Agrobacterium-mediated transformation has been explored to enhance pyrethrin production, highlighting the potential of genetic engineering for value addition.

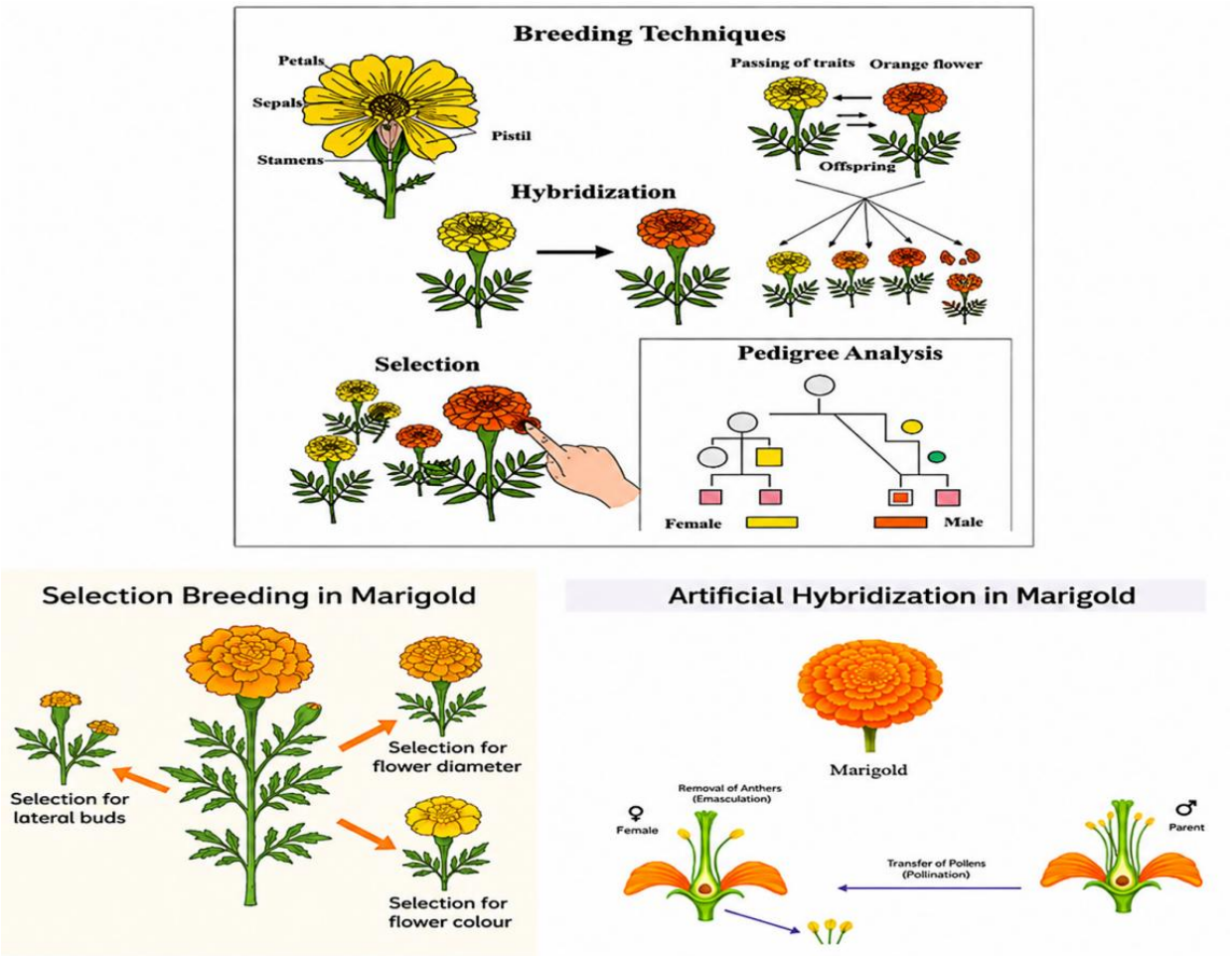


Figure 3 Schematic representation of breeding techniques and improvement strategies in marigold

3.4 Tissue culture and micropropagation in marigold breeding

Tissue culture, particularly in vitro propagation, provides a rapid and efficient method for large-scale multiplication of marigold while ensuring uniform expression of desirable traits (Figure 4). Advanced protocols enable regeneration from various explants such as shoot tips, leaves, and floral tissues. These micropropagation techniques have become valuable tools in modern breeding programs for quick multiplication of elite genotypes, conservation of genetic resources, and improvement of breeding efficiency.

Natural pigments such as carotenoids have important antioxidant, functional, medicinal, and nutraceutical properties, making them more valuable than synthetic colorants. Marigold (*Tagetes erecta*) is an important ornamental plant and a rich source of carotenoids. In vitro callus cultures of marigold can be induced from leaf explants using MS medium supplemented with 2,4-D and BA hormones. Marigold callus cultures can continuously accumulate pigments even after repeated subculturing, indicating stable pigment production potential (Benítez-García et al., 2014). Somaclonal variation has been effectively utilized to develop drought-tolerant marigold lines.exposing marigold tissue cultures to osmotic stress using mannitol led to the selection of drought-tolerant genotypes. These selected clones exhibited higher proline and soluble sugar content, contributing to enhanced drought tolerance. Such drought-resistant lines are particularly valuable in regions facing water scarcity, ensuring sustainable marigold cultivation (Ferreira et al., 2023).