 block5b_dwconv (DepthwiseConv2  (None, None, None,   16800      ['block5b_expand_activa
tion[0][0]
 D)                             672)                             ']

 block5b_bn (BatchNormalization  (None, None, None,   2688       ['block5b_dwconv[0]
[0]']
 )                              672)

 block5b_activation (Activation  (None, None, None,   0          ['block5b_bn[0][0]']

 )                              672)

 block5b_se_squeeze (GlobalAver  (None, 672)         0           ['block5b_activation[0]
[0]']
 agePooling2D)

 block5b_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5b_se_squeeze[0]
[0]']
```

```
 block5b_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5b_se_reshape[0]
[0]']

 block5b_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5b_se_reduce[0]
[0]']

 block5b_se_excite (Multiply)   (None, None, None,   0           ['block5b_activation[0]
[0]',
                                672)                              'block5b_se_expand[0]
[0]']

 block5b_project_conv (Conv2D)  (None, None, None,   75264       ['block5b_se_excite[0]
[0]']
                                112)

 block5b_project_bn (BatchNorma  (None, None, None,   448        ['block5b_project_conv
[0][0]']
 lization)                      112)

 block5b_drop (Dropout)         (None, None, None,   0           ['block5b_project_bn[0]
[0]']
                                112)

 block5b_add (Add)              (None, None, None,   0           ['block5b_drop[0][0]',

                                112)                              'block5a_project_bn[0]
[0]']

 block5c_expand_conv (Conv2D)   (None, None, None,   75264       ['block5b_add[0][0]']

                                672)

 block5c_expand_bn (BatchNormal  (None, None, None,   2688       ['block5c_expand_conv
[0][0]']
 ization)                       672)

 block5c_expand_activation (Act  (None, None, None,   0          ['block5c_expand_bn[0]
[0]']
 ivation)                       672)

 block5c_dwconv (DepthwiseConv2  (None, None, None,   16800      ['block5c_expand_activa
tion[0][0]
 D)                             672)                             ']

 block5c_bn (BatchNormalization  (None, None, None,   2688       ['block5c_dwconv[0]
[0]']
```

```
 )                              672)

 block5c_activation (Activation  (None, None, None,   0          ['block5c_bn[0][0]']
 )                              672)

 block5c_se_squeeze (GlobalAver  (None, 672)         0           ['block5c_activation[0]
[0]']
 agePooling2D)

 block5c_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5c_se_squeeze[0]
[0]']

 block5c_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5c_se_reshape[0]
[0]']

 block5c_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5c_se_reduce[0]
[0]']

 block5c_se_excite (Multiply)   (None, None, None,   0           ['block5c_activation[0]
[0]',
                                672)                             'block5c_se_expand[0]
[0]']

 block5c_project_conv (Conv2D)  (None, None, None,   75264       ['block5c_se_excite[0]
[0]']
                                112)

 block5c_project_bn (BatchNorma  (None, None, None,   448        ['block5c_project_conv
[0][0]']
 lization)                      112)

 block5c_drop (Dropout)         (None, None, None,   0          ['block5c_project_bn[0]
[0]']
                                112)

 block5c_add (Add)              (None, None, None,   0          ['block5c_drop[0][0]',
                                112)                             'block5b_add[0][0]']

 block6a_expand_conv (Conv2D)   (None, None, None,   75264      ['block5c_add[0][0]']
                                672)

 block6a_expand_bn (BatchNormal  (None, None, None,   2688       ['block6a_expand_conv
[0][0]']
```

```
 ization)                       672)

 block6a_expand_activation (Act  (None, None, None,   0          ['block6a_expand_bn[0]
[0]']
 ivation)                       672)

 block6a_dwconv_pad (ZeroPaddin  (None, None, None,   0          ['block6a_expand_activa
tion[0][0]
 g2D)                           672)                             ']

 block6a_dwconv (DepthwiseConv2  (None, None, None,   16800      ['block6a_dwconv_pad[0]
[0]']
 D)                             672)

 block6a_bn (BatchNormalization  (None, None, None,   2688       ['block6a_dwconv[0]
[0]']
 )                              672)

 block6a_activation (Activation  (None, None, None,   0          ['block6a_bn[0][0]']

 )                              672)

 block6a_se_squeeze (GlobalAver  (None, 672)          0          ['block6a_activation[0]
[0]']
 agePooling2D)

 block6a_se_reshape (Reshape)   (None, 1, 1, 672)    0          ['block6a_se_squeeze[0]
[0]']

 block6a_se_reduce (Conv2D)     (None, 1, 1, 28)     18844      ['block6a_se_reshape[0]
[0]']

 block6a_se_expand (Conv2D)     (None, 1, 1, 672)    19488      ['block6a_se_reduce[0]
[0]']

 block6a_se_excite (Multiply)   (None, None, None,   0          ['block6a_activation[0]
[0]',
                                672)                             'block6a_se_expand[0]
[0]']

 block6a_project_conv (Conv2D)  (None, None, None,   129024     ['block6a_se_excite[0]
[0]']
                                192)

 block6a_project_bn (BatchNorma  (None, None, None,   768        ['block6a_project_conv
[0][0]']
```

