# Cotton Leaf Disease Detector Analysis

## Training Phase Comparison – Cotton Leaf Disease Classification

### MobileNetV2 (Baseline)

**Phase 1 (frozen backbone, 10 epochs):**

- Started at 64% train / 91% val accuracy.
- Validation accuracy improved sharply within first 3 epochs (reaching 94–95%).
- By epoch 10: ~97.6% train / ~95.5% val accuracy, with validation loss stable (~0.145).
- No overfitting; solid transfer learning performance.

**Phase 2 (fine-tuning, 20 epochs):**

- Began at 97.3% train / 96.4% val accuracy.
- Over 20 epochs, validation accuracy peaked at ~97.0% (epochs 5–10), and then plateaued.
- Training accuracy pushed past 99%, indicating near-complete fitting to training set.
- Slight fluctuations in val accuracy (96–97%) during later epochs → mild overfitting.

MobileNetV2 stabilized quickly, delivering peak val accuracy ~97% within 30 epochs. Its lightweight design makes it efficient and fast, ideal when resources are limited.

### EfficientNetB3 (Deeper Model)

**Phase 1 (frozen backbone, 10 epochs):**

- Started weaker: 44% train / 83% val accuracy.
- Improved gradually across 10 epochs → ended with ~93% train / ~94.5% val accuracy.

- Still behind MobileNetV2 at this stage, but loss trends showed stronger long-term potential.

**Phase 2 (fine-tuning, 20 epochs):**

- Began at 96.2% val accuracy in the first epoch of fine-tuning.
- Across 20 epochs, validation accuracy steadily climbed to ~98%, with val loss dropping as low as 0.062.
- Training accuracy exceeded 98.5%, improving smoothly with no instability.
- Unlike MobileNetV2, EfficientNetB3 kept improving throughout fine-tuning, showing better capacity for complex feature learning.

**Summary:** EfficientNetB3 required more training (slower convergence), but outperformed MobileNetV2 by the end of 30 epochs, reaching ~98% val accuracy with lower validation loss.

## Direct Comparison – Cotton Leaf Disease Classification

| Model | Final Train Acc | Final Val Acc | Overfitting Signs |
|---|---|---|---|
| **MobileNetV2** | ~99% | ~97% | Mild overfit (train > val, small gap ~2%) |
| **EfficientNetB3** | ~98.5% | ~98% | Very low overfit (gap <1%, smooth loss trend) |

