

by remobilization from vegetative tissues. Nitrogen-management research further shows that better photosynthetic function and higher light availability can improve nitrogen-use efficiency, water-use efficiency, and allocation of biomass toward flowers, while predictive modeling confirms that aboveground dry matter and nitrogen accumulation are tightly linked across the chrysanthemum growth period (Liu et al., 2025).

5.3 Flower bud differentiation and flowering progression

Topping affects flower bud differentiation primarily by postponing the reproductive transition while increasing the number of potential flowering sites. Across chrysanthemum studies, no pinching consistently resulted in the earliest flower bud appearance, whereas repeated pinching delayed bud initiation because plants re-entered or prolonged vegetative development after apex removal. This delay can become substantial under stronger treatments, with twice or thrice pinched plants showing longer periods to inflorescence bud formation and later 50% flowering than unpinched controls.

Even though bud initiation is delayed, the later flowering phase often becomes more productive and more extended. Double pinching increased flower number and total yield in annual chrysanthemum, indicating that delayed bud differentiation is compensated by the formation of more reproductive shoots. Other studies show the same developmental trade-off: double pinching delayed flowering progression but increased branch number, flowers per stem, flowering span, and total flower yield, whereas single pinching more often balanced flowering quality and display uniformity (Kaur and Singh, 2024). Overall, different topping methods influence Hangbaiju not only through visible architectural change but through coordinated shifts in leaf function, assimilate partitioning, and timing of reproductive development. In practice, lighter topping tends to preserve earlier flowering and stronger individual-organ performance, whereas repeated topping tends to favor cumulative branch formation and total flower production.

6 Case Study: Effects of Different Topping Methods on Branch Formation and Flower Yield of Hangbaiju

6.1 Case study design and experimental treatments

A case study on different topping methods in Hangbaiju should be framed as a comparative experiment in which branch formation and flower yield are evaluated under clearly defined pinching schedules. Existing chrysanthemum studies commonly use randomized designs with replicated treatment combinations, such as factorial randomized block designs with three replications and treatments contrasting no pinching with one or more topping times after transplanting. This structure is appropriate for Hangbaiju because flower production depends strongly on branch number, and Hangbaiju cultivation has traditionally relied on repeated manual decapitation to increase shoot branching (Zhang et al., 2023).

The treatment system should include at least a control without topping, a single early topping treatment, a single later topping treatment, and one repeated topping treatment, because these contrasts recur across the chrysanthemum literature and capture the main agronomic decision points. For example, studies have compared no pinching with pinching at 30 or 40 days after transplanting, while others have extended the range to twice or thrice pinching treatments to test increasing intensity (Ehsanullah et al., 2021). Similar design logic has also been used in tea-applied chrysanthemum, where different pinching schemes were evaluated together with planting-date effects in a split-split plot field experiment, showing that topping pattern itself can be treated as a main analytical factor (Figure 2).

6.2 Responses of branch formation and flower yield

The expected response pattern in Hangbaiju is that topping reduces apical dominance, increases branch production, and then raises the number of flower-bearing shoots, although the strongest treatment is not always the one that produces the highest marketable yield. In *Chrysanthemum morifolium* cv. Ratlam Selection, pinching at 30 days after transplanting increased branch number and plant spread relative to no pinching, showing the value of timely apex removal for canopy expansion. In tea-applied chrysanthemum, two-time pinching increased crown width, flower number, fresh mass, yield per plant, and yield per unit area over no pinching, while also markedly reducing plant height.