```
 lization)                      192)

 block6b_expand_conv (Conv2D)   (None, None, None,   221184      ['block6a_project_bn[0]
[0]']
                                1152)

 block6b_expand_bn (BatchNormal  (None, None, None,   4608       ['block6b_expand_conv
[0][0]']
 ization)                       1152)

 block6b_expand_activation (Act  (None, None, None,   0          ['block6b_expand_bn[0]
[0]']
 ivation)                       1152)

 block6b_dwconv (DepthwiseConv2  (None, None, None,   28800      ['block6b_expand_activa
tion[0][0]
 D)                             1152)                            ']

 block6b_bn (BatchNormalization  (None, None, None,   4608       ['block6b_dwconv[0]
[0]']
 )                              1152)

 block6b_activation (Activation  (None, None, None,   0          ['block6b_bn[0][0]']

 )                              1152)

 block6b_se_squeeze (GlobalAver  (None, 1152)        0          ['block6b_activation[0]
[0]']
 agePooling2D)

 block6b_se_reshape (Reshape)   (None, 1, 1, 1152)   0          ['block6b_se_squeeze[0]
[0]']

 block6b_se_reduce (Conv2D)     (None, 1, 1, 48)     55344      ['block6b_se_reshape[0]
[0]']

 block6b_se_expand (Conv2D)     (None, 1, 1, 1152)   56448      ['block6b_se_reduce[0]
[0]']

 block6b_se_excite (Multiply)   (None, None, None,   0          ['block6b_activation[0]
[0]',
                                1152)                            'block6b_se_expand[0]
[0]']

 block6b_project_conv (Conv2D)  (None, None, None,   221184      ['block6b_se_excite[0]
[0]']
```

```
                                192)

 block6b_project_bn (BatchNorma  (None, None, None,   768         ['block6b_project_conv
[0][0]']
 lization)                      192)

 block6b_drop (Dropout)         (None, None, None,   0           ['block6b_project_bn[0]
[0]']
                                192)

 block6b_add (Add)              (None, None, None,   0           ['block6b_drop[0][0]',

                                192)                             'block6a_project_bn[0]
[0]']

 block6c_expand_conv (Conv2D)   (None, None, None,   221184      ['block6b_add[0][0]']

                                1152)

 block6c_expand_bn (BatchNormal  (None, None, None,   4608       ['block6c_expand_conv
[0][0]']
 ization)                       1152)

 block6c_expand_activation (Act  (None, None, None,   0          ['block6c_expand_bn[0]
[0]']
 ivation)                       1152)

 block6c_dwconv (DepthwiseConv2  (None, None, None,   28800      ['block6c_expand_activa
tion[0][0]
 D)                             1152)                            ']

 block6c_bn (BatchNormalization  (None, None, None,   4608       ['block6c_dwconv[0]
[0]']
 )                              1152)

 block6c_activation (Activation  (None, None, None,   0          ['block6c_bn[0][0]']

 )                              1152)

 block6c_se_squeeze (GlobalAver  (None, 1152)        0           ['block6c_activation[0]
[0]']
 agePooling2D)

 block6c_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6c_se_squeeze[0]
[0]']
```

```
 block6c_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6c_se_reshape[0]
[0]']

 block6c_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6c_se_reduce[0]
[0]']

 block6c_se_excite (Multiply)   (None, None, None,   0           ['block6c_activation[0]
[0]',
                                1152)                             'block6c_se_expand[0]
[0]']

 block6c_project_conv (Conv2D)  (None, None, None,   221184      ['block6c_se_excite[0]
[0]']
                                192)

 block6c_project_bn (BatchNorma  (None, None, None,   768        ['block6c_project_conv
[0][0]']
 lization)                      192)

 block6c_drop (Dropout)         (None, None, None,   0           ['block6c_project_bn[0]
[0]']
                                192)

 block6c_add (Add)              (None, None, None,   0           ['block6c_drop[0][0]',
                                192)                              'block6b_add[0][0]']

 block6d_expand_conv (Conv2D)   (None, None, None,   221184      ['block6c_add[0][0]']
                                1152)

 block6d_expand_bn (BatchNormal  (None, None, None,   4608       ['block6d_expand_conv
[0][0]']
 ization)                       1152)

 block6d_expand_activation (Act  (None, None, None,   0          ['block6d_expand_bn[0]
[0]']
 ivation)                       1152)

 block6d_dwconv (DepthwiseConv2  (None, None, None,   28800      ['block6d_expand_activa
tion[0][0]
 D)                             1152)                            ']

 block6d_bn (BatchNormalization  (None, None, None,   4608       ['block6d_dwconv[0]
[0]']
```

```
 )                              1152)

 block6d_activation (Activation  (None, None, None,   0          ['block6d_bn[0][0]']
 )                              1152)

 block6d_se_squeeze (GlobalAver  (None, 1152)        0           ['block6d_activation[0]
[0]']
 agePooling2D)

 block6d_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6d_se_squeeze[0]
[0]']

 block6d_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6d_se_reshape[0]
[0]']

 block6d_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6d_se_reduce[0]
[0]']

 block6d_se_excite (Multiply)   (None, None, None,   0           ['block6d_activation[0]
[0]',
                                1152)                            'block6d_se_expand[0]
[0]']

 block6d_project_conv (Conv2D)  (None, None, None,   221184      ['block6d_se_excite[0]
[0]']
                                192)

 block6d_project_bn (BatchNorma  (None, None, None,   768        ['block6d_project_conv
[0][0]']
 lization)                      192)

 block6d_drop (Dropout)         (None, None, None,   0           ['block6d_project_bn[0]
[0]']
                                192)

 block6d_add (Add)              (None, None, None,   0           ['block6d_drop[0][0]',
                                192)                             'block6c_add[0][0]']

 block7a_expand_conv (Conv2D)   (None, None, None,   221184      ['block6d_add[0][0]']
                                1152)

 block7a_expand_bn (BatchNormal  (None, None, None,   4608       ['block7a_expand_conv
[0][0]']
```