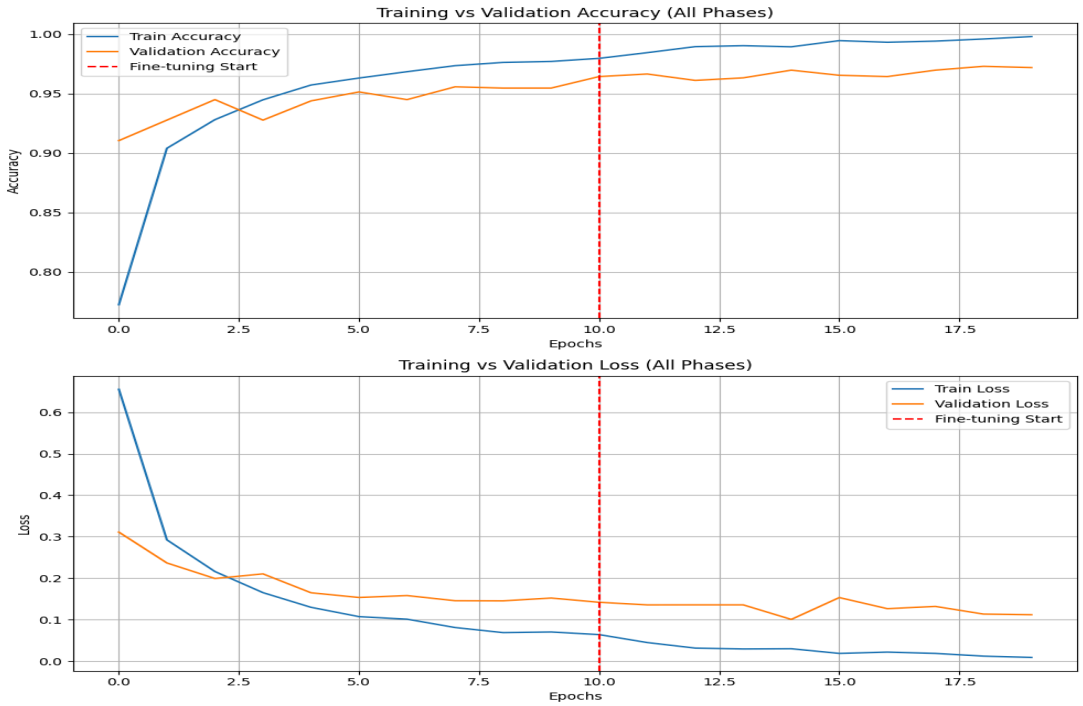
## Conclusion

- MobileNetV2 → fast convergence, lighter model, reached 97% validation accuracy, but plateaued early. Shows mild overfitting once training exceeded 99%.
- EfficientNetB3 → slower convergence but surpassed MobileNetV2, reaching ~98% validation accuracy with lower log loss (0.176 vs 0.255). It generalizes slightly better, with smoother learning and minimal overfitting.

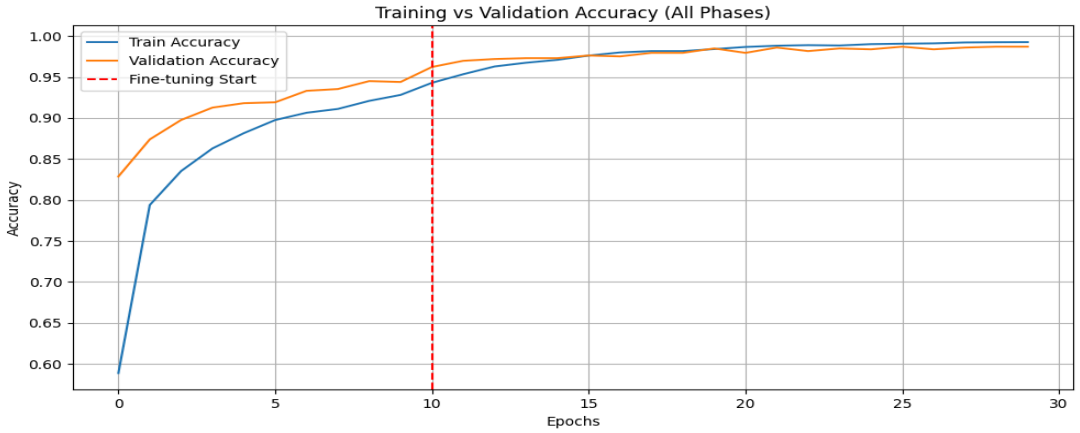
EfficientNetB3 is the stronger model for cotton disease classification, offering higher validation accuracy and more stable generalization despite requiring more compute.

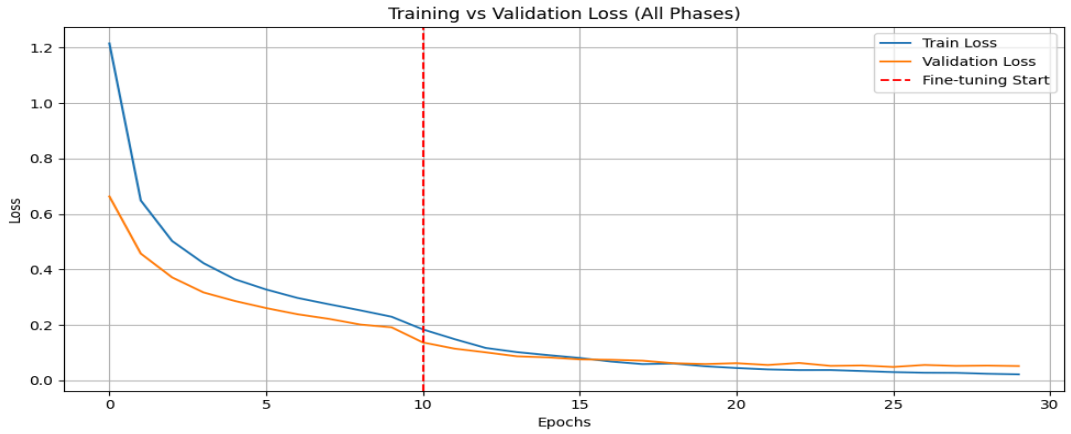
## Training / Validation accuracy & loss curves:

