

Transforming arid lands into profit

Dryland horticulture insights

Prakash Patil* and Vani N. U.

ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka 560 089

Dryland horticulture offers a transformative approach to horticulture in arid and semi-arid regions, addressing the challenges of water scarcity, poor soil, and climate variability. By leveraging drought-tolerant crops, efficient water management techniques like drip irrigation and rainwater harvesting, in addition to sustainable practices, this approach enables the cultivation of diverse fruits, vegetables, and medicinal crops under limited water conditions. Dryland horticulture enhances food security, promotes farmer income, and fosters resilience against climate change through agroforestry, crop diversification, and climate-smart crop selection. Successful examples from India's drylands underscore the potential of this method to boost economic stability and local biodiversity while supporting environmental sustainability. Government initiatives and research are pivotal in overcoming challenges, expanding access to resources, and mitigating risks for farmers. With further investment and support, dryland horticulture could transform arid landscapes into productive hubs, offering sustainable solutions to global food and water demands.

Keywords: Climate change, Drylands, Food security, Horticulture

Dryland horticulture

IN a world increasingly threatened by climate change and water scarcity, dryland horticulture offers a promising pathway to transform arid and semi-arid regions into productive landscapes. These areas, which make up a significant portion of the world's landmass (In India, 68% of the cultivated area is under dryland agriculture, contributing about 44% to the country's total food production), are often seen as inhospitable for farming due to limited water availability and poor soil quality. Dryland horticulture refers to the cultivation of fruit, vegetables, and other horticultural crops in regions characterized by low rainfall and limited water resources. Unlike traditional horticultural practices that rely on consistent rainfall or irrigation, dryland horticulture utilizes drought-tolerant crops, efficient water management techniques, and innovative farming practices to thrive in arid or semi-arid environments. This method is becoming increasingly important in areas affected by climate variability and water shortages, providing farmers with a sustainable way to boost productivity. By focusing on crops that can survive with minimal water, farmers can not only sustain their livelihoods but also mitigate the risks associated with climate change and erratic weather patterns.

Dryland horticulture presents a promising solution for enhancing farmer income and building resilience against environmental challenges, while promoting sustainable land use and resource management.

Importance of dryland horticulture in arid regions

Dryland horticulture is essential in arid and semi-arid regions, where water scarcity and unpredictable rainfall present significant challenges to traditional horticulture. By focusing on the cultivation of drought-resistant fruits, vegetables, and other horticultural crops, dryland horticulture offers a sustainable solution for improving food security, enhancing farmer livelihoods, and promoting climate resilience. The yield of horticultural crops in dryland regions varies significantly based on the quantity and distribution of rainfall. Dryland horticulture emphasizes efficient water-use through techniques like drip irrigation, mulching, and rainwater harvesting, which maximize crop yields in water-scarce areas. By cultivating drought-tolerant crops such as fruits, nuts, and vegetables, farmers can increase their income and diversify production, boosting economic stability. This approach also supports climate-resilient farming, helping communities adapt to rising temperatures and erratic rainfall. Additionally, dryland

horticulture enhances food security by providing a diverse, nutritious food supply and promotes sustainable land use practices that preserve soil health and prevent erosion. Utilizing native or adapted crops further aligns farming with local ecosystems, fostering biodiversity and long-term land productivity.

Crop selection for dryland horticulture

Choosing the right crops is critical for the success of dryland horticulture, especially in arid and semi-arid regions as the primary focus in crop selection for dryland horticulture is to identify species that are drought-tolerant, adaptable to harsh conditions, and capable of yielding high economic returns. Dryland crops should be deep-rooted and perennial, with low water requirements and the ability to withstand harsh conditions. These crops typically have small, thick, shiny leaves to minimize water loss. They should be hardy, capable of enduring intense monsoons, and able to shed leaves during the summer, with flowering and fruiting occurring in the rainy season. Examples of crops suited for dryland horticulture are given below.