```
 ization)                       1152)

 block7a_expand_activation (Act  (None, None, None,   0          ['block7a_expand_bn[0]
[0]']
 ivation)                       1152)

 block7a_dwconv (DepthwiseConv2  (None, None, None,   10368      ['block7a_expand_activa
tion[0][0]
 D)                             1152)                            ']

 block7a_bn (BatchNormalization  (None, None, None,   4608       ['block7a_dwconv[0]
[0]']
 )                              1152)

 block7a_activation (Activation  (None, None, None,   0          ['block7a_bn[0][0]']

 )                              1152)

 block7a_se_squeeze (GlobalAver  (None, 1152)        0           ['block7a_activation[0]
[0]']
 agePooling2D)

 block7a_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block7a_se_squeeze[0]
[0]']

 block7a_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block7a_se_reshape[0]
[0]']

 block7a_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block7a_se_reduce[0]
[0]']

 block7a_se_excite (Multiply)   (None, None, None,   0           ['block7a_activation[0]
[0]',
                                1152)                            'block7a_se_expand[0]
[0]']

 block7a_project_conv (Conv2D)  (None, None, None,   368640      ['block7a_se_excite[0]
[0]']
                                320)

 block7a_project_bn (BatchNorma  (None, None, None,   1280       ['block7a_project_conv
[0][0]']
 lization)                      320)

 top_conv (Conv2D)              (None, None, None,   409600      ['block7a_project_bn[0]
[0]']
```

```
                                1280)

 top_bn (BatchNormalization)    (None, None, None,   5120        ['top_conv[0][0]']
                                1280)

 top_activation (Activation)    (None, None, None,   0           ['top_bn[0][0]']
                                1280)

==================================================================================================
Total params: 4,049,571
Trainable params: 1,350,960
Non-trainable params: 2,698,611
__________________________________________________________________________________________________
```

Step 3: Model Training

Create a function to set up TensorBoard logging

In [13]:
```
def create_tensorboard_callback(dir_name, experiment_name):
    log_dir = dir_name + "/" + experiment_name + "/" + datetime.datetime.now().strftime(
    tensorboard_callback = tf.keras.callbacks.TensorBoard(
        log_dir=log_dir
    )
    print(f"Saving TensorBoard log files to: {log_dir}")
    return tensorboard_callback
```

Set up callbacks for training

In [14]:
```
early_stopping = tf.keras.callbacks.EarlyStopping(monitor="val_loss", patience=3)
reduce_lr = tf.keras.callbacks.ReduceLROnPlateau(monitor="val_loss", factor=0.2, patienc
checkpoint_path = "fine_tune_checkpoints/"
model_checkpoint = tf.keras.callbacks.ModelCheckpoint(
    checkpoint_path,
    save_weights_only=True,
    save_best_only=True,
    monitor="val_loss"
)
```

Train the model with early stopping, learning rate reduction, and checkpointing

In [15]:
```
epochs = 10
history = feature_model.fit(train_data, epochs=epochs,
                            steps_per_epoch=len(train_data),
                            validation_data=test_data,
                            validation_steps=len(test_data),
                            callbacks=[early_stopping, model_checkpoint, reduce_lr,
                                       create_tensorboard_callback('Crop_Diseases_Detect
)
```

```
Saving TensorBoard log files to: Crop_Diseases_Detection_Model/EfficientNetB010/20231024
-185639
```

```
WARNING:tensorflow:Model failed to serialize as JSON. Ignoring... Unable to serialize
[2.0896919 2.1128857 2.1081853] to JSON. Unrecognized type <class 'tensorflow.python.fra
mework.ops.EagerTensor'>.
Epoch 1/10
2197/2197 [==============================] - 4475s 2s/step - loss: 0.2253 - accuracy: 0.
9371 - val_loss: 0.0563 - val_accuracy: 0.9817 - lr: 1.0000e-04
Epoch 2/10
2197/2197 [==============================] - 4603s 2s/step - loss: 0.0361 - accuracy: 0.
9880 - val_loss: 0.0390 - val_accuracy: 0.9875 - lr: 1.0000e-04
Epoch 3/10
2197/2197 [==============================] - 4848s 2s/step - loss: 0.0183 - accuracy: 0.
9941 - val_loss: 0.0321 - val_accuracy: 0.9908 - lr: 1.0000e-04
Epoch 4/10
2197/2197 [==============================] - 5152s 2s/step - loss: 0.0122 - accuracy: 0.
9964 - val_loss: 0.0276 - val_accuracy: 0.9912 - lr: 1.0000e-04
Epoch 5/10
2197/2197 [==============================] - 5088s 2s/step - loss: 0.0077 - accuracy: 0.
9976 - val_loss: 0.0282 - val_accuracy: 0.9912 - lr: 1.0000e-04
Epoch 6/10
2197/2197 [==============================] - 5001s 2s/step - loss: 0.0069 - accuracy: 0.
9979 - val_loss: 0.0210 - val_accuracy: 0.9936 - lr: 1.0000e-04
Epoch 7/10
2197/2197 [==============================] - 5114s 2s/step - loss: 0.0046 - accuracy: 0.
9985 - val_loss: 0.0174 - val_accuracy: 0.9953 - lr: 1.0000e-04
Epoch 8/10
2197/2197 [==============================] - 5147s 2s/step - loss: 0.0035 - accuracy: 0.
9989 - val_loss: 0.0191 - val_accuracy: 0.9943 - lr: 1.0000e-04
Epoch 9/10
2197/2197 [==============================] - ETA: 0s - loss: 0.0036 - accuracy: 0.9991
Epoch 9: ReduceLROnPlateau reducing learning rate to 1.9999999494757503e-05.
2197/2197 [==============================] - 5116s 2s/step - loss: 0.0036 - accuracy: 0.
9991 - val_loss: 0.0227 - val_accuracy: 0.9933 - lr: 1.0000e-04
Epoch 10/10
2197/2197 [==============================] - 5114s 2s/step - loss: 7.2055e-04 - accurac
y: 0.9999 - val_loss: 0.0148 - val_accuracy: 0.9962 - lr: 2.0000e-05
```

Step 4: Model Evaluation

Load the best model checkpoint

In [16]:
```
feature_model.load_weights(checkpoint_path)
```

Out[16]:
```
<tensorflow.python.checkpoint.checkpoint.CheckpointLoadStatus at 0x205ec03e770>
```

Evaluate the model on the test data

In [17]:
```
test_loss, test_accuracy = feature_model.evaluate(test_data)
```