Mobilenetv2:




Efficientnetb3:




The training and validation curves show notable distinctions between EfficientNetB3 and MobileNetV2. EfficientNetB3 exhibits consistently strong performance, with both training and validation accuracy steadily increasing and closely tracking each other throughout training. After the fine-tuning phase (epoch 10), the model continues to improve, ultimately reaching nearly 99% validation accuracy with very low validation loss—indicating excellent generalization and minimal overfitting.

On the other hand, MobileNetV2 also demonstrates solid improvement, but its validation accuracy plateaus around 96–97%, with a persistent gap between training and validation curves, especially post fine-tuning. This suggests mild overfitting, as the model fits the training data better than the validation set. Additionally, the validation loss for MobileNetV2 fluctuates more than EfficientNetB3's, particularly in the fine-tuning phase, which may point to less stable generalization.

Overall, EfficientNetB3 not only converged more smoothly and to a higher accuracy, but also showed more stable and reliable validation performance, making it the superior model for this task.

## Metrics:

### Confusion Matrix Observations

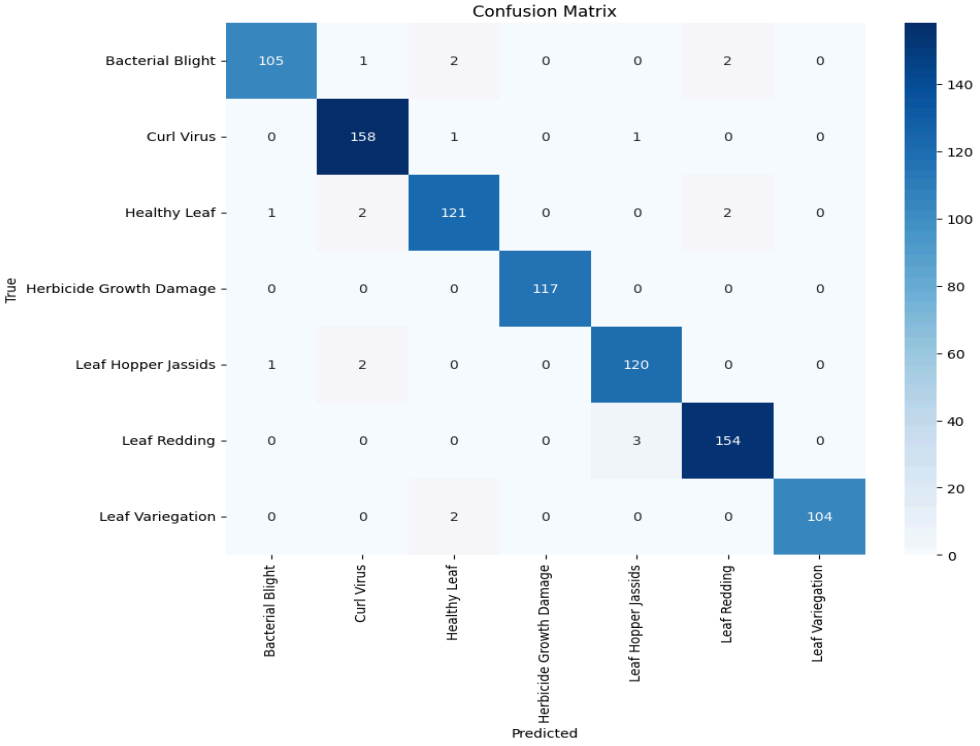
**MobileNetV2:**

- Overall performance is strong, but a few patterns of confusion are noticeable.
- *Bacterial Blight* shows minor misclassifications into *Healthy Leaf* (2) and *Leaf Redding* (2).
- *Curl Virus* and *Healthy Leaf* are mostly well separated, but a few cross-errors occur (e.g., 2 healthy misclassified as curl, 2 curl misclassified as healthy).
- *Leaf Redding* vs. *Leaf Hopper Jassids* shows small but consistent confusion (3 cases).
- Most other classes (Herbicide Growth Damage, Leaf Variegation) are almost perfectly classified.

