



Exploring Seed Production Techniques for Flowering Annuals: A Comprehensive Overview

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2024/v30i51918

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/113302>

Review Article

Received: 23/12/2023

Accepted: 27/02/2024

Published: 11/03/2024

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ABSTRACT

This comprehensive overview delves into the intricate techniques involved in seed production for flowering annuals. From selecting suitable varieties to understanding pollination dynamics, harvesting, and storage, this review provides valuable insights into the complex process of seed production. Drawing upon the latest research and practical considerations, it highlights the importance of proper management practices for maintaining genetic purity and seed viability. By exploring the various methodologies and considerations, this abstract aims to provide a foundational understanding for both home gardeners and commercial growers seeking to optimize seed production in flowering annuals. This paper presents a thorough examination of seed production methodologies tailored for flowering annuals. By addressing key aspects such as variety selection, pollination strategies, harvesting techniques, and storage protocols, it offers a comprehensive guide for both novice gardeners and seasoned professionals. Through a synthesis of empirical research and practical insights, it underscores the significance of meticulous management in ensuring the quality and sustainability of seed stocks. With a focus on enhancing understanding and proficiency, this abstract serves as a valuable resource for individuals seeking to maximize the yield and diversity of flowering annuals in their cultivation endeavors.

Keywords: Germinate; flower; set seed; valuable resource; home gardeners; commercial growers.

1. INTRODUCTION

Flowering annuals play a vital role in the garden landscape, offering bursts of color, fragrance, and beauty throughout the growing season. Seed production methodologies in flowering annuals are critical for ensuring genetic diversity, maintaining plant populations, and meeting the demands of both home gardeners and commercial growers [1-3]. This article will explore various techniques and considerations involved in seed production for selected flowering annuals. In the realm of garden landscapes, flowering annuals stand out as essential contributors, providing bursts of vibrant color,

captivating fragrance, and natural beauty throughout the growing season. Seed production methodologies specific to flowering annuals are pivotal elements in maintaining genetic diversity, sustaining plant populations, and meeting the needs of diverse stakeholders, ranging from home gardeners to commercial growers. This article embarks on a journey to explore the multifaceted techniques and considerations intrinsic to the seed production process for selected flowering annuals. By delving into these methodologies, we aim to illuminate the intricate mechanisms that underpin the cultivation and propagation of these cherished botanical treasures [4-6].

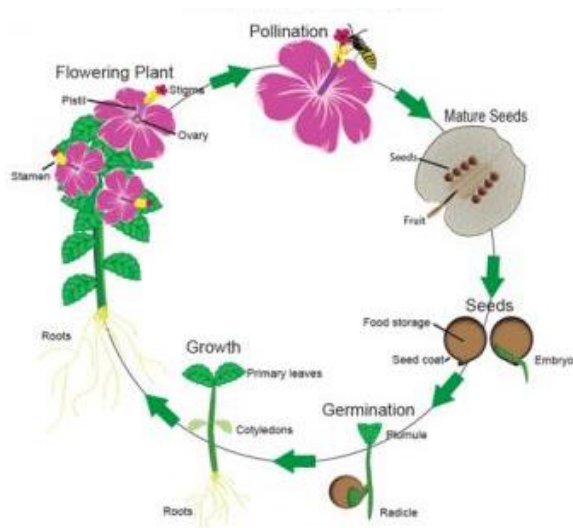


Fig. 1. Flowering plant life cycle

Source: adopted: <https://www.lovetoknow.com/home/garden/flowering-plants-life-cycle>

2. UNDERSTANDING ANNUALS

Flowering annuals are plants that complete their life cycle within a single growing season. They germinate, flower, set seed, and die within a year. Common examples include marigolds, zinnias, petunias, cosmos, and sunflowers. Understanding the life cycle and reproductive habits of these plants is essential for effective seed production [7].

Flowering annuals, revered for their ephemeral yet captivating presence, occupy a unique niche in the botanical world. Unlike perennial plants that endure through multiple growing seasons, flowering annuals complete their life cycle within a single year. This distinctive characteristic shapes their growth patterns, reproductive strategies, and significance in garden landscapes.