```
550/550 [==============================] - 1028s 2s/step - loss: 0.0148 - accuracy: 0.99
62
```

Print the evaluation results

In [18]:
```
print(f"Test Loss: {test_loss:.2f}")
print(f"Test Accuracy: {test_accuracy * 100:.2f}%")
```

```
Test Loss: 0.01
Test Accuracy: 99.62%
```

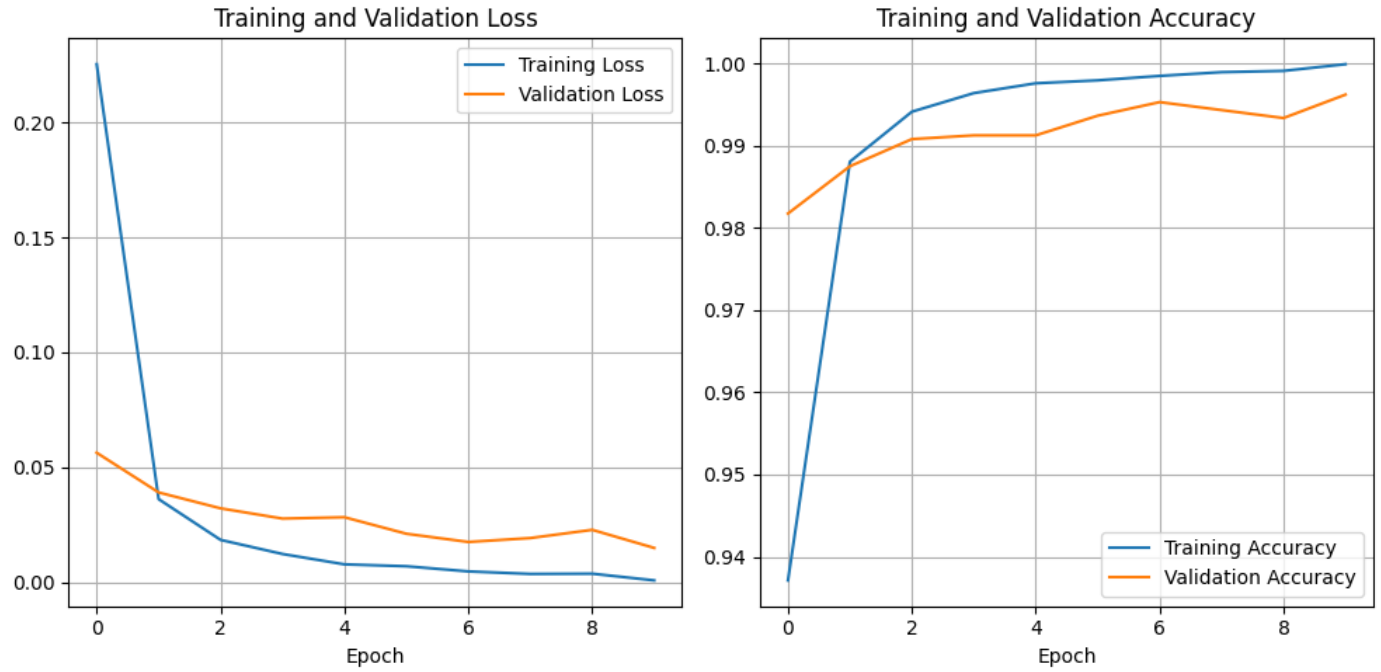
Step 5: Data Visualization and Model Metrics

Define a function to plot training history

In [19]:
```
def plot_history(history):
    loss = history.history['loss']
    val_loss = history.history['val_loss']
    epochs = history.epoch
    acc = history.history['accuracy']
    val_acc = history.history['val_accuracy']

    plt.figure(figsize=(10, 5))
    plt.subplot(1, 2, 1)
    plt.plot(epochs, loss, label='Training Loss')
    plt.plot(epochs, val_loss, label='Validation Loss')
    plt.title('Training and Validation Loss')
    plt.xlabel('Epoch')
    plt.legend()
    plt.grid(True)

    plt.subplot(1, 2, 2)
    plt.plot(epochs, acc, label='Training Accuracy')
    plt.plot(epochs, val_acc, label='Validation Accuracy')
    plt.title('Training and Validation Accuracy')
    plt.xlabel('Epoch')
    plt.legend()
    plt.grid(True)

    plt.tight_layout()
    plt.show()
```

Plot the training history

In [20]:
```
plot_history(history)
```



Calculate additional metrics for model evaluation

In [21]:
```
from sklearn.metrics import classification_report

def calculate_metrics(model, test_data):
    y_true = []
    y_pred = []
```

```
    for images, labels in test_data:
        y_true.extend(np.argmax(labels, axis=1))
        y_pred.extend(np.argmax(model.predict(images), axis=1))

    return y_true, y_pred
```

In [22]:
```
y_true, y_pred = calculate_metrics(feature_model, test_data)
```