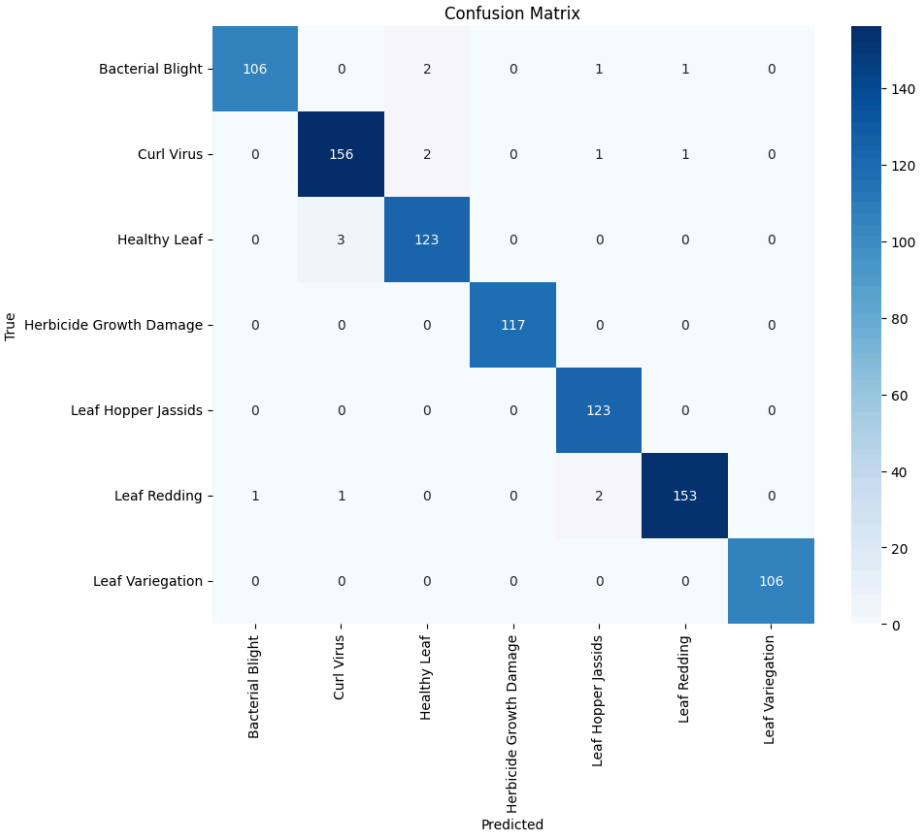
**EfficientNetB3:**

- Delivers clearer separation across nearly all classes compared to MobileNetV2.
- *Healthy Leaf* still shows a few errors with *Curl Virus* (3 cases), but overall confusion is reduced.
- *Bacterial Blight* and *Curl Virus* are classified with higher precision, with only 1–2 errors each.
- *Leaf Hopper Jassids* achieves perfect recognition (123/123).
- *Leaf Variegation* and *Herbicide Growth Damage* are also classified with complete accuracy.
- The only minor overlap is between *Leaf Redding* and other classes (a total of 4 misclassifications).

## Mobilenetv2




## Efficientnetb3:



**Summary:**
MobileNetV2 performs well but exhibits small confusions between visually similar conditions (*Healthy vs. Curl Virus*, *Leaf Redding vs. Jassids*). EfficientNetB3, however, provides more distinct class separation, nearly perfect recognition for several categories, and overall fewer misclassifications.

