



IMPACT OF PLANT BREEDING ON IMPROVEMENT OF MEDICINAL PLANTS

Sainath Rao M¹, Sowmya, H M², Ramanjineyulu M³ and Preethi B V⁴

¹Assistant Professor, Dept. of Spices, Plantation, Medicinal and Aromatic crops

²Assistant Professor, Dept. of Genetics and Plant breeding

³Assistant Professor, Dept. of Agronomy

⁴Assistant Professor, Dept. of Agricultural Economics

Sri Krishnadevaraya College of Horticultural Sciences, Ananthapuramu, Andhra Pradesh, India

*Corresponding Author Mail ID: sainath99sainath@gmail.com

Introduction

In the lush fields of botanical research centers worldwide, a quiet revolution is unfolding. The ancient art of plant breeding is undergoing a transformation from the process of forward genetics to reverse genetics, powered by cutting-edge technology which is driven by the requirement of effective sustainable medicines. This revolution promises to reshape not only our medicine cabinets but also the global agricultural economy by improving the agriculture production and also by exploiting the underutilized medicinal crops.

The Green Gold Rush

In the today's era where the cure for cancer grows in carefully tended fields, where chronic pain is managed with a cup of herbal tea and where the next blockbuster drug is harvested from the medicinal plants rather than synthesized. This isn't science fiction—it's the tantalizing possibility offered by modern medicinal plant breeding. The global market for plant-based medicines is already substantial, valued at \$83.1 billion in 2019 and projected to reach \$117.2 billion by 2024 (Persistence Market Research, 2020). But these figures may be just the tip of the iceberg. With

advancement in the breeding techniques we're unlocking the potential to create and conserve the "super plants" with enhanced medicinal properties, consistent quality and improved cultivation characteristics.

From Serendipity to Science

Traditionally, the discovery and development of medicinal plants relied heavily on chance and generations of traditional knowledge. A farmer might notice that a particular variant of an herb seemed to be more potent, or a healer might observe that plants from a specific location had profound effects in controlling many human diseases. This approach is valuable, slow and unpredictable. Entry into the modern breeding techniques gave us an opportunity to exploit and best utilization of these improved medicinal plants for human benefits. Today's plant breeders are armed with an arsenal of sophisticated tools that allow them to precisely identify, select and enhance desirable traits in medicinal plants. These techniques include:

1. Marker-Assisted Selection (MAS): This technique uses DNA or sequence based markers to identify plants with desired traits, intern which dramatically speeding up the breeding process.

2. Genomic Selection: By analyzing a plant's entire genome, breeders can predict which individuals will have the best combination of traits.

3. CRISPR gene editing: This revolutionary technique allows for precise modifications to a plant's DNA, potentially enhancing medicinal properties or removing undesirable traits.

4. Polyploidy induction: By doubling or tripling a plant's chromosomes, breeders can create varieties with enhanced vigor and potency.

These techniques are not just incremental improvements—they represent a paradigm shift in how we approach medicinal plant development.

The Economic Ripple Effect:

The impact of these advanced breeding techniques extends far beyond the laboratory. They're reshaping the agricultural landscape by creating crop diversity, creating new opportunities to work with the crop and challenges for farmers to grow, pharmaceutical companies and entire national economies.

Consider the case of artemisinin, a potent anti-malarial compound derived from sweet wormwood (*Artemisia annua*). Traditional cultivation of this plant was plagued by low and inconsistent yields of the active compound. However, through advanced breeding techniques, researchers have developed varieties that produce up to three times more artemisinin (Ferreira *et al.*, 2018). This breakthrough not only improves the global supply of this critical medicine but also provides a significant economic boost to farmers in artemisinin-producing regions. Similarly, the development of high-CBD

cannabis strains through selective breeding has fueled a boom in the medical cannabis industry. In the United States alone, the legal cannabis market is projected to reach \$30 billion by 2025 (New Frontier Data, 2021), creating thousands of jobs and generating substantial tax revenue.

Precision Agriculture Meets Precision Medicine

The integration of advanced breeding techniques with precision agriculture is ushering in an era of "precision phytomedicine." Farmers can now cultivate medicinal plants with unprecedented control over their chemical composition, ensuring consistent quality and improved potency.

Imagine fields of echinacea where every plant produces the optimal balance of immune-boosting compounds, or rows of St. John's Wort with carefully calibrated levels of hyperforin and hypericin. This level of consistency is a game-changer for the herbal medicine industry, addressing one of the key challenges that has long held it back: variability in active compounds.

Moreover, these precisely bred plants can be tailored to specific growing conditions with improved yield and quality of medicinal drugs. Drought-resistant varieties of medicinal plants could expand cultivation into arid regions, while cold-tolerant strains could push the boundaries of traditional growing zones. This adaptability not only increases the potential supply of medicinal plants but also offers new economic opportunities for farmers in diverse climatic regions for many agricultural farmers.

The Bio-Economic Feedback Loop

As breeding techniques become more sophisticated, they're creating a virtuous cycle of innovation and economic growth. Improved

varieties lead to higher yields and better quality, which in turn drives increased demand and higher prices for medicinal plants. This economic incentive fuels further investment in research and development, leading to even more advanced breeding techniques to fulfill human needs.