```
1/1 [==============================] - 11s 11s/step
1/1 [==============================] - 4s 4s/step
1/1 [==============================] - 4s 4s/step
1/1 [==============================] - 4s 4s/step
1/1 [==============================] - 4s 4s/step
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1/1 [==============================] - 4s 4s/step
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1/1 [==============================] - 4s 4s/step
1/1 [==============================] - 5s 5s/step
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1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 12s 12s/step
1/1 [==============================] - 9s 9s/step
1/1 [==============================] - 8s 8s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 8s 8s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 6s 6s/step
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1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 8s 8s/step
1/1 [==============================] - 9s 9s/step
1/1 [==============================] - 11s 11s/step
1/1 [==============================] - 13s 13s/step
1/1 [==============================] - 8s 8s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 6s 6s/step
```

```
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 7s 7s/step
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 5s 5s/step
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Print classification report

In [23]:
```
print(classification_report(y_true, y_pred, target_names=class_names))
```

```
                                                    precision    recall  f1-score   supp
ort

                                Apple___Apple_scab       1.00      1.00      1.00
504
                                 Apple___Black_rot       1.00      1.00      1.00
497
                          Apple___Cedar_apple_rust       1.00      1.00      1.00
440
                                   Apple___healthy       1.00      1.00      1.00
502
                               Blueberry___healthy       1.00      1.00      1.00
