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Promising trends in agricultural practices towards food security: expanding the desert landscape and flora into mainstream farming

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Rapid climate change and degrading quality of once-fertile agricultural lands makes it imperative to turn attention towards marginal and desert lands for practice of farming. Additionally, wild xerophytes (desert plants) have been successfully thriving on such lands of extreme temperatures and water scarcity, and provide important clues for traits desired in food crops (such as stress tolerance). In past, the local human communities have derived nutrition from the underexplored (semi)arid plants during drought and famine. Latest technological innovations like application of clay nanoparticles and xerophyte-derived rhizobacteria, vertical farming, horticulture crop-based site management, and restoration of degraded agricultural lands using native and climate-resilient plant varieties offer a glimpse of hope. Therefore, (i) farming of popular food crops (like *Solanum lycopersicum* using techniques like drip irrigation) on desert lands, as well as, (ii) bringing desert plants (such as the superior varieties of tree legumes like *Prosopis cineraria*) into mainstream agriculture are two approaches that have shown promise. These actions would also align with the UN Sustainable Development Goals, viz.: SDG 2 (Zero hunger), SDG 12 (Responsible consumption and production) and SDG 13 (Climate action) in particular. Through the current article, we intend to highlight recent success stories on desert landscapes/plants and present the way forward for sustainable agriculture in future.

KEYWORDS

desert plants, sustainable agriculture, horticultural crop, farming trends, climate change, smart technology, food security

1 Introduction

Drylands, including desert ecosystems across the world, occupy a significant portion of the earth's land surface (almost 41.5%, as per Wang et al., 2023), presenting attractive options for practice of agriculture. A few representative examples of global desert lands include Sahara and Kalahari (Africa), Gobi and Thar (Asia); deserts of the Arabian Peninsula; Atacama (South America); and, Chihuahuan desert (North America). The criteria of varying rainfall pattern further lead to their classification into arid, semi-arid and hyper-arid (Golla, 2021). Extreme environmental conditions are the hallmarks of such lands, and have shaped the evolution of their plant, animal and microbial life in a unique manner. Over the past few decades, the two interrelated issues of sustainable agriculture and food security have helped garner increased attention of scientists and agronomists towards such landscapes.

Historically, the desert lands have faced extremely challenging climates (high solar radiation during summers, very high to very low temperatures, uneven rainfall and drought), and the plants therein have developed suitable adaptations to survive and flourish (Mohanta et al., 2023). The adaptations in desert plants (xerophytes) involve modifications pertaining to the following properties: physiological (CAM photosynthetic pathway), morphological (reduced leaf size, waxy cuticle, and roots extended deeply into soil) as well as biochemical (expression of heat shock proteins (HSPs) to achieve proper protein folding; production and storage of specialized secondary metabolites like polyphenols and terpenoids, as well as enzymes like superoxide dismutase and catalase (Joshi et al., 2023a; Berwal et al., 2021). Current climate change patterns suggest that our popular food crops are going to face similar challenges in near future.

Therefore, scientists need to consider solution paths centered around two ideas. *First*, since a major portion of the land area on earth is categorized as deserts, technological aids must be developed and utilized to grow suitable varieties of popular food crops on such lands. *Second*, suitable varieties of desert food crops must be developed/selected for large scale farming on desert lands, in order to cater to future food and nutrition security for all (Joshi et al., 2023b). The drip irrigation technique, which delivers water droplets precisely at the root zone, thereby maximizing water use efficiency, has been quite successful in the dryland agriculture in the past (Megersa and Abdulahi, 2015). In this article, we intend to review a few recent examples and offer our insights in context of desert farming.

2 Identification of potential candidate crops for desert farming

Desertification is a growing phenomenon, and has raised concerns among the scientific community to combat it and restore the degraded lands. Since such lands are available in many countries, the potential of farming on their soils cannot be ignored when targeting future food security. In recent past, the right cultivar coupled with the right technology (e.g. drip irrigation) has enabled the farmers to grow popular fruit- and vegetable-bearing plants in western, arid zones of Rajasthan (India). A few representative examples include pomegranate (*Punica granatum*) and tomatoes (*Solanum lycopersicum*).

Many of the edible plants occurring in the desert ecosystems grow in the wild, and there could be a diversity of potential crops among them. These could be prime candidates for practicing low input sustainable agriculture (LISA) as their requirement for irrigation water and artificial fertilizers/pesticides is relatively less. From an agro-food perspective, the most important varieties requiring relevant research here would be those with high yield, high disease resistance, and having potential to be developed as consistent sources of functional foods. The search for such candidates could be accelerated by studying the food habits of indigenous communities.

For instance, Nabhan et al. (2020) used a number of different criteria (corresponding to agroecological functions, human health, community well-being and agronomic suitability) to assess and select 17 desert plant genera with high potential as food crops in the face of climate change. The candidate crop list, which was prepared by studying the historic diets of local people of Sonoran Desert, included CAM succulents. As per the authors, the selected crops have potential to be incorporated into two agroecosystem designs: one, where (legume) trees shield and support understory plants from various stresses including solar radiation; second, where crops are grown beneath solar arrays (agrivoltaics), thereby combining renewable energy and food production.

