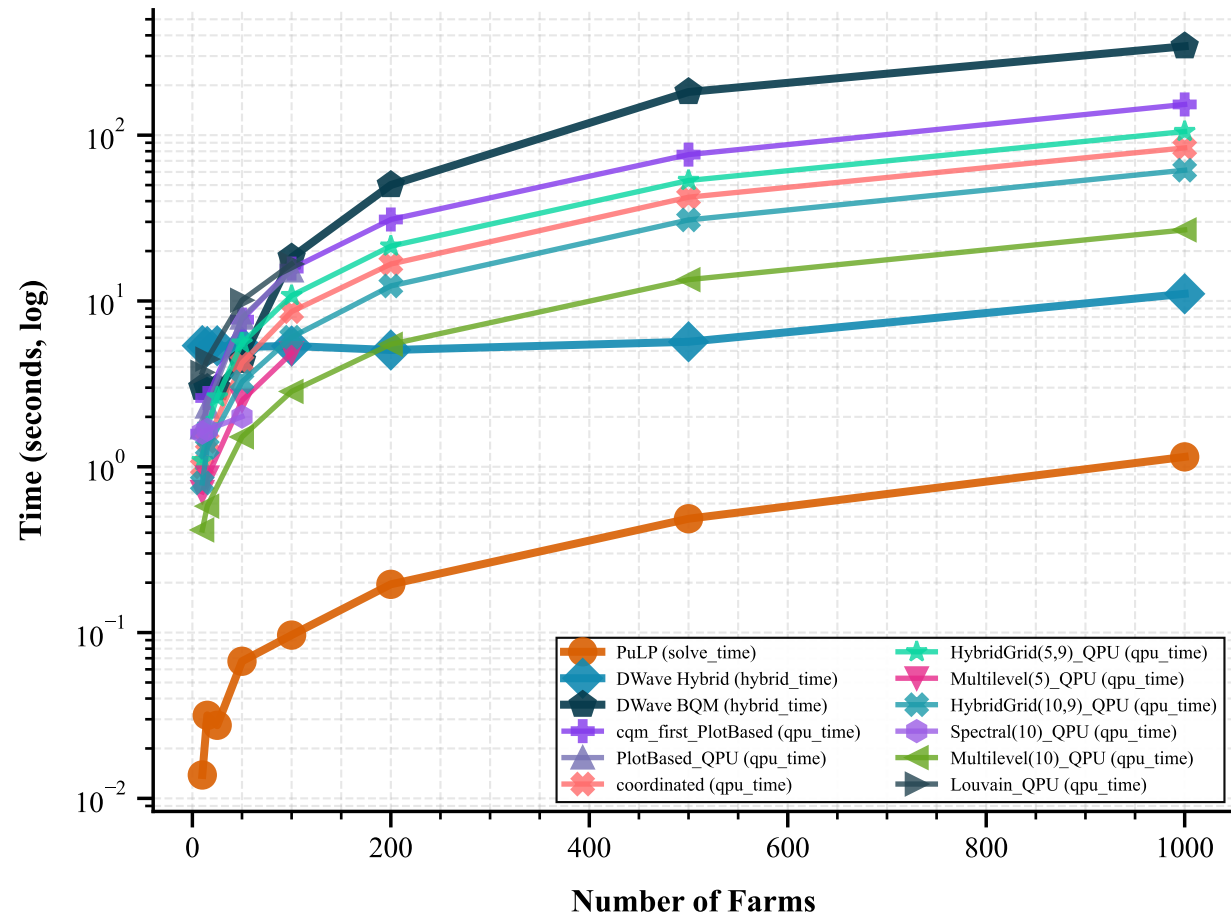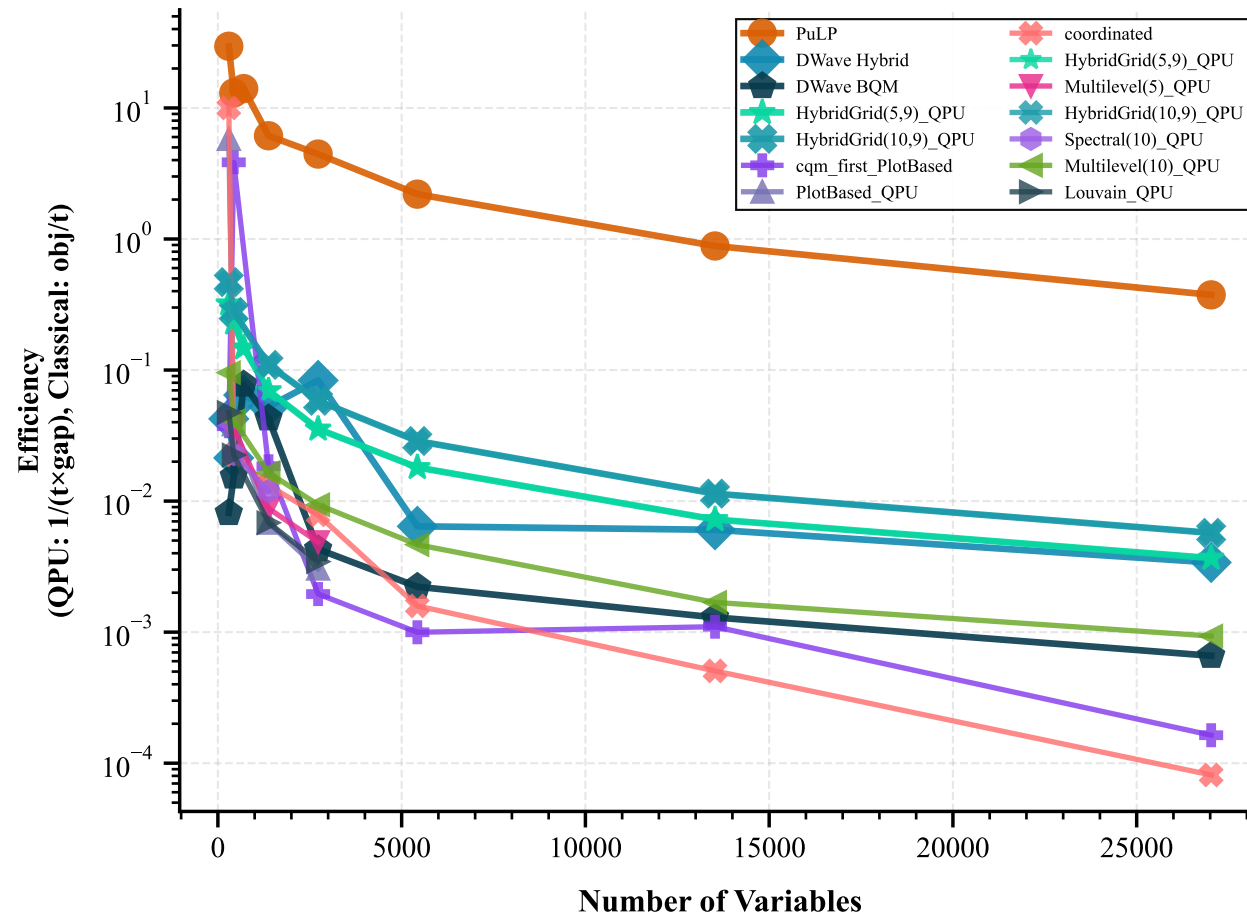# Comprehensive Solver Comparison: Classical vs Hybrid vs Pure QPU
Binary Crop Allocation Problem
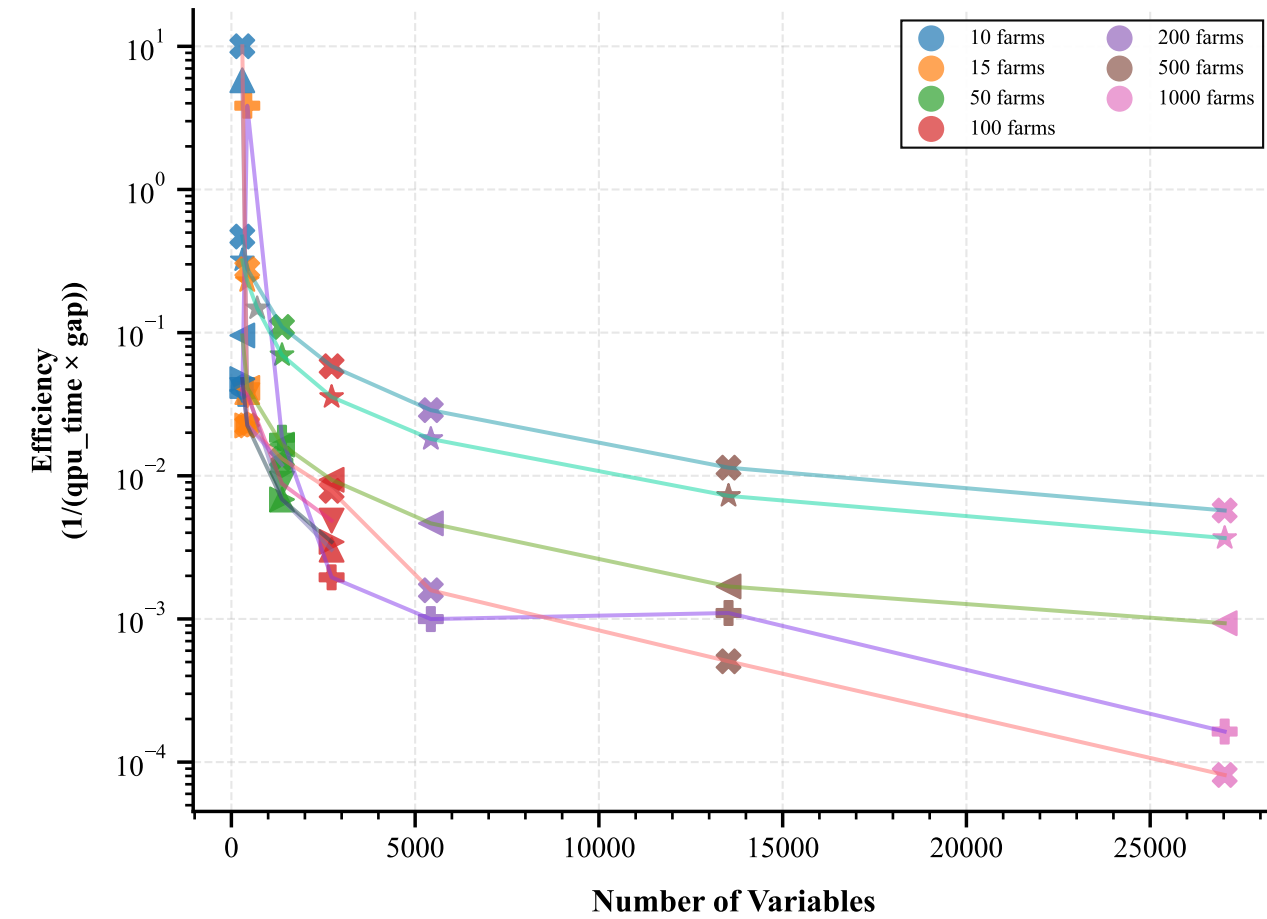