454
          Cherry_(including_sour)___Powdery_mildew       1.00      1.00      1.00
421
                 Cherry_(including_sour)___healthy       1.00      1.00      1.00
456
Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot       0.99      0.96      0.97
410
                       Corn_(maize)___Common_rust_       1.00      1.00      1.00
477
               Corn_(maize)___Northern_Leaf_Blight       0.96      0.99      0.98
477
                            Corn_(maize)___healthy       1.00      1.00      1.00
465
                                 Grape___Black_rot       0.99      1.00      1.00
472
                      Grape___Esca_(Black_Measles)       1.00      0.99      1.00
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Grape___Leaf_blight_(Isariopsis_Leaf_Spot)	1.00	1.00	1.00	
Grape___healthy	1.00	1.00	1.00	
Orange___Haunglongbing_(Citrus_greening)	1.00	1.00	1.00	
Peach___Bacterial_spot	1.00	1.00	1.00	
Peach___healthy	1.00	1.00	1.00	
Pepper,_bell___Bacterial_spot	1.00	1.00	1.00	
Pepper,_bell___healthy	1.00	1.00	1.00	
Potato___Early_blight	1.00	1.00	1.00	
Potato___Late_blight	1.00	1.00	1.00	
Potato___healthy	1.00	1.00	1.00	
Raspberry___healthy	1.00	1.00	1.00	
Soybean___healthy	1.00	1.00	1.00	
Squash___Powdery_mildew	1.00	1.00	1.00	
Strawberry___Leaf_scorch	1.00	1.00	1.00	
Strawberry___healthy	1.00	1.00	1.00	
Tomato___Bacterial_spot	1.00	0.99	0.99	
Tomato___Early_blight	0.99	0.99	0.99	
Tomato___Late_blight	1.00	0.99	0.99	
Tomato___Leaf_Mold	1.00	0.99	0.99	
Tomato___Septoria_leaf_spot	1.00	0.98	0.99	
Tomato___Spider_mites Two-spotted_spider_mite	0.98	0.99	0.99	
Tomato___Target_Spot	0.98	0.98	0.98	
Tomato___Tomato_Yellow_Leaf_Curl_Virus	1.00	1.00	1.00	
Tomato___Tomato_mosaic_virus	1.00	1.00	1.00	
Tomato___healthy	1.00	1.00	1.00	
accuracy			1.00	17
macro avg	1.00	1.00	1.00	17
weighted avg	1.00	1.00	1.00	17

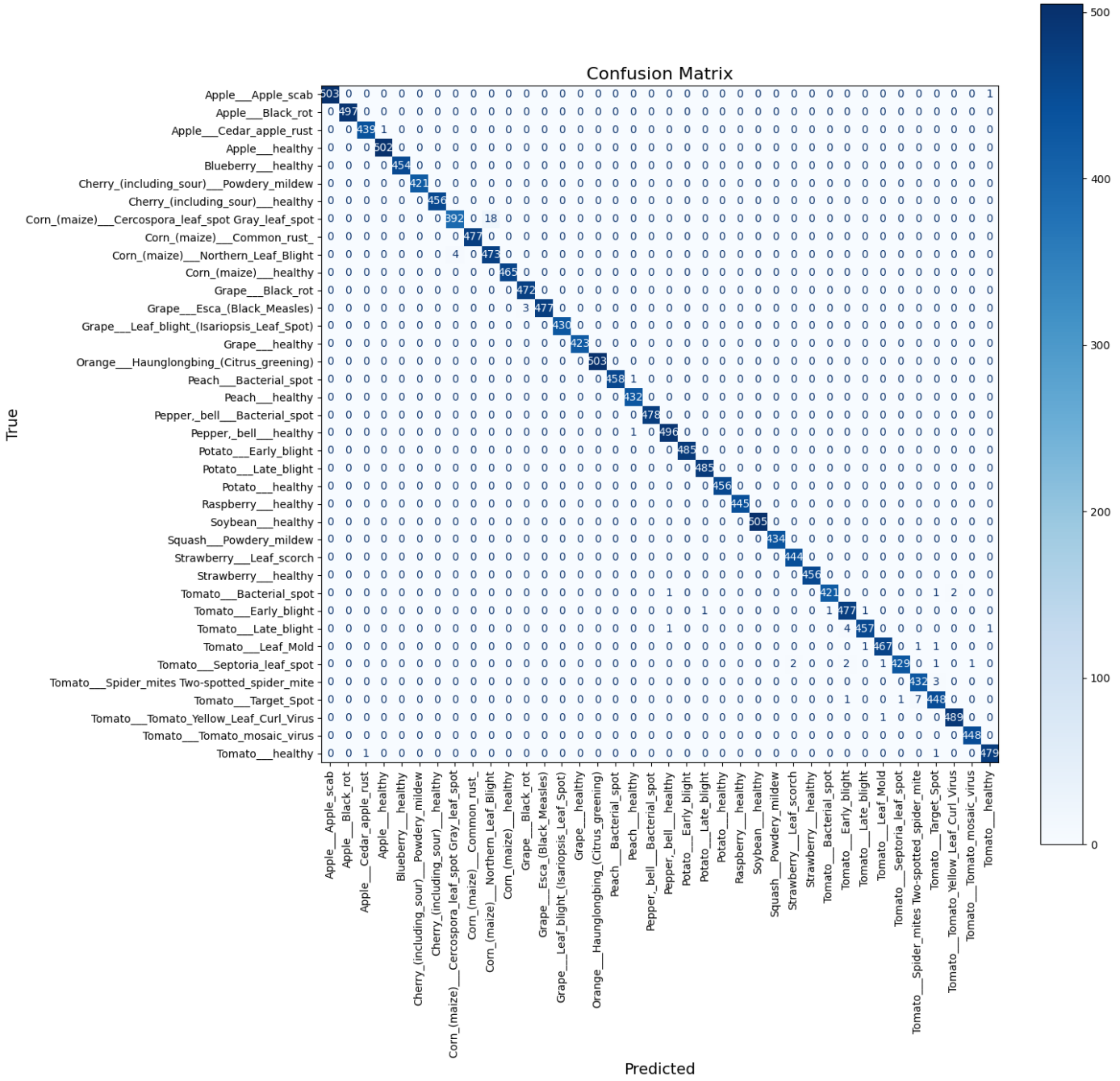
Compute the confusion matrix

In [24]:
```
confusion = confusion_matrix(y_true, y_pred)
```

Plot the confusion matrix

In [32]:

```
from sklearn.metrics import ConfusionMatrixDisplay

def plot_confusion_matrix(confusion, class_names):
    num_classes = len(class_names)
    fig, ax = plt.subplots(figsize=(14, 14))

    # Convert the confusion matrix values to integers
    confusion = confusion.astype(int)

    disp = ConfusionMatrixDisplay(confusion, display_labels=class_names)
    disp = disp.plot(cmap=plt.get_cmap("Blues"), values_format="d", ax=ax)

    # Rotate y-axis class names to be straight at 90 degrees
    ax.set_yticklabels(class_names, rotation=0, fontsize=10)

    # Set the tick labels and fontsize for x-axis
    tick_marks = np.arange(num_classes)
    plt.xticks(tick_marks, class_names, rotation=90, fontsize=10)

    plt.title("Confusion Matrix", fontsize=16)
    plt.xlabel("Predicted", fontsize=14)
    plt.ylabel("True", fontsize=14)
    plt.show()

plot_confusion_matrix(confusion, class_names)
```



Step 6: Save Model

In [34]:
```
tf.saved_model.save(feature_model, 'crop_disease_detection_model')
```

```
WARNING:absl:Found untraced functions such as _update_step_xla, _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op while saving (showing 5 of 82). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: crop_disease_detection_model\assets
INFO:tensorflow:Assets written to: crop_disease_detection_model\assets
```

Step 7: Image Prediction

Define a function to load and preprocess an image

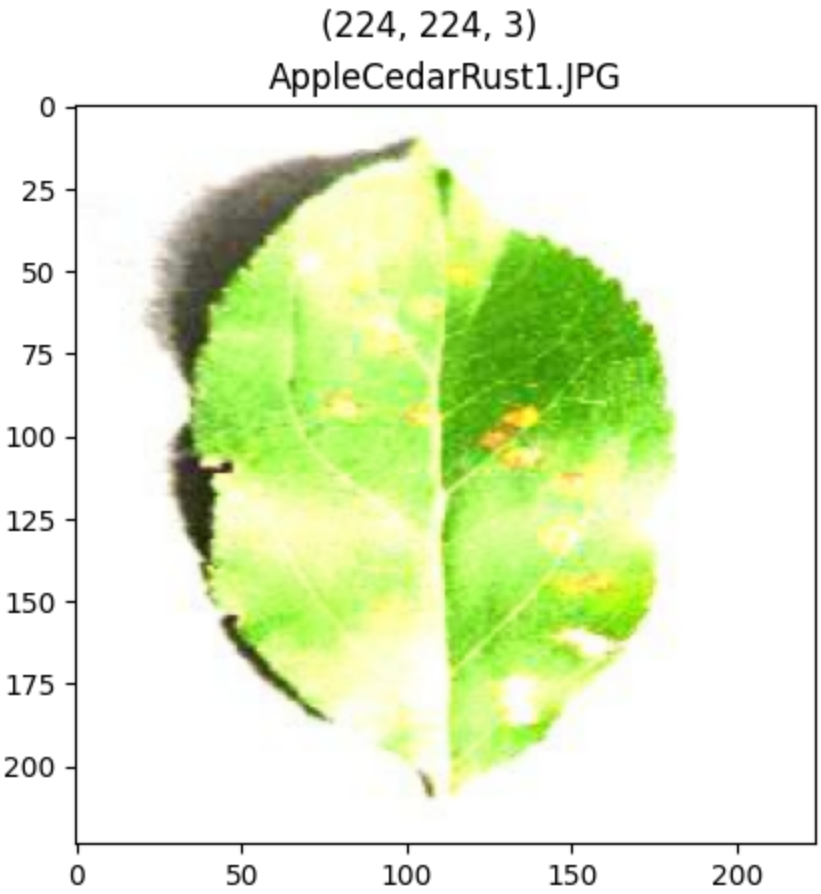
In [35]:
```
def load_prep(img_path):
    img = tf.io.read_file(img_path)
```

```
    img = tf.image.decode_image(img)
    img = tf.image.resize(img, size=(224, 224))
    return img
```

Load and preprocess an image, and make a prediction

In [36]:
```
image = load_prep('test/AppleCedarRust1.JPG')
plt.imshow(image / 255.)
plt.title('AppleCedarRust1.JPG')
plt.suptitle(image.shape)
```

Out[36]:
```
Text(0.5, 0.98, '(224, 224, 3)')
```



In [37]:
```
pred = feature_model.predict(tf.expand_dims(image, axis=0))
predicted_class = class_names[pred.argmax()]
predicted_prob = pred.max()
```

```
1/1 [==============================] - 0s 301ms/step
```

Print the predicted class and probability

In [38]:
```
print(f'Predicted Class: {predicted_class}')
print(f'Predicted Probability: {predicted_prob * 100:.2f}%')
```

```
Predicted Class: Apple___Cedar_apple_rust
Predicted Probability: 100.00%
```

Define a function to randomly select an image from the test data and make a prediction

In [41]:
```
def random_image_predict(model, test_dir=test_dir, class_names=class_names, rand_class=T
    if rand_class:
        ran_cls = random.randint(0, len(class_names) - 1)
        cls = class_names[ran_cls]

        # Get a list of all files in the class directory
```

```
        class_dir = os.path.join(test_dir, cls)
        files = os.listdir(class_dir)

        # Choose a random file from the list
        random_file = random.choice(files)

        # Create the full path to the random file
        ran_path = os.path.join(class_dir, random_file)
    else:
        cls = class_names[cls_name]

        # Get a list of all files in the class directory
        class_dir = os.path.join(test_dir, cls)
        files = os.listdir(class_dir)

        # Choose a random file from the list
        random_file = random.choice(files)

        # Create the full path to the random file
        ran_path = os.path.join(class_dir, random_file)

    prep_img = load_prep(ran_path)

    pred = model.predict(tf.expand_dims(prep_img, axis=0))
    pred_cls = class_names[pred[0].argmax()]
    pred_percent = pred[0][pred[0].argmax()] * 100
    plt.imshow(prep_img / 255.)
    if pred_cls == cls:
        c = 'g'
    else:
        c = 'r'
    plt.title(f'Actual: {cls}\nPredicted: {pred_cls}\nProbability: {pred_percent:.2f}%',
    plt.axis(False)
```

Display 9 randomly predicted images from the test data

In [42]:
```
plt.figure(figsize=(15, 15))
for i in range(9):
    plt.subplot(3, 3, i + 1)
    random_image_predict(feature_model, test_dir)
```

```
1/1 [==============================] - 0s 280ms/step
1/1 [==============================] - 0s 279ms/step
1/1 [==============================] - 0s 282ms/step
1/1 [==============================] - 0s 275ms/step
1/1 [==============================] - 0s 270ms/step
1/1 [==============================] - 0s 272ms/step
1/1 [==============================] - 0s 267ms/step
1/1 [==============================] - 0s 265ms/step
1/1 [==============================] - 0s 274ms/step
```

Define a directory containing images for prediction

In [43]:
```
data_dir = 'test'
plt.figure(figsize=(15, 10))
for i in range(9):
    plt.subplot(3, 3, i + 1)
    rn = random.choice(os.listdir(data_dir))
    image_path = os.path.join(data_dir, rn)
    img = load_prep(image_path)
    pred = feature_model.predict(tf.expand_dims(img, axis=0))
    pred_name = class_names[pred.argmax()]
    plt.imshow(img / 255.)
    plt.title(f'True: {rn}\nPredicted Class: {pred_name}')
    plt.axis(False)
```