Tree legumes like *Prosopis cineraria* (native to India), have a historical and cultural significance for indigenous communities in Rajasthan, India. Kong et al. (2023) recently reported on the draft genome sequence of a related species, *Prosopis alba* (*Neltuma alba*, as per Hughes et al., 2022), which helped the authors to identify genes related to multiple stress tolerance (for possible utilization in breeding programs).

Selected cultivars of native legumes could further benefit from gene editing (via CRISPR/Cas systems) to improve organoleptic properties or other traits of the edible pods derived from the same (Joshi et al., 2023c). However, careful experimental designs are required to rule out off-target effects (e.g. elimination of unintended mutations by back crossing). Also, combination techniques like single guide RNA (sgRNA)/ligand-dependent aptazyme strategy, employed at temperatures of 34-37°C, have been suggested to be a promising approach (Hajiahmadi et al., 2019). Aptazymes are ligand-dependent, self-cleaving ribozymes that avoid unwanted mutations by the CRISPR/Cas9 system.

Figure 1 shows some of the desert plants (bearing edible fruits/pods) of Rajasthan state, India (in areas between 27°011′ and 29°03′ North latitude and 71°54′ and 74°12′ East longitude).

Therefore, edible desert plants, validated by indigenous food habits, could act as valuable sources of future food crops, also targeting malnutrition, wherever feasible.

3 Horticultural crop-based site management

Enhancing resource utilization and effectively managing production sites of horticulturally significant crops through

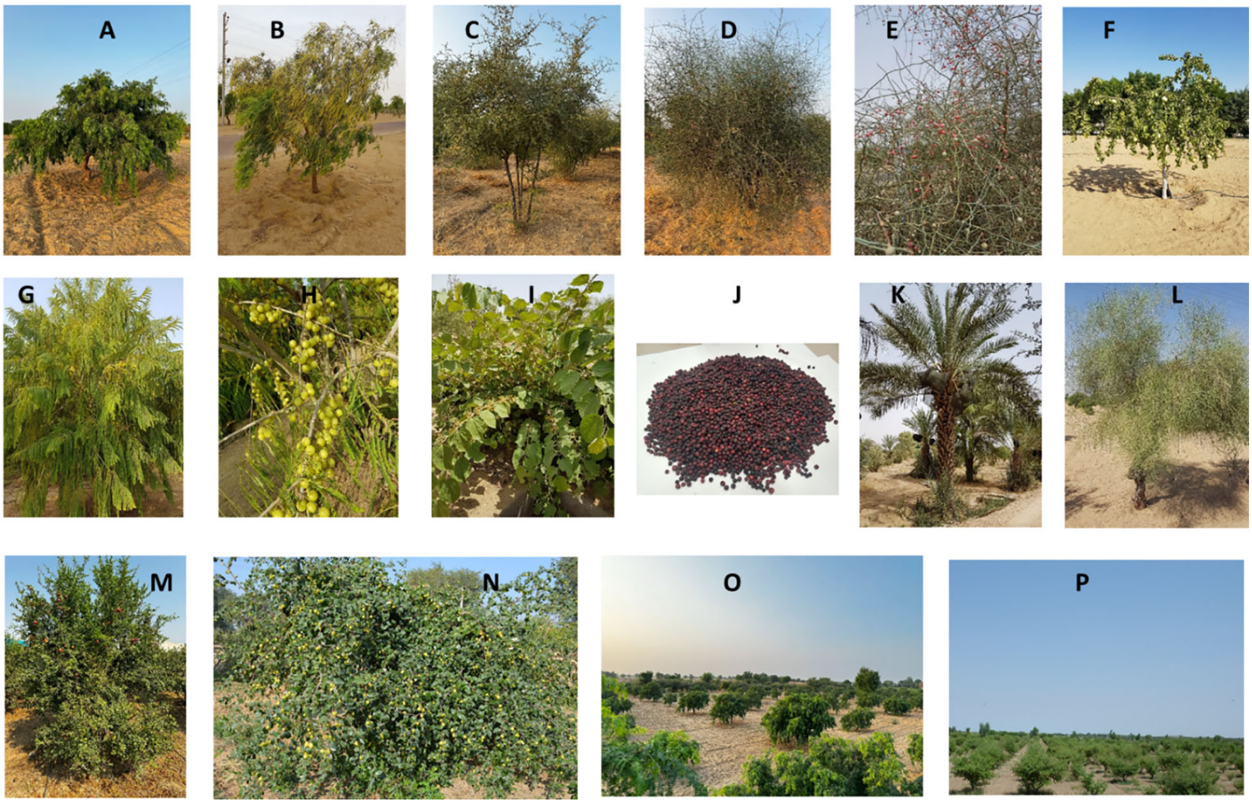

FIGURE 1
A few edible desert horticultural plants with potential for large-scale farming. **(A, B)**, *Prosopis cineraria*. **(C)**, *Ziziphus mauritiana*. **(D, E)**, *Capparis decidua*. **(F)**, *Aegle marmelos*. **(G, H)**, *Emblica officinalis*. **(I)**, *Grewia asiatica* plant. **(J)**, *Grewia asiatica* fruits. **(K)**, date palm (*Phoenix dactylifera* L). **(L)**, *Calligonum polygonoides*. **(M)**, Pomegrenate (*Punica granatum*). **(N)**, *Ziziphus mauritiana*. **(O, P)**, HBCPSMA for *Prosopis cineraria and Ziziphus mauritiana* (See Section 3).

technological advancements is critical. The primary focus of this concept involves creating favorable micro-climates and safeguarding crops at production sites. Furthermore, adopting innovative management practices and crop-specific agro-techniques is vital for optimizing resource use and mitigating the adverse impacts of abiotic and biotic stresses. This approach, emphasizing crop-genotype-environment interactions, is encapsulated in the Horticulture-Based Crop Production Site Management Approach (HBCPSMA) (Samadia, 2016). It has been successfully demonstrated in the field at ICAR-Central Institute for Arid Horticulture, Bikaner India, (28° 06'01.9"N 73°21'22.5"E) which is situated in the Thar Desert of India.

3.1 Khejri (*P. cineraria*)-based crop production site management

Across expansive arid farmlands, crops such as pearl millet, cluster bean, moth bean, sesame, and native cucurbits are cultivated alongside natural plantations of khejri (*Prosopis cineraria*). Additional native trees, shrubs, and grasses, including jharber (*Ziziphus nummularia*), bordi (*Ziziphus rotundifolia*), lasora (*Cordia myxa*), pilu (*Salvadora oleoides*), ker (*Capparis decidua*), phog (*Calligonum polygonoides)*, and sewan (*Lasiurus scindicus*), form integral components of the agri-horti-silvi-pastoral system practiced under rainfed conditions (Samadia, 2015).

Incorporating native crop-plants and leveraging technological advancements under the *P. cineraria*-Based Crop Production Site Management Approach offers a promising strategy to enhance yields and boost farm incomes.

3.2 Innovative practices under HBCPSMA

The HBCPSMA framework involves multiple innovative practices to maximize productivity and sustainability: Site selection and preparation (optimized for *in-situ* rainwater harvesting and soil moisture conservation), soil health management (by keeping fields fallow for 1–2 months), ploughing techniques (by adopting deep ploughing before the monsoon in June and post-harvest ploughing in November), crop and seed management (by selecting appropriate seeds/plants and determining optimal sowing/planting times) and population maintenance and protection (by ensuring proper crop-plant density and safeguarding against biotic and abiotic stressors).

3.3 Low-tunnel technology

Vegetable production, especially off-season, has been difficult in the past because of abiotic stress and poor germination. But recent introduction of horticultural crops based site management through low tunnel technology has been a game-changer for marginal and small farmers.

Krishi Vigyan Kendras (KVKs or Farm Science Centers) and research centers such as ICAR-Central Institute for Arid Horticulture (ICAR-CIAH), Bikaner and ICAR-Central Arid Zone Research Institute (CAZRI), Jodhpur, India, encouraged low-cost polyethylene tunnels (low tunnels) for developing favorable microclimates for off-season vegetable crop production. Low tunnels with crops like bottle gourd, ridge gourd, watermelon, muskmelon, tomato, and cucumber were prepared. Low tunnels created a controlled environment at the time of germination and seedling growth by maintaining soil moisture, retaining heat in winter months, and shielding the seedlings from strong winds and sandstorms (Rani et al., 2022).

In brief, creation of favorable microclimates around horticulturally relevant crops and low tunnel technology could result in higher farm yield.

4 Application of nanotechnology

Nanotechnology is an interdisciplinary area of science, where molecules are constructed/studied at the nanoscale level (1–100 nm size) for diverse applications. The most important features of the nanomaterials are large surface area-to-volume ratio, better shelf life and higher chemical reactivity. In agriculture, the use of nanoparticles is considered an environment-friendly and sustainable approach (due to lesser dosage requirement), and holds tremendous potential for efficient delivery of plant growth regulators, fertilizers and pesticides. Besides, nano-sensors have been used as diagnostic tools for accurate and early disease detection and subsequent plant protection, thereby alleviating economic losses in agriculture. Such systems are able to detect on-site the various bacterial, fungal or viral pathogens of the plants, with enhanced detection limit, sensitivity and specificity (Kashyap et al., 2019).

Due to its sustainable nature and the ability to retain water, nanoclay has recently been suggested to potentially enhance agricultural output in desert areas (Abd-Elsalam et al., 2024). Such clays are composed of layered sheets of mineral octahedral and tetrahedral silicates. Some examples of nanoclays include palygorskite, sepiolite, montmorillonites, kaolinites, illites, halloysite, zeolite and bentonite (Rao et al., 2024; Hnamte and Pulikkal, 2022). The technology (being used in Norway) employs mixing of clay with irrigation water in the agricultural land itself, resulting in formation of liquid nanoclay (LNC), that is sprinkled in the field (Liu, 2020; Olesen, 2010). Here, the negative charge on the LNC surface attracts water molecules, leading to reduction in nutrient leaching. This technology also helps to stabilize sandy soils and tackle wind-effected soil erosