decisive step in branching capacity, and KNOX genes appear to promote bud formation partly by enhancing the cytokinin pathway while suppressing auxin and gibberellin pathways.

The key trade-off is that topping usually increases the number of reproductive sites while delaying floral transition and redistributing assimilates among more sinks. Double or repeated pinching often increases flowers per plant and total yield, but unpinched plants typically initiate flower buds earlier and flower sooner. This developmental coupling is consistent with chrysanthemum flowering regulators: CmTFL1c delays flowering, promotes axillary bud formation, and alters inflorescence architecture, showing that branching and reproductive timing are mechanistically linked rather than independent traits. Under controlled photoperiods, the same balance reappears agronomically, with no pinch favoring earlier bud initiation and double pinch favoring more branches and flowers, so the best topping method is the one that optimizes branch-derived flowering sites without delaying harvest beyond the production goal. Taken together, different topping methods affect flower yield through an integrated sequence of bud release, canopy reconstruction, and reproductive conversion of lateral shoots. For Hangbaiju, the most productive treatment is therefore not simply the one with the strongest branching response, but the one that best coordinates branching compensation with efficient canopy function and timely flower-bud formation.

8 Production Applications and Optimized Cultivation Strategies

8.1 Selection of topping methods for different production objectives

For production systems targeting early flowering and larger individual flowers, lighter topping or no topping is generally more suitable than repeated pinching. In annual chrysanthemum, no pinching gave the earliest flower bud appearance and the largest flower diameter, even though branch number and total flower number were lower than under stronger pinching treatments. A similar trade-off was reported in Dendranthema grandiflorum cv. Pusa Shwet, where no pinching produced the longest plants, the longest internodes, and the earliest bud appearance, while double pinching increased flowers per stem (Kaur and Singh, 2024). For balanced commercial performance, single pinching often remains a practical compromise, because single pinching at 30 days after transplanting gave satisfactory flower characters in one study, whereas single pinching at 40 days improved shelf life in spray chrysanthemum.

When the objective is to maximize branch number, flower number, and loose-flower yield, repeated pinching is usually superior. Double pinching increased flower number and yield in several annual chrysanthemum studies, and was explicitly recommended for commercial cultivation where total production is the main target. In spray chrysanthemum, however, the agronomic optimum was not always the most severe treatment: thrice pinching produced the strongest vegetative branching response, but pinching twice at 30 and 40 days gave the highest flower number and yield by weight. For *Chrysanthemum morifolium* cv. Ratlam Selection, pinching at 30 days after transplanting also improved branch number and plant spread, supporting the use of an earlier, moderate topping regime when canopy expansion is prioritized without excessive flowering delay.

8.2 Synergistic regulation of topping, planting density, and water and fertilizer management

Pinching responses are strongly shaped by planting density, so topping should be selected together with spacing rather than as an isolated treatment. In annual chrysanthemum, wider spacing increased stem girth and branching, whereas the highest flower yield per hectare was obtained at 45 × 30 cm combined with pinching at 30 days after transplanting. In *C. morifolium* cv. Ratlam Selection, wider spacing plus pinching at 30 days increased branches and plant spread, while closer spacing accelerated bud initiation and 50% flowering, indicating that density modifies whether the crop favors vegetative expansion or earlier reproductive progression. Planting date also changes the economic optimum, because the highest B:C ratio in one staggered-planting study was obtained with first-week-of-October planting and pinching at 30 days, even though the highest branch number occurred under double pinching.

Fertilizer and growth-regulator management further determine how effectively topped plants convert extra branches into yield. Standard field protocols in chrysanthemum commonly split nitrogen, applying part basally and the remainder around 30 days after transplanting, which aligns nutrient availability with the active regrowth phase after pinching. Nitrogen-response data show that pinching at 20 days combined with 150 kg·N·ha^{-1}