## Classification Report

**MobileNetV2:**

- Accuracy: ~0.98
- Macro Precision/Recall/F1: ~0.98
- Weakest class: *Bacterial Blight* (recall = 0.95, slightly lower than others).
- mAP: 0.9972

**EfficientNetB3:**

- Accuracy: ~0.98
- Macro Precision/Recall/F1: ~0.98
- Weakest class: *Bacterial Blight* (recall = 0.96, but precision higher = 0.99).
- mAP: 0.9987

Mobilenetv2 Efficientnetb3

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Classification Report:

                     precision    recall  f1-score   support

      Bacterial Blight       0.98      0.95      0.97       110
             Curl Virus       0.97      0.99      0.98       160
           Healthy Leaf       0.96      0.96      0.96       126
Herbicide Growth Damage       1.00      1.00      1.00       117
    Leaf Hopper Jassids       0.97      0.98      0.97       123
           Leaf Redding       0.97      0.98      0.98       157
      Leaf Variegation       1.00      0.98      0.99       106

               accuracy                           0.98       899
              macro avg       0.98      0.98      0.98       899
           weighted avg       0.98      0.98      0.98       899

AP for Bacterial Blight: 0.9968
AP for Curl Virus: 0.9967
AP for Healthy Leaf: 0.9946
AP for Herbicide Growth Damage: 1.0000
AP for Leaf Hopper Jassids: 0.9951
AP for Leaf Redding: 0.9971
AP for Leaf Variegation: 1.0000

Mean Average Precision (mAP): 0.9972
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Classification Report:

                     precision    recall  f1-score   support

      Bacterial Blight       0.99      0.96      0.98       110
             Curl Virus       0.97      0.97      0.97       160
           Healthy Leaf       0.97      0.98      0.97       126
Herbicide Growth Damage       1.00      1.00      1.00       117
    Leaf Hopper Jassids       0.97      1.00      0.98       123
           Leaf Redding       0.99      0.97      0.98       157
      Leaf Variegation       1.00      1.00      1.00       106

               accuracy                           0.98       899
              macro avg       0.98      0.98      0.98       899
           weighted avg       0.98      0.98      0.98       899

AP for Bacterial Blight: 0.9994
AP for Curl Virus: 0.9977
AP for Healthy Leaf: 0.9954
AP for Herbicide Growth Damage: 1.0000
AP for Leaf Hopper Jassids: 0.9994
AP for Leaf Redding: 0.9993
AP for Leaf Variegation: 1.0000