Fruit crops: Drought-tolerant fruit trees like fig, karonda, jamun, bael, phalsa, dates, ber, guava and pomegranate are ideal for dryland regions. These crops can thrive with minimal water and are known for their resilience to dry conditions.

Table 1. Fruit crops for drylands in different rainfall zones

Mean annual rainfall (mm)	Plains	Plateaus and sub-mountain regions
>500	Kherji, Ber, Phalsa, Indian Fig, Karonda	Custard apple, Bael, Karonda, Ber, Jamun
500–1000	Ber, Aonla, Jamun, Wood apple, Custard apple, Guava, Sour Lime, Lemon, Mango, Tamarind, Pomegranate	Ber, Custard apple, Wood apple, Karonda, Indian Almond, Mango, Sour Lime, Lemon, Grapefruit, Pomegranate
>1000	Mango, Jackfruit, Mandarin, Tamarind, Jamun	Mango, Jack fruit, Guava, Tamarind, Cashew nut, Cherry, Pomegranate

Source: Reddy *et al.* 2022



High-density planting of mandarin at Akola (Maharashtra)



High-density planting of sweet orange at Akola (Maharashtra)



High-density planting of sweet orange at Tirupati (Andhra Pradesh)

Nut crops: Almonds and pistachios are excellent options due to their ability to grow in dry environments and their high market value.

Vegetable crops: Certain vegetables like onion, tomato, chili pepper, bittergourd, bottlegourd, ridgegourd, spongegourd, watermelon, roundmelon, longmelon, snapmelon, drumstick, cluster bean, cowpea, amaranth, brinjal, and okra are suitable, as they have shorter growing cycles and require less water compared to other vegetable varieties. Techniques like mulching and drip irrigation can further enhance their water efficiency.

Flower crops: Tuberose, chrysanthemum, crossandra, marigold, jasmine and aster along with ornamental cut flowers like rose, carnation, gerbera, tulip, lily, alstroemeria, orchid and anthurium have path to dryland horticulture.

Medicinal and aromatic crops: Isabgol (Gujarat Isabgol-1 and Gujarat Isabgol-2), aloe (*Aloe vera*), senna (Anand Late Selection), Egyptian henbane (HMI-80-1), palmarosa (*Rosa Gross 49a*), lemongrass (NLG 84), and vetiver (Hyb 8) can be commercially cultivated in dryland areas to boost income through crop diversification.

Spice crops: Cumin (GC 4), fennel, fenugreek (Ajmer Fenugreek-4), sesame, ajwain (Ajmer Ajwain 93), and nigella (Ajmer Nigella 20) can be cultivated in a multi-story cropping system along with fruit crops to further boost farm income.

Perennial crops: Olives, moringa, and agave are suited because of their deep root systems that enable them to access water from deeper soil layers. They also provide long-term income sources with less frequent replanting needs.

Annual crops: Melons and squash, which have shorter growing seasons, can be integrated into dryland systems, especially when paired with water-efficient practices.

Agroforestry and multi-cropping systems: Agroforestry, combining trees, shrubs, and ground crops, optimizes land use and boosts income. For instance, pairing fruit or nut trees with crops like aloe vera and ashwagandha enhances productivity.

Local adapted varieties: Using locally adapted or indigenous crop varieties that have evolved to survive in arid environments is a key strategy in dryland horticulture. These crops are often more resilient to local pests, diseases, and climatic extremes, making them a sustainable choice for long-term cultivation.

Climate-smart crop choices: Priority should be given to crops developed for climate resilience, such as drought-tolerant varieties from breeding programs. Examples include sorghum, pearl millet, and drought-resistant pulses like chickpea and cowpea, which can support horticultural systems.

Cultivating high-value crops: One of the key strategies in dryland horticulture is focusing on high-value crops like fruits, nuts, and vegetables. Compared to staple crops, these horticultural products often command higher prices in the market, allowing farmers to diversify their income streams and enhance their economic resilience.