Solve Time Comparison
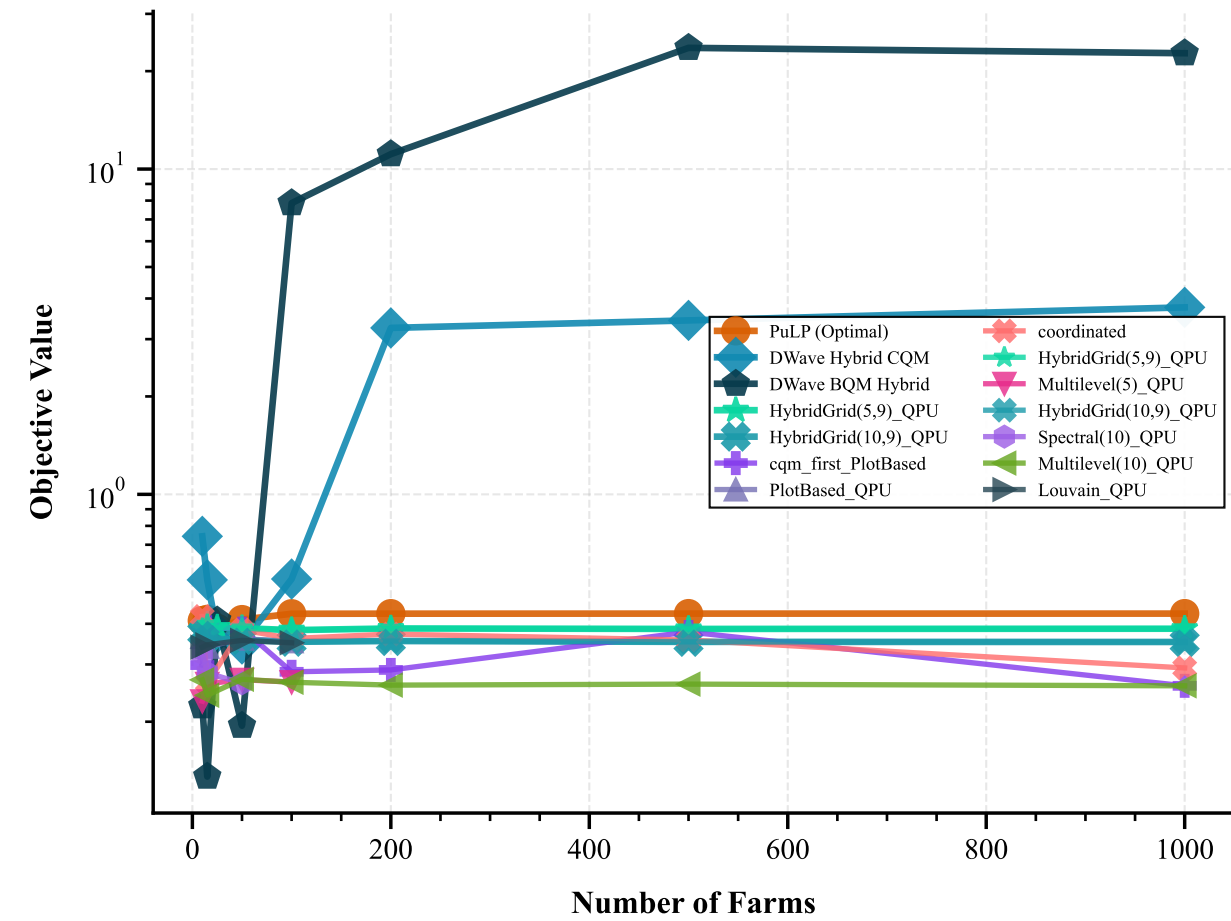**(PuLP: solve_time, DWave: hybrid_time, QPU: qpu_time)**

X-axis: Number of Farms; Y-axis: Time (seconds, log)

Legend:
- PuLP (solve_time)
- DWave Hybrid (hybrid_time)
- DWave BQM (hybrid_time)
- cqm_first_PlotBased (qpu_time)
- PlotBased_QPU (qpu_time)
- coordinated (qpu_time)
- HybridGrid(5,9)_QPU (qpu_time)
- Multilevel(5)_QPU (qpu_time)
- HybridGrid(10,9)_QPU (qpu_time)
- Spectral(10)_QPU (qpu_time)
- Multilevel(10)_QPU (qpu_time)
- Louvain_QPU (qpu_time)

Solution Efficiency vs Problem Size
(higher is better)

X-axis: Number of Variables; Y-axis: Efficiency (QPU: 1/(t×gap), Classical: obj/t)

Legend:
- PuLP
- DWave Hybrid
- DWave BQM
- HybridGrid(5,9)_QPU
- HybridGrid(10,9)_QPU
- cqm_first_PlotBased
- PlotBased_QPU
- coordinated
- HybridGrid(5,9)_QPU
- Multilevel(5)_QPU
- HybridGrid(10,9)_QPU
- Spectral(10)_QPU
- Multilevel(10)_QPU
- Louvain_QPU

QPU Efficiency by Scale
(higher is better)

X-axis: Number of Variables; Y-axis: Efficiency (1/(qpu_time × gap))

Legend:
- 10 farms
- 15 farms
- 50 farms
- 100 farms
- 200 farms
- 500 farms
- 1000 farms

Solution Quality Comparison

X-axis: Number of Farms; Y-axis: Objective Value

Legend:
- PuLP (Optimal)
- DWave Hybrid CQM
- DWave BQM Hybrid
- HybridGrid(5,9)_QPU
- HybridGrid(10,9)_QPU
- cqm_first_PlotBased
- PlotBased_QPU
- coordinated
- Multilevel(5)_QPU
- HybridGrid(10,9)_QPU
- Spectral(10)_QPU
- Multilevel(10)_QPU
- Louvain_QPU

Optimality Gap - All QPU Methods

X-axis: Number of Farms; Y-axis: Gap from Optimal (%)

