4 Advancement in Gomphrena Production technology

Recent advances in the production technology of *Gomphrena globosa* have focused on improving flower yield, quality, post-harvest longevity, and commercial value through the integration of improved cultivation practices, biotechnology, genetic characterization, and value-added processing. Compared with marigold, where breeding technologies are relatively well developed, technological improvements in gomphrena have relied primarily on optimizing agronomic practices, plant growth regulation, substrate management, germplasm evaluation, and post-harvest technologies. These integrated approaches have enhanced production efficiency while supporting the increasing demand for fresh and dried flowers, natural pigments, and pharmaceutical raw materials.

4.1 Cultivation and growth optimization

Cultivation management plays a fundamental role in determining the growth, flowering behaviour, and market quality of *Gomphrena globosa*. Among various cultural practices, pinching is one of the most effective techniques for regulating plant architecture and increasing flower production. Pinching suppresses apical dominance by reducing auxin concentration in the terminal shoot, thereby promoting lateral bud development, increasing branching, and improving assimilate partitioning toward reproductive organs. Consequently, plants produce more flowering shoots and a greater number of marketable flowers. However, the response to pinching varies among cultivars, production objectives, and environmental conditions. For example, cut flower production generally favours longer stems with limited pinching, whereas potted plant production benefits from increased branching and compact growth. Recent studies have shown that double pinching performed at 20 and 35 days after planting significantly increases productive branches, flower number, and overall yield, although some cultivars may exhibit greater plant height and primary branching without pinching (Saputra et al., 2025).

The comparative effects of pinching on branching, flower production, flower diameter, and stalk length are summarized in Table 2, which demonstrates that appropriate pinching improves overall flower productivity while modifying plant architecture according to production requirements.

Table 2 Effects of different pinching treatments on growth and flowering characteristics of *Gomphrena globosa*

Parameter	Pinched (at 15 Days)	Non-Pinched
Branching	High (more side branches)	Low (terminal focus)
Flower Count	~602 per plant	~518 per plant
Flower Diameter	2.85 cm	1.5 cm
Stalk Length	Reduced	Longer

Note: Adopted from Rajasekaran et al. (1983)

Biofertilizer application has also become an important component of sustainable gomphrena cultivation. The combined use of Azotobacter, phosphate-solubilizing bacteria (PSB), and potash-solubilizing bacteria (KSB) enhances nutrient availability through biological nitrogen fixation, phosphorus solubilization, and potassium mobilization. These beneficial microorganisms also improve root development, stimulate phytohormone production, and enhance soil microbial activity, resulting in increased vegetative growth, flower yield, and nutrient-use efficiency (Yaseen et al., 2022). Although biofertilizers reduce dependence on chemical fertilizers and improve soil health, their field performance may vary depending on soil type, environmental conditions, and microbial survival.

Selection of suitable growing substrates further influences flower quality and productivity by improving root aeration, water retention, and nutrient availability. A substrate mixture consisting of garden soil, Baltic peat, and Klasmann-Deilmann TS3 medium has been reported to produce larger flowers, greater fresh and dry flower weight, and higher overall yield than conventional substrates (Zeljković et al., 2021). Nevertheless, the commercial adoption of specialized substrates should also consider production costs, availability of raw materials, environmental sustainability, and feasibility for large-scale cultivation.