Challenges of dryland horticulture

Dryland horticulture faces significant challenges due to water scarcity, poor soil quality, and extreme climate conditions. Limited rainfall, high temperatures, and unpredictable weather make it difficult to sustain crops, while poor soil fertility, salinity, and erosion further reduce productivity. Only a narrow range of drought-tolerant crops can thrive, and pests often pose a greater threat in these regions. Farmers in dryland areas also struggle with limited access to technology, infrastructure, and markets, leading to inconsistent yields and low

economic returns. Climate change exacerbates these issues by increasing drought frequency and altering weather patterns, further threatening crop survival and productivity.

Maximizing water efficiency

Water scarcity is the primary challenge in dryland areas, making efficient water management crucial. Dryland horticulture emphasizes techniques such as drip irrigation, rainwater harvesting, and mulching to make the most of limited water resources. Drip irrigation delivers water directly to the plant roots, reducing evaporation and ensuring minimal water is wasted. Mulching, on the other hand, helps retain soil moisture and regulates soil temperature, creating a more favourable microclimate for crops. Rainwater harvesting systems collect and store rainwater during wet periods, providing a critical water supply during dry spells. These methods not only help farmers optimize water use but also increase crop yields in water-constrained regions.

Climate-resilient farming

Arid regions are particularly vulnerable to the impacts of climate change, including rising temperatures, erratic rainfall patterns, and increased frequency of droughts. Dryland horticulture offers a climate-resilient approach by promoting crops that are naturally adapted to withstand these harsh conditions. This focuses on developing sustainable agricultural systems that can thrive in arid conditions and adapt to climate change. Efficient water management techniques like rainwater harvesting and drip irrigation are crucial, as are soil health practices such as crop rotation and organic manure. Protected cultivation, like polyhouses, shields crops from extreme climates, while integrated pest management reduces climate-induced risks. This approach boosts productivity, water efficiency, and farmer resilience in dryland areas. Farmers in dryland areas also adopt agroforestry practices, combining trees

Success stories

Horticulture in India's drylands has witnessed impressive success through innovative practices and resilient crop choices. Farmers in Maharashtra and Karnataka have adopted pomegranate, utilizing drip irrigation and improved varieties like Bhagwa, while regions in Rajasthan and Gujarat have transformed arid land with date palm cultivation supported by tissue culture techniques. Ber, bael and watermelon grown in Rajasthan and Maharashtra, thrives with minimal irrigation, and aonla in Madhya Pradesh and Uttar Pradesh offers sustainable income with its hardy nature. Kinnow mandarin in Punjab and bael in Uttar Pradesh and drought-resistant crops like cowpea have similarly adapted well to these climates. Key strategies like efficient water management, drought-resistant crop varieties, and strong market linkages, supported by government schemes, have enhanced productivity and economic stability in these challenging landscapes.

In India's dryland regions, various horticultural crop varieties are cultivated for their adaptability to water-scarce conditions and resilience to arid climates. Among fruit crops, ber varieties like Kashmiri Red Apple and Goma Kriti; aonla varieties such as Chakaiya and NA-7, and pomegranate types like Ganesh and Bhagya are popular for their drought tolerance. Other resilient fruits include custard apple (Balanagar), guava (Allahabad Safeda, Lalit), and bael (Goma Yashi). Vegetables also play a key role, with tomato (Pusa Ruby), chilli (Pusa Jwala), cowpea (Pusa Komal), cluster bean (Goma Manjari), brinjal (Pusa Purple Long), and okra (Arka Anamika) varieties showing high water efficiency and productivity. In addition, muskmelon (Pusa Sharbati), watermelon (Sugar Baby), onion (Arka Niketan), and drumstick (PKM-1) are cultivated widely for their robust performance in dry climates. These crop choices not only improve food security but also support economic stability for farmers in arid regions through sustainable land use.



Farm ponds lined with 750 μ polythene in Udaipur (Rajasthan)



Life saving irrigation from harvested rainwater in Udaipur

and crops to improve land productivity and enhance ecosystem services. This not only provides shade and reduces soil erosion but also helps create a more diverse and resilient agricultural system capable of withstanding climate variability.

Enhancing food security

In regions where food security is a pressing concern, dryland horticulture plays a crucial role in providing a stable and nutritious food supply. By growing a variety of fruits and vegetables that can thrive with minimal water, communities in arid areas can reduce their reliance on imported food products. This diversification of crops helps ensure a more balanced diet, improves nutritional outcomes, and creates local food self-sufficiency. Moreover, horticultural crops offer longer storage life when they are processed allowing farmers to preserve their produce for sale or consumption during off-seasons. This contributes to food availability year-round, further enhancing food security in dryland regions.

Sustainable land use and biodiversity conservation

Dryland horticulture promotes sustainable land management practices that help preserve soil health and prevent land degradation. In many arid regions, overgrazing, deforestation, and unsustainable farming practices have led to soil erosion and loss of fertility. Dryland horticulture counters these challenges by encouraging agroforestry, conservation horticulture, and organic farming techniques. By maintaining ground cover and minimizing soil disturbance, these practices prevent erosion and enhance the long-term productivity of the land. Furthermore, dryland

horticulture often focuses on utilizing native or locally adapted crop varieties, which are better suited to the specific environmental conditions of the region. This not only supports biodiversity but also helps farmers work in harmony with their ecosystems, rather than against them. In doing so, it ensures that farming in arid regions is both economically viable and ecologically sustainable.

Risk mitigation strategies in dryland horticulture

Risk mitigation in dryland horticulture focuses on efficient water management, soil health improvement, and climate-adapted practices. Key strategies include rainwater harvesting, drip irrigation, mulching, and the use of drought-tolerant crop varieties. Conservation tillage, organic matter addition, and cover crops help improve soil moisture retention. Agroforestry, intercropping, and optimized planting schedules further enhance resilience to climate variability. Integrated pest management and crop rotation reduce pest and disease risks, while crop insurance and cooperatives offer financial protection. Access to early warning systems and farmer training also plays a crucial role in adapting to dry conditions.

Path forward

The potential of dryland horticulture to transform arid lands into profitable hubs is undeniable. However, for this potential to be fully realized, investment in research, infrastructure, and training is essential. Governments, development agencies, and private sector actors all have a role to play in supporting farmers with access to the necessary resources and knowledge to implement water-efficient technologies and sustainable practices. By leveraging the insights from dryland



Water conservation under NICRA project at Udaipur

Government initiatives

The Ministry of Agriculture and Farmers' Welfare (MoAFW) implements the Rainfed Area Development Programme (RADP) under the *Rashtriya Krishi Vikas Yojana* (RKVY) to address the concerns of dryland farmers, alongside major initiatives like the National Food Security Mission (NFSM), National Horticulture Mission (NHM), and National Mission on Micro Irrigation (NMMI), which focus on dryland areas. Research by CRIDA and ICAR aims to boost productivity in these regions. The Ministry of Rural Development (MoRD) runs the Integrated Watershed Management Programme (IWMP) for rainfed and degraded areas, integrating programs like the Desert Development Programme (DDP) and Drought Prone Areas Programme (DPAP). The IWMP promotes rainwater harvesting, drip irrigation, and sprinkler technologies to enhance water-use efficiency and irrigation potential.

horticulture, farmers can turn the challenges of arid environments into opportunities for growth, resilience, and prosperity. With the right support, dryland areas can become not only productive but also profitable, offering a sustainable solution to the growing global demands for food and water.

SUMMARY

Dryland horticulture is more than just a farming strategy; it is a holistic approach that integrates soil and water conservation, climate adaptation, and sustainable land management. By transforming arid lands into productive and profitable agricultural systems, it holds the promise of addressing some of the most pressing challenges of horticulture while providing new opportunities for farmers and communities living in some of the world's most challenging environments.

*Corresponding author email: Prakash.Patil@icar.gov.in

HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.

The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional, protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

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to teachers, students, trainers, line-department personnel and policy makers.



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