2.1 Life Cycle

The life cycle of flowering annuals unfolds with remarkable efficiency within a span of one year. It commences with the germination of seeds, often triggered by favorable environmental conditions such as adequate moisture and temperature. As seedlings emerge, they develop into robust plants, branching out and producing foliage in preparation for flowering [8].

2.2 Flowering

The hallmark of flowering annuals lies in their prolific bloom production. With meticulous care, these plants grace the garden with an array of colorful blossoms, ranging from delicate petals to bold, showy displays. The duration and intensity of flowering vary among different annual species, influenced by factors such as day length, temperature, and soil fertility [9].

2.3 Reproduction

Reproductive success is paramount for the survival and propagation of flowering annuals. Throughout the growing season, these plants employ various mechanisms to ensure pollination and seed set. Many annuals rely on pollinators such as bees, butterflies, and birds to transfer pollen between flowers, facilitating fertilization. Others possess adaptations for self-pollination or wind dispersal of pollen to optimize reproductive outcomes [10].

FLOWERING

2.4 Adaptations

Flowering annuals have evolved an array of adaptations to thrive in diverse environmental conditions. Some species exhibit rapid growth rates, enabling them to capitalize on brief windows of favorable weather. Others demonstrate resilience to environmental stressors, such as drought or poor soil quality, through mechanisms like succulence or deep root systems. These adaptive traits contribute to the versatility and resilience of annual plants in various ecological settings [11].

2.5 Ecological Significance

Beyond their ornamental value, flowering annuals play vital ecological roles in terrestrial ecosystems. They provide nectar and pollen sources for pollinators, supporting insect populations essential for ecosystem functioning and food production. Additionally, annual plants contribute to soil stabilization, nutrient cycling, and biodiversity conservation, enriching the ecological fabric of natural habitats and cultivated landscapes alike, understanding the intricate life cycle, reproductive strategies, adaptations, and ecological significance of flowering annuals enhances our appreciation for these ephemeral botanical wonders. As stewards of the natural world, we are tasked with nurturing and preserving the diversity and vitality of flowering annuals, ensuring their continued splendor and contribution to garden landscapes and ecosystems worldwide [12].

2.6 Selecting Suitable Varieties

The first step in seed production is selecting suitable varieties of flowering annuals. Factors to consider include bloom time, flower color, plant size, disease resistance, and adaptability to local growing conditions. It's important to choose varieties that are well-suited to the intended use of the seeds, whether for personal enjoyment, landscaping projects, or commercial sales.

2.7 Selecting Suitable Varieties of Flowering Annuals

Choosing the right varieties of flowering annuals is a critical step in successful gardening and seed production. The selection process involves consideration of various factors, including bloom time, flower color, plant size, disease resistance, and adaptability to local growing conditions. By carefully evaluating these characteristics,

gardeners and growers can ensure that their chosen varieties thrive and contribute to the beauty and biodiversity of their gardens and landscapes.

2.8 Bloom Time

The timing of flowering is a key consideration when selecting annual varieties. Gardeners may seek plants that bloom early in the season to provide color and interest as the garden awakens from winter dormancy. Alternatively, late-blooming varieties can extend the floral display into the fall, adding vibrancy to the landscape as temperatures cool. By choosing a mix of early, mid-season, and late-blooming annuals, gardeners can maintain continuous color throughout the growing season [13].

2.9 Flower Color and Form

The color and form of flowers are defining characteristics that influence the aesthetic appeal of garden displays. Gardeners may opt for a harmonious color palette, selecting annuals that complement each other and create visually pleasing combinations. Alternatively, they may embrace contrasting colors to create bold and striking contrasts in their garden beds and borders. Considerations such as flower shape, size, and texture also contribute to the overall design and impact of the garden landscape.

2.10 Plant Size and Growth Habit

The size and growth habit of annual plants determine their suitability for various garden settings and purposes. Compact, mounding varieties are well-suited for edging borders, containers, and hanging baskets, where they provide a tidy appearance. Taller, upright varieties can serve as focal points or backdrops in garden beds, adding height and vertical interest to the landscape. Trailing or cascading annuals are ideal for spilling over the edges of containers or cascading down slopes, creating dynamic and flowing compositions [14].