Legend:
- cqm_first_PlotBased
- PlotBased_QPU
- coordinated
- HybridGrid(5,9)_QPU
- Multilevel(5)_QPU
- HybridGrid(10,9)_QPU
- Spectral(10)_QPU
- Multilevel(10)_QPU
- Louvain_QPU
- Optimal
- 10% Gap
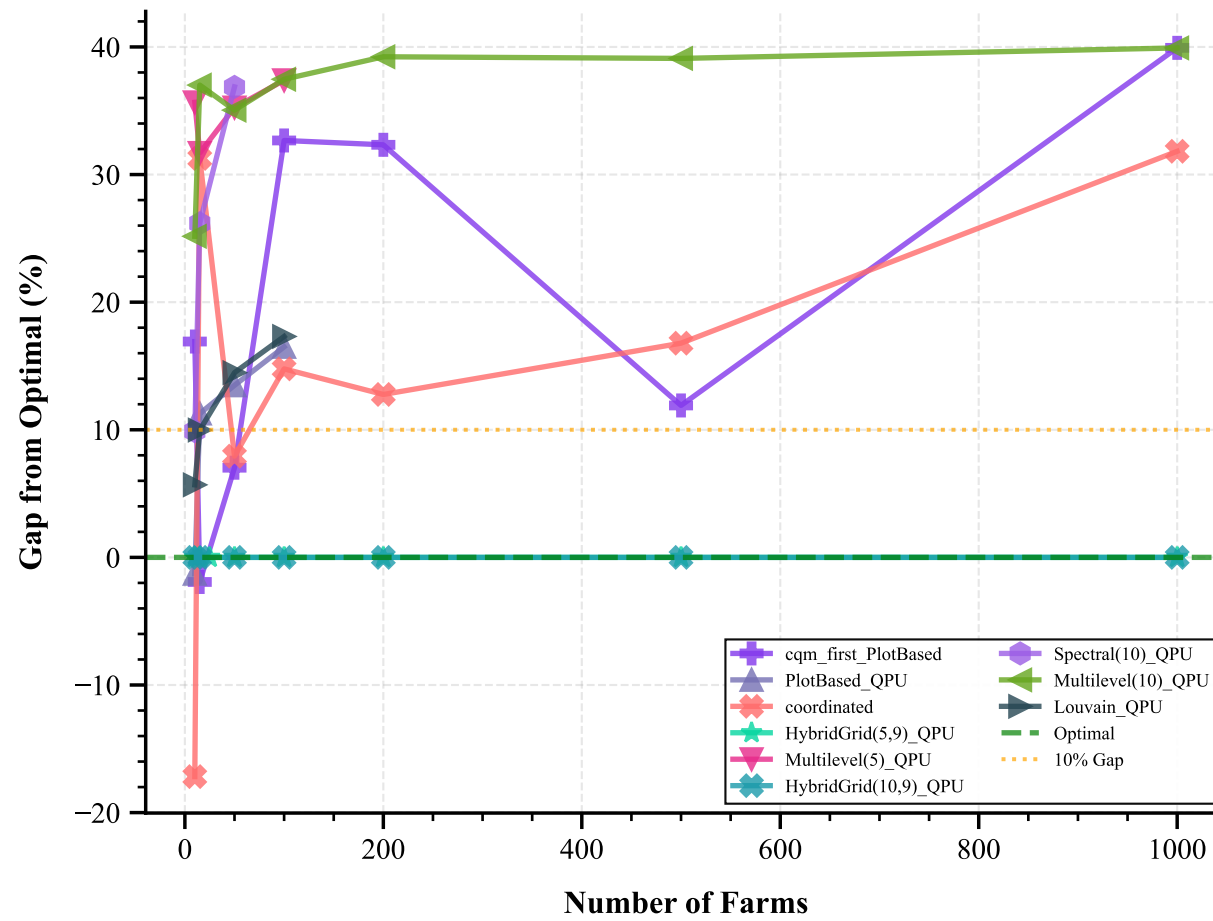
Feasibility: Violations by Method

X-axis: Number of Farms; Y-axis: Constraint Violations

Legend:
- cqm_first_PlotBased
- PlotBased_QPU
- coordinated
- HybridGrid(5,9)_QPU
- Multilevel(5)_QPU
- HybridGrid(10,9)_QPU
- Spectral(10)_QPU
- Multilevel(10)_QPU
- Louvain_QPU