

is still early and depends on faster, more robust perception-control pipelines. Precision chemical thinning is moving in the same direction: computer-vision-guided variable-rate spraying achieved thinning effects comparable to conventional spraying while using about 18% less thinning agent (Kang et al., 2025). For loquat, these trends suggest that future thinning systems will likely be hybrid, not purely manual or purely automated. Traditional orchard operations already combine pruning, thinning, bagging, and crop-load adjustment, so loquat is well suited to integrated digital management rather than stand-alone hardware substitution. More broadly, PACMAN-type frameworks in apple show that precision crop-load management works best when pruning, chemical thinning, and hand thinning are treated as linked decisions rather than isolated interventions.

8.3 Future research priorities

The first research priority is to generate more loquat-specific thinning evidence across cultivars, environments, and management systems. Existing loquat studies already show that responses differ with cultivar, season, and thinning intensity, but the literature remains thin relative to apple and other major tree fruits. This gap is especially clear for chemical thinning, where additional work has long been identified as necessary before commercial-scale recommendations can be made. A second priority is to build loquat-adapted sensing and decision models rather than transferring tools directly from apple. Automated thinning depends on reliable datasets and detection models, yet even in apple, progress has required dedicated annotated datasets and optimized models to handle small fruit, occlusion, and natural-scene variability. For loquat, this means creating image datasets spanning panicle architectures, fruitlet sizes, lighting conditions, and canopy forms, then linking those inputs to crop-load thresholds that predict marketable yield and quality.

A third priority is to connect precision thinning with whole-orchard economics and sustainability. Variable-rate systems can reduce chemical inputs and potentially improve economic return by matching thinning intensity to local fruit set, but adoption barriers still include calibration demands, equipment compatibility, and grower familiarity with prescription-based systems (Kang et al., 2025). Robotic systems face parallel barriers in platform cost, sensor cost, and operational speed, so progress will depend as much on simplification and affordability as on accuracy alone. A final priority is to widen the concept of thinning from fruit removal alone to resource valorization and integrated orchard design. Loquat flower thinning generates large quantities of discarded biomass, yet recent work shows that these flowers contain recoverable flavonoids and antioxidant activity, creating a plausible by-product pathway for value-added use. In parallel, loquat management studies indicate that thinning interacts with pruning, vigor, and carbohydrate supply, so future work should optimize thinning within integrated canopy and source-sink management rather than treat it as an isolated operation.

9 Conclusions

Fruit thinning should be regarded as a core crop-load regulation practice in loquat because natural fruit set commonly exceeds the tree's carrying capacity, resulting in many undersized fruits and unstable commercial output. Loquat orchards therefore need thinning not simply to reduce fruit number, but to balance marketable yield with fruit size, sweetness, and packout. The main conclusion across loquat studies is that heavier thinning improves individual fruit performance, whereas lighter thinning usually preserves higher total yield. In 'Precoce de Itaquera', maintaining four flower buds per cluster produced the best overall quality response, while twelve buds per cluster gave the highest cluster weight and yield. In 'Algerie', heavier thinning slightly improved packout, but four fruits per panicle generated the highest revenue under both irrigation regimes because severe fruit removal reduced output too strongly. This balance between quality and retained productivity is consistent with broader crop-load evidence from other fruit systems, where low to medium crop loads generally produce higher-quality fruit than overloaded trees. Taken together, the evidence indicates that the practical goal in loquat is optimized crop load, not maximum thinning intensity, and that moderate thinning usually offers the best economic compromise under commercial conditions.

The most consistent quality benefit of fruit thinning in loquat is the improvement of external fruit traits, especially fruit size, fruit weight, and uniformity. Across cultivars, thinning to four fruits per panicle produced superior fruit length, width, and weight. Growth studies also show that thinning increases fruit growth rate, which helps explain