3. DISEASE RESISTANCE AND VIGOR

Selecting disease-resistant varieties can help mitigate the risk of common fungal and bacterial pathogens that affect flowering annuals. Disease resistance traits may vary among different varieties, so it is essential to research and choose cultivars with proven resistance to prevalent diseases in your region. Vigorous and

healthy plants are more likely to withstand environmental stressors and outcompete weeds, contributing to the overall resilience and longevity of garden displays.

4. ADAPTABILITY TO GROWING CONDITIONS

Annual varieties vary in their adaptability to specific growing conditions, including soil type, sunlight exposure, and moisture levels. Some plants thrive in full sun and well-drained soils, while others prefer partial shade or moist, humus-rich environments. Understanding the unique requirements of each species and selecting varieties suited to local growing conditions can optimize plant performance and minimize the need for supplemental care and maintenance., selecting suitable varieties of flowering annuals requires thoughtful consideration of bloom time, flower color, plant size, disease resistance, and adaptability to growing conditions. By choosing a diverse array of annuals that complement each other and thrive in their respective environments, gardeners can create stunning displays that enrich the landscape with color, fragrance, and vitality throughout the growing season [15].

5. POLLINATION AND ISOLATION

Many flowering annuals rely on pollinators, such as bees, butterflies, and birds, to transfer pollen between flowers for successful fertilization. To maintain genetic purity and prevent cross-pollination between different varieties or species, isolation techniques may be employed. This involves spacing plants adequately or using physical barriers like nets or bags to prevent unintended pollination.

Pollination is a pivotal process in the reproductive cycle of flowering annuals, ensuring the transfer of pollen grains from the male reproductive organs (anthers) to the female reproductive organs (stigmas) of flowers. Effective pollination is essential for the production of viable seeds and the perpetuation of plant populations. However, in seed production for flowering annuals, controlling pollination becomes paramount to maintain genetic purity and prevent unintended hybridization. Pollination and isolation techniques are therefore crucial considerations for growers and breeders seeking to produce high-quality seeds of specific varieties [16].

6. UNDERSTANDING POLLINATION MECHANISMS

Flowering annuals exhibit diverse pollination mechanisms, including insect-mediated (entomophily), wind-mediated (anemophily), and self-pollination (autogamy). Many annuals rely on pollinators such as bees, butterflies, moths, and birds to facilitate pollen transfer between flowers. These pollinators are attracted to flowers by visual cues, fragrance, and nectar rewards. Wind-pollinated species produce lightweight pollen grains that are dispersed by air currents to neighboring flowers. Some annuals have evolved mechanisms for self-pollination, where pollen is transferred within the same flower or between flowers on the same plant.

6.1 Implementing Isolation Techniques

To prevent unwanted cross-pollination between different varieties or species of flowering annuals, growers employ isolation techniques that physically separate plants and control pollinator access. Isolation distances vary depending on the pollination mechanism and the degree of genetic compatibility between plants. For insect-pollinated annuals, isolation can be achieved by spacing plants apart or using barriers such as row covers or netting to exclude pollinators. For wind-pollinated species, isolation distances may need to be greater to minimize pollen drift between plants. Additionally, timing flowering periods to avoid overlap between different varieties can further reduce the risk of cross-pollination [17].

6.2 Utilizing Pollinator Exclusion

In situations where precise control over pollination is required, growers may resort to pollinator exclusion techniques to prevent unintended pollination events. This involves covering flowers with mesh bags or cages to physically block access to pollinators while allowing for natural fertilization to occur within the enclosed environment. Pollinator exclusion is particularly useful for breeding programs aimed at developing new cultivars or maintaining genetic purity in seed production for commercial purposes [18].

6.3 Hand Pollination

In some cases, hand pollination may be necessary to ensure controlled fertilization and seed set in flowering annuals. Hand pollination involves manually transferring pollen from the

stamens of one flower to the stigma of another flower, either within the same plant or between different plants of the same variety. This technique allows breeders to achieve specific crosses and select desired traits for future generations. Hand pollination is labor-intensive but can yield precise results in controlled breeding programs.