Mean Average Precision (mAP): 0.9987
```

**Direct Comparison**

- Both models reach 98% accuracy and balanced precision/recall across all classes.
- MobileNetV2 shows slightly weaker recall on *Bacterial Blight* (0.95).
- EfficientNetB3 achieves higher mAP (0.9987 vs 0.9972) and improves class-wise stability (perfect scores for *Herbicide Damage* & *Leaf Variegation*, and near-perfect for *Leaf Hopper Jassids*).
- Overall: EfficientNetB3 is marginally better – especially in average precision and balanced recognition across all cotton leaf diseases.

## Top-K Accuracy

| Metric | MobileNetV2 | EfficientNetB3 |
|---|---|---|
| **Top-1 Accuracy** | 0.9778 (~97.8%) | 0.9833 (~98.3%) |
| **Top-3 Accuracy** | 0.9978 (~99.8%) | 1.0000 (100%) |

| | | |
|---|---|---|
| **Top-5 Accuracy** | 1.0000 (100%) | 1.0000 (100%) |

- Both models are excellent → very high accuracy, near-perfect Top-3 & Top-5.
- EfficientNetB3 edges ahead with slightly higher Top-1 accuracy (98.3% vs 97.8%) and a perfect Top-3 score.
- In real-world use (like farmer diagnosis apps showing top-3 predictions), EfficientNetB3 would be practically flawless.

### Log Loss (Cotton Dataset)

| Metric | MobileNetV2 | EfficientNetB3 |
|---|---|---|
| **Log Loss** | 0.0670 | 0.0492 |

- MobileNetV2:
  Log loss of 0.0670 → predictions are solid but slightly less confident; probabilities don't perfectly match the true outcomes.
- EfficientNetB3:
  Log loss of 0.0492 → lower than MobileNetV2, meaning predictions are both more accurate and better calibrated. The model is more confident while still being correct.

EfficientNetB3 clearly outperforms MobileNetV2 in terms of probability calibration and confidence, making it the stronger choice for a decision-support system (where reliable probabilities are as important as raw accuracy).

## Overall Results: MobileNetV2 vs EfficientNetB3 (Cotton Leaf Disease Detection)

| Metric | MobileNetV2 | EfficientNetB3 | Better |
|---|---|---|---|
| **Validation Accuracy (final)** | 97% | 98.5% | EfficientNetB3 |
| **Precision / Recall / F1 (avg.)** | ~0.98 | ~0.98 | Tie (slight edge to B3 on certain classes) |
| **Confusion Matrix Insights** | Very strong overall, but a few misclassifications (e.g., Bacterial Blight recall slightly lower). | Balanced across all classes; higher recall for tricky cases like Leaf Hopper Jassids & Leaf Redding. | EfficientNetB3 |
| **mAP (Mean Average Precision)** | 0.9972 | 0.9987 | EfficientNetB3 |
| **Top-1 Accuracy** | 97.8% | 98.3% | EfficientNetB3 |
| **Top-3 Accuracy** | 99.8% | 100% | EfficientNetB3 |
| **Top-5 Accuracy** | 100% | 100% | Tie |
| **Log Loss** | 0.0670 | 0.0492 | EfficientNetB3 |

| | | | |
|---|---|---|---|
| **Training Behavior** | Trained quickly, stable convergence. | Slightly heavier, but converged smoothly and gave better calibration. | EfficientNetB3 |

### Final Interpretation

- **MobileNetV2** is lightweight, fast, and highly accurate (~98% accuracy, mAP 0.997). It performs excellently and is suitable for real-time deployment on limited hardware.
- **EfficientNetB3**, however, edges out MobileNetV2 in nearly every metric:
    - Slightly higher Top-1 accuracy (98.3% vs. 97.8%).
    - Perfect Top-3 and Top-5 accuracy.
    - Lower log loss (0.0492 vs. 0.0670) → better confidence calibration.
    - Stronger per-class recall in tricky categories.
- Both models are excellent, but EfficientNetB3 is the superior choice for a decision-support system in cotton leaf disease detection due to its higher robustness, confidence, and per-class balance.

**Overall Result:**
While MobileNetV2 remains a great lightweight option, EfficientNetB3 is the recommended model for cotton leaf disease detection, offering marginally higher accuracy, stronger probability calibration, and virtually flawless top-K performance.

# Overall Results: MobileNetV2 vs EfficientNetB3 (Sugarcane Leaf Disease Detection)

| Metric | MobileNetV2 | EfficientNetB3 | Better |
|---|---|---|---|
| **Validation Accuracy (final)** | ~83–84% | ~85% | EfficientNetB3 (slightly) |

| | | | |
|---|---|---|---|
| **Precision / Recall / F1 (avg.)** | ~0.89 | ~0.84 | MobileNetV2 |
| **Confusion Matrix Insights** | Strong overall, high precision/recall, only a few weak spots (e.g., Viral Disease recall). | More misclassifications, weaker recall in certain classes (e.g., smut, Yellow Leaf). | MobileNetV2 |
| **mAP (Mean Average Precision)** | **0.9444** | 0.8913 | MobileNetV2 |
| **Top-1 Accuracy** | **88.8%** | 84.5% | MobileNetV2 |
| **Top-3 Accuracy** | **99.6%** | 97.8% | MobileNetV2 |
| **Top-5 Accuracy** | 100% | 99.3% | MobileNetV2 (tiny edge) |
| **Log Loss** | **0.3124** | 0.4845 | MobileNetV2 |
| **Training Behavior** | Trained quickly, converged well, slightly overfit but robust overall. | Stable but heavier, lower calibration and higher loss. | MobileNetV2 |

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## Final Interpretation

- **MobileNetV2** clearly outperforms **EfficientNetB3** on sugarcane:
    - Higher accuracy (0.89 vs 0.84).
    - Better per-class F1 and mAP (0.944 vs 0.891).
    - Superior Top-1, Top-3, and Top-5 accuracy.
    - Lower log loss → better calibrated predictions.
- **EfficientNetB3** is heavier and shows some improvement in raw validation accuracy, but struggles in recall for difficult classes.

👉 **Overall Result:**
For sugarcane leaf disease detection, **MobileNetV2 is the recommended model** — lightweight, more accurate, better calibrated, and stronger across nearly all key metrics. EfficientNetB3 is less competitive here.