This feedback loop is particularly evident in the realm of plant-based pharmaceuticals. As breeding techniques produce plants with higher concentrations of target compounds, the economics of plant-derived drugs become increasingly favorable compared to synthetic alternatives. This shift could reshape the pharmaceutical industry, potentially leading to more affordable medicines and new treatment options for a variety of conditions.

Achievements in medicinal and aromatic crops through plant breeding methods

Crop	Variety	Breeding method	Significance
Lemon grass	Sugandhi		Red stemmed variety adopted to wide range of soil and climatic condition
	Pragati	Clonal selection	Tall growing with deep purple leaf sheath
	Praman	Clonal selection	Tetraploid with profuse tillering
	SD-68	Mutation breeding (radiation)	Improved yield up to 375 kg oil/ha/year
	Chirharit	Systemic breeding	Frost resistant and 81% citral content

Menthol mint	Himalaya		Resistant to leaf spot and rust disease.
	Kosi		Early maturing
	Saksham		High yielding
	Kushal		Early maturing
Patchouli	IIHR 5		Nitrogen responsive
Vetiver	Dharini, gulabi khesari	Selection	High essential oil and tolerant to sodic soils

Challenges and Controversies:

However, this brave new world of medicinal plant breeding is not without its challenges and controversies. The use of genetic modification techniques, particularly CRISPR, has raised concerns among some consumers and regulators. There are fears about potential unintended consequences and the long-term safety of genetically modified medicinal plants. Moreover, the ability to patent new plant varieties has led to heated debates about intellectual property rights and access to medicines. There's a risk that advanced breeding techniques could concentrate control of medicinal plants in the hands of a few large corporations, potentially limiting access for small-scale farmers and traditional healers.

Environmental concerns also loom large. As we develop more potent medicinal plants, there's a risk of these varieties escaping cultivation and disrupting natural ecosystems. Careful regulation and containment strategies will be crucial to mitigate these risks.

The Future of Phytomedicine:

Despite these challenges, the potential benefits of advanced medicinal plant breeding are too significant to ignore. As we look to the

future, several trends are likely to shape the evolution of this field:

1. Personalized Phytoedicine

Just as personalized medicine is revolutionizing healthcare, we may see the development of medicinal plant varieties tailored to specific genetic profiles or health conditions.

2. Climate-Resilient Varieties

As climate change alters growing conditions worldwide, breeders will focus on developing medicinal plant varieties that can thrive in changing environments.

3. Bioreactor Cultivation

Advanced breeding techniques may produce plant varieties optimized for cultivation in controlled bioreactors, allowing for year-round production and precise control of growing conditions.

4. AI-Driven Breeding

Machine learning algorithms could accelerate the breeding process by predicting which genetic combinations are most likely to produce desired traits.

5. Phyto-Nutraceuticals

The line between food and medicine may blur further as we develop plant varieties with enhanced nutritional and medicinal properties.

Cultivating a Healthier Future

As we stand on the brink of this new era in medicinal plant breeding, it's clear that the potential impact on global health and agricultural economics is immense. From the farmer tending her fields to the researcher in a high-tech lab, from the herbalist crafting traditional remedies to the pharmaceutical executive planning the next blockbuster drug,

the ripple effects of these advances will be felt far and wide.

The plants that have served as our medicines for millennia are being reborn, their ancient wisdom amplified by modern science. As we cultivate these new varieties, we're not just growing plants—we're growing hope for a healthier, more sustainable future. In the end, the story of modern medicinal plant breeding is a deeply human one. It's a tale of our enduring connection to the natural world, our drive to innovate and improve and our eternal quest for better health and wellbeing. As we write the next chapter of this story, we have the opportunity to create a world where the medicine we need is as close as our gardens, where farmers prosper by cultivating health and where the bounty of nature is harnessed in service of human flourishing.

The seeds of this future have been planted. With careful tending and wise stewardship, we can ensure a bountiful harvest for generations to come.

References

1. Chaturvedi, T., Gupta, A. K., Lal, R. K., & Tiwari, G. (2022). March of molecular breeding techniques in the genetic enhancement of herbal medicinal plants: present and future prospects. *The Nucleus*, 65(3), 413-436.
2. Ferreira, J. F., Luthria, D. L., Sasaki, T., & Heyerick, A. (2018). Flavonoids from *Artemisia annua* L. as antioxidants and their potential synergism with artemisinin against malaria and cancer. *Molecules*, 23(6), 1361.
3. Nalina, L., Rajamani, K., Shanmugasundaram, K. A., & Boomiga, M. (2022). Breeding and Conservation of Medicinal Plants in India.

In *Medicinal and Aromatic Plants of India*
Vol. 1 (pp. 201-236). Cham: Springer
International Publishing.

4. New Frontier Data. (2021). U.S. cannabis report: 2020-2021 industry outlook. *New Frontier Data*.
5. Persistence Market Research. (2020). Global market study on herbal medicines: Traditional healing techniques gaining significant traction globally. *Persistence Market Research*.