6.4 Monitoring and Management

Throughout the pollination and seed production process, diligent monitoring and management practices are essential to ensure the success of isolation techniques and the purity of seed lots. Regular inspection of plants for signs of cross-pollination, removal of off-type or hybridized individuals, and documentation of breeding records are integral aspects of maintaining genetic integrity and traceability in seed production operations. , pollination and isolation techniques are integral components of seed production methodologies for flowering annuals. By understanding the pollination mechanisms of specific species, implementing appropriate isolation measures, and utilizing advanced breeding techniques when necessary, growers and breeders can safeguard genetic purity, enhance seed quality, and meet the diverse needs of the horticultural industry and gardening enthusiasts alike.

6.5 Seed Collection and Processing

Seed collection should be timed carefully to ensure optimal seed maturity and viability. For most flowering annuals, seeds are ready for harvest once the flowers fade and seed pods or capsules begin to dry and change color. Seeds can be collected by hand or through mechanical means, depending on the scale of production. After harvesting, seeds should be properly cleaned, dried, and stored in a cool, dry place to maintain viability.

7. SEED COLLECTION AND PROCESSING IN FLOWERING ANNUALS

Seed collection and processing are critical steps in the seed production cycle of flowering annuals. Proper harvesting and processing techniques ensure the viability, purity, and longevity of seeds, thereby facilitating successful propagation and cultivation. In this section, we explore the essential considerations and best practices involved in seed collection and processing for flowering annuals.

7.1 Timing of Seed Collection

Timing is crucial when collecting seeds from flowering annuals. Seeds should be harvested when they are fully mature but before they are dispersed from the plant. For many annuals, this occurs after the flowers have faded and seed pods or capsules have begun to dry and change color. Monitoring the development of seeds and observing changes in seed coat color and texture can help determine the optimal time for harvest.

7.2 Selecting Healthy Seeds

When collecting seeds, it is essential to select those that are healthy, fully developed, and free from signs of damage or disease. Avoid harvesting seeds from plants that show symptoms of stress, nutrient deficiency, or pest infestation, as these factors can compromise seed quality and viability. Selecting seeds from vigorous, well-nourished plants with robust growth habits improves the chances of producing high-quality seed stocks.

7.3 Seed Harvesting Techniques

Seed harvesting techniques vary depending on the type of flowering annual and the structure of its seed-bearing organs. Some annuals produce seeds in capsules, pods, or seed heads that can be easily collected by hand once they have ripened. Others may require more specialized harvesting methods, such as gently shaking seed heads or pods to dislodge mature seeds into collection containers. Care should be taken to minimize damage to seeds and avoid contamination during the harvesting process.

7.4 Seed Cleaning and Preparation

After harvesting, seeds should be properly cleaned and prepared for storage. This involves removing debris, chaff, and other impurities that may be present in the seed lot. Seed cleaning can be accomplished using manual methods such as winnowing, sieving, or hand sorting, or through mechanical equipment such as seed cleaners or air separators. Thorough cleaning helps improve seed purity and enhances germination rates by eliminating potential sources of fungal or bacterial contamination [19].

7.5 Drying Seeds

Proper drying is essential to reduce seed moisture content and prevent deterioration during

storage. Seeds should be spread out in a single layer on trays or screens in a well-ventilated area away from direct sunlight. Air circulation helps facilitate drying and prevents the formation of mold or mildew. Monitoring seed moisture levels and ensuring uniform drying across the seed batch are key considerations to prevent overheating or overdrying, which can adversely affect seed viability.

7.6 Storing Seeds

Once dried, seeds should be stored in a cool, dry environment to maintain their viability over time. Airtight containers such as glass jars or resealable plastic bags are suitable for seed storage, as they help protect seeds from moisture, pests, and environmental fluctuations. Labeling containers with the species name, variety, and date of collection facilitates organization and tracking of seed stocks. Stored seeds should be periodically checked for signs of deterioration and rotated or replaced as needed to ensure freshness and viability, seed collection and processing are integral components of seed production methodologies for flowering annuals. By adhering to proper harvesting, cleaning, drying, and storage practices, growers can preserve seed quality, enhance germination rates, and sustain genetic diversity in their horticultural endeavors [20].

7.7 Seed Treatment and Storage

Some flowering annual seeds may benefit from pre-sowing treatments to enhance germination rates or protect against pests and diseases. Common treatments include scarification, stratification, and seed coating with fungicides or insecticides. Proper storage conditions are crucial for preserving seed viability over time. Seeds should be stored in airtight containers in a cool, dark environment with low humidity levels.

7.8 Scaling Up for Commercial Production

Commercial seed production involves specialized equipment, infrastructure, and management practices to meet the demands of a large-scale market. Seed companies may use mechanized harvesting equipment, seed cleaning and processing facilities, and quality control measures to ensure uniformity and purity of seed lots.

8. SCALING UP FOR COMMERCIAL PRODUCTION OF FLOWERING ANNUAL SEEDS

Commercial production of flowering annual seeds requires careful planning, efficient operations, and adherence to industry standards to meet the demands of the market while ensuring seed quality and genetic purity. Scaling up for commercial production involves various considerations, from selecting suitable cultivars to implementing advanced production techniques and quality control measures explore key factors and strategies involved in scaling up for commercial production of flowering annual seeds [21].

8.1 Variety Selection and Breeding Programs

Commercial seed production begins with the selection of high-performing cultivars that exhibit desirable traits such as uniformity, vigor, disease resistance, and market appeal. Breeders may develop new cultivars through controlled breeding programs aimed at introducing novel traits or improving existing ones. Selecting cultivars that are well-suited to local growing conditions and market preferences is essential for maximizing yield and profitability.

8.2 Field Production Techniques

Commercial seed production of flowering annuals often takes place in large-scale field settings where optimal growing conditions can be achieved. Field preparation, including soil conditioning, fertilization, and weed control, is critical for ensuring robust plant growth and seed development. Planting density, spacing, and row configuration may be optimized to maximize pollination efficiency and seed yield per unit area. Irrigation and pest management practices are also carefully managed to minimize stress and optimize seed production.

8.3 Pollination Management

Controlling pollination is essential for maintaining genetic purity and preventing unintended cross-pollination in commercial seed production. Growers may utilize isolation distances, physical barriers, or timing strategies to minimize the risk of pollen contamination between different varieties or species. Pollinator exclusion techniques, such as covering plants with mesh bags or cages, can further enhance control over

pollination and seed set in large-scale production settings.

8.4 Mechanized Harvesting and Processing

Efficient harvesting and processing techniques are critical for maximizing productivity and maintaining seed quality in commercial seed production operations. Mechanized equipment, such as seed combines, threshers, and cleaning machinery, may be employed to streamline the harvesting and processing of seed lots on a large scale. Automation and mechanization help reduce labor costs, minimize handling damage, and ensure uniformity in seed size and purity [22,23].

8.5 Quality Assurance and Testing

Quality assurance measures play a crucial role in commercial seed production, ensuring that seed lots meet industry standards for purity, germination, and genetic identity. Regular quality control checks, including germination tests, purity analysis, and seed health screenings, help identify any deviations or abnormalities in seed lots that may impact performance. Certified seed production facilities adhere to rigorous quality assurance protocols and undergo regular inspections to maintain compliance with regulatory requirements [24].

8.6 Packaging and Distribution

Once seeds have been processed and tested, they are packaged and labeled for distribution to customers. Packaging materials should be durable, moisture-resistant, and tamper-evident to protect seeds during storage and transit. Accurate labeling with product information, including species name, variety, lot number, and germination rate, helps ensure traceability and customer confidence [25]. Efficient distribution channels, including wholesale distributors, retailers, and online platforms, enable widespread access to commercial seed products, scaling up for commercial production of flowering annual seeds requires strategic planning, advanced production techniques, and robust quality control measures. By leveraging breeding programs, optimizing field production practices, implementing mechanized harvesting and processing technologies, and maintaining stringent quality assurance standards, growers can meet the demands of the market while

delivering high-quality seeds for a diverse range of horticultural applications [26-27].

9. CONCLUSION

Seed production methodologies in flowering annuals require careful planning, attention to detail, and knowledge of plant biology and reproductive mechanisms. By understanding the unique characteristics of each species and implementing appropriate techniques, growers can produce high-quality seeds for both personal and commercial use. Investing time and effort in seed production ensures a steady supply of vibrant and diverse flowering annuals for gardens, landscapes, and floral arrangements. In conclusion, the production of flowering annual seeds is a multifaceted process that encompasses various stages, from selecting suitable varieties to scaling up for commercial production. Throughout this journey, growers and seed producers must navigate complexities such as pollination dynamics, seed collection, processing techniques, and quality assurance measures to ensure the viability, purity, and genetic integrity of seed stocks.

Understanding the unique characteristics of flowering annuals, including their life cycles, reproductive strategies, and environmental requirements, is essential for successful seed production. By selecting appropriate varieties, implementing effective pollination and isolation techniques, and employing best practices in seed collection, processing, and storage, growers can optimize seed yields and maintain genetic diversity within plant populations. In both home gardens and commercial operations, the cultivation of flowering annuals enriches landscapes with vibrant colors, fragrances, and ecological benefits. Whether for personal enjoyment, landscaping projects, or commercial sales, high-quality seeds play a pivotal role in propagating these botanical treasures and sustaining their beauty for generations to come. As stewards of biodiversity and guardians of our natural heritage, it is incumbent upon us to uphold the principles of responsible seed production, conservation, and stewardship. By fostering collaboration, innovation, and knowledge sharing within the horticultural community, we can continue to advance the science and art of flowering annual seed production while preserving the richness and diversity of our botanical heritage.

In essence, the journey of producing flowering annual seeds is not merely a technical endeavor but a testament to our reverence for nature's splendor and our commitment to nurturing and safeguarding its wonders for future generations to enjoy. Through diligence, dedication, and a deep appreciation for the marvels of the plant kingdom, we can sow the seeds of beauty, diversity, and sustainability in gardens and landscapes around the world.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Borrás L, Slafer GA, Otegui ME. Seed dry weight response to source-sink manipulations in wheat, maize and soybean: a quantitative reappraisal. *Field Crops Research*. 2004;86(2-3):131-146.
2. Soltis, Douglas, Pamela Soltis, Peter Endress, Mark Chase, Steven Manchester, Walter Judd, Lucas Majure, and Evgeny Mavrodiev. *Phylogeny and Evolution of the Angiosperms*. University of Chicago Press; 2018.
3. Niranjana C. Characterization of bacteriocin from lactic acid bacteria and its antibacterial activity against *Ralstonia solanacearum* causing tomato wilt. *Plant Science Archives*; 2016.
4. Umezawa, Taishi, Miki Fujita, Yasunari Fujita, Kazuko Yamaguchi-Shinozaki, and Kazuo Shinozaki. Engineering drought tolerance in plants: discovering and tailoring genes to unlock the future. *Current Opinion in Biotechnology*. 2006;17(2):113-122.
5. Prasad PVV, Staggenborg SA, Ristic Z. Impacts of drought and/or heat stress on physiological, developmental, growth, and yield processes of crop plants. *Response of crops to limited water: Understanding and Modeling Water Stress Effects on Plant Growth Processes*. 2008;1:301-355.
6. Touseef M. Exploring the complex underground social networks between plants and mycorrhizal fungi known as the wood wide web. *Plant Science Archives*. 2023;V08i01:5.

7. Rehman S, Bahadur S, Wei X. An overview of floral regulatory genes in annual and perennial plants. *Gene*. 2023;147699.
8. Salam MA, Islam MR, Diba SF, Hossain MM. Marker assisted foreground selection for identification of aromatic rice genotype to develop a modern aromatic line. *Plant Science Archives*; 2019.
9. Islam MS, Rahman MM, Paul NK. Arsenic-induced morphological variations and the role of phosphorus in alleviating arsenic toxicity in rice (*Oryza sativa* L.). *Plant Science Archives*; 2016.
10. Corpuz MC, Balan HR, Panares NC. Biodiversity of benthic macroinvertebrates as bioindicator of water quality in Badiangon Spring, Gingoog City. *Plant Science Archives* ; 2016.
11. Herrera CM, Jordano P, Guitián J, Traveset A. Annual variability in seed production by woody plants and the masting concept: reassessment of principles and relationship to pollination and seed dispersal. *The American Naturalist*. 1998;152(4):576-594.
12. Knight, Tiffany M., Janette A. Steets, Jana C. Vamosi, Susan J. Mazer, Martin Burd, Diane R. Campbell, Michele R. Dudash, Mark O Johnston, Randall J. Mitchell, and Tia-Lynn Ashman. Pollen limitation of plant reproduction: pattern and process. *Annu. Rev. Ecol. Evol. Syst.* 2005;36:467-497.
13. Khatana K, Malgotra V, Sultana R, Sahoo NK, Maurya S. Das Anamika and Chetan DM Advancements in Immunomodulation. *Drug Discovery, and Medicine: A Comprehensive Review*. *Acta Botanica Plantae*. 2023;V02i02:39:52.
14. Kumar A, Sharma S. An evaluation of multipurpose oil seed crop for industrial uses (*Jatropha curcas* L.): A review. *Industrial Crops and Products*. 2008;28(1):1-10.
15. Openshaw, K. (2000). A review of *Jatropha curcas*: An oil plant of unfulfilled promise. *Biomass and bioenergy*, 19(1):1-15.
16. Amente G, Gemechu M, Chimdessa I. Protocol optimization for Micropropagation of Banana Varieties (*Musa* spp.) Using Shoot-Tip Culture. *Acta Botanica Plantae*. V01i02, 01-09.
17. Pyšek P, Richardson DM. Traits associated with invasiveness in alien plants: Where do we stand?. *Biological Invasions*. 2007;97-125.
18. Ogori AF, Eke MO, Girgih TA, Abu JO. Influence of Aduwa (*Balanites aegyptiaca* del) Meal Protein Enrichment on the Proximate, Phytochemical, Functional and Sensory Properties of Ogi. *Acta Botanica Plantae*. 2022;V01i03:22-35.
19. Goodwillie C, Kalisz S, Eckert CG. (2005). The evolutionary enigma of mixed mating systems in plants: Occurrence, theoretical explanations, and empirical evidence. *Annu. Rev. Ecol. Evol. Syst.* 2005;36:47-79.
20. Engelmann F. Use of biotechnologies for the conservation of plant biodiversity. *In vitro Cellular & Developmental Biology-Plant*. 2011;47:5-16.
21. Zhang X, Zhang Z, Zhou R, Wang Q, Wang L. Ratooning annual cotton (*Gossypium* spp.) for perennial utilization of heterosis. *Frontiers in Plant Science*. 2020;11:554970.
22. Kapoor L. Opium poppy: botany, chemistry, and pharmacology. CRC Press; 2020.
23. Ashman, Tia-Lynn, Tiffany M. Knight, Janette A. Steets, Priyanga Amarasekare, Martin Burd, Diane R. Campbell, Michele R. Dudash et al. Pollen limitation of plant reproduction: Ecological and evolutionary causes and consequences. *Ecology*. 2004;85(9):2408-2421.
24. Horlings LG, Marsden TK. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'. *Global Environmental Change*. 2011;21(2):441-452.
25. Singh AK, Yadav N, Singh A, Singh A. Stay-green rice has greater drought resistance: one unique, functional SG Rice increases grain production in dry conditions. *Acta Botanica Plantae*. 2023; 2(31):38.
26. Nweze CC, Muhammad BY. Wandoo Tseaa, Rahima Yunusa, Happy Abimiku Manasseh, Lateefat Bisola Adedipe, Eneh William Nebechukwu, Yakubu Atanyi Emmanuel. Comparative Biochemical Effects of Natural and Synthetic Pesticides on Preserved *Phaseolus vulgaris* in Male Albino Rats. *Acta Botanica Plantae*. 2023;2:01-10.

27. Romay, Maria C, Mark J. Millard, Jeffrey C. Glaubitz, Jason A. Peiffer, Kelly L. Swarts, Terry M. Casstevens, Robert J. Elshire et al. Comprehensive genotyping of the USA national maize inbred seed bank. *Genome Biology*. 2013:14:1-18.

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Peer-review history:

The peer review history for this paper can be accessed here:
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