```
1/1 [==============================] - 0s 362ms/step
1/1 [==============================] - 0s 424ms/step
1/1 [==============================] - 0s 300ms/step
1/1 [==============================] - 0s 287ms/step
1/1 [==============================] - 0s 315ms/step
1/1 [==============================] - 0s 267ms/step
```

```
1/1 [==============================] - 0s 271ms/step
1/1 [==============================] - 0s 265ms/step
1/1 [==============================] - 0s 272ms/step
```

True: TomatoEarlyBlight5.JPG
Predicted Class: Tomato___Early_blight

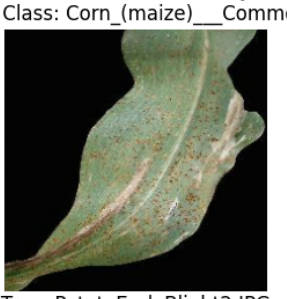
True: PotatoEarlyBlight5.JPG
Predicted Class: Potato___Early_blight

True: AppleScab3.JPG
Predicted Class: Apple___Apple_scab

True: TomatoHealthy4.JPG
Predicted Class: Tomato___healthy

True: PotatoHealthy1.JPG
Predicted Class: Potato___healthy

True: CornCommonRust1.JPG
Predicted Class: Corn_(maize)___Common_rust_



True: PotatoHealthy2.JPG
Predicted Class: Potato___healthy

True: TomatoEarlyBlight5.JPG
Predicted Class: Tomato___Early_blight

True: PotatoEarlyBlight2.JPG
Predicted Class: Potato___Early_blight

Define a function to predict an image from a given path

In [44]:
```
def predict_img(img_path, model=feature_model):
    img = load_prep(img_path)
    pred = model.predict(tf.expand_dims(img, axis=0))
    pred_name = class_names[pred.argmax()]
    plt.imshow(img / 255.)
    plt.title(f'Predicted Class: {pred_name}')
    plt.axis(False)
```

Step 9: Image Prediction for load Crop Diseases Detection model

In [51]:
```
loaded_model = tf.saved_model.load('crop_disease_detection_model')
```

Define a function to load and preprocess an image

In [52]:
```
def load_prep(img_path):
    img = tf.io.read_file(img_path)
    img = tf.image.decode_image(img)
    img = tf.image.resize(img, size=(224, 224))
    return img
```

Define the directory containing the images for prediction

```
image_directory = 'test'
```

In [53]:

Get a list of image file paths

In [54]:
```
image_paths = [os.path.join(image_directory, img) for img in os.listdir(image_directory)
```

Make predictions on each image

In [56]:
```
predictions = []

for img_path in image_paths:
    img = load_prep(img_path)
    img = tf.expand_dims(img, axis=0)

    # Run inference using the loaded model
    prediction = loaded_model(img)
    predicted_class = class_names[np.argmax(prediction)]
    predictions.append((img_path, predicted_class))
```

Display the predictions

In [57]:
```
for img_path, predicted_class in predictions:
    print(f'Image: {os.path.basename(img_path)} - Predicted Class: {predicted_class}')
```

```
Image: AppleCedarRust1.JPG - Predicted Class: Apple___Cedar_apple_rust
Image: AppleCedarRust2.JPG - Predicted Class: Apple___Cedar_apple_rust
Image: AppleCedarRust3.JPG - Predicted Class: Apple___Cedar_apple_rust
Image: AppleCedarRust4.JPG - Predicted Class: Apple___Cedar_apple_rust
Image: AppleScab1.JPG - Predicted Class: Apple___Apple_scab
Image: AppleScab2.JPG - Predicted Class: Apple___Apple_scab
Image: AppleScab3.JPG - Predicted Class: Apple___Apple_scab
Image: CornCommonRust1.JPG - Predicted Class: Corn_(maize)___Common_rust_
Image: CornCommonRust2.JPG - Predicted Class: Corn_(maize)___Common_rust_
Image: CornCommonRust3.JPG - Predicted Class: Corn_(maize)___Common_rust_
Image: PotatoEarlyBlight1.JPG - Predicted Class: Potato___Early_blight
Image: PotatoEarlyBlight2.JPG - Predicted Class: Potato___Early_blight
Image: PotatoEarlyBlight3.JPG - Predicted Class: Potato___Early_blight
Image: PotatoEarlyBlight4.JPG - Predicted Class: Potato___Early_blight
Image: PotatoEarlyBlight5.JPG - Predicted Class: Potato___Early_blight
Image: PotatoHealthy1.JPG - Predicted Class: Potato___healthy
Image: PotatoHealthy2.JPG - Predicted Class: Potato___healthy
Image: TomatoEarlyBlight1.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoEarlyBlight2.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoEarlyBlight3.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoEarlyBlight4.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoEarlyBlight5.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoEarlyBlight6.JPG - Predicted Class: Tomato___Early_blight
Image: TomatoHealthy1.JPG - Predicted Class: Tomato___healthy
Image: TomatoHealthy2.JPG - Predicted Class: Tomato___healthy
Image: TomatoHealthy3.JPG - Predicted Class: Tomato___healthy
Image: TomatoHealthy4.JPG - Predicted Class: Tomato___healthy
Image: TomatoYellowCurlVirus1.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
Image: TomatoYellowCurlVirus2.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
Image: TomatoYellowCurlVirus3.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
Image: TomatoYellowCurlVirus4.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
Image: TomatoYellowCurlVirus5.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
Image: TomatoYellowCurlVirus6.JPG - Predicted Class: Tomato___Tomato_Yellow_Leaf_Curl_Vi
rus
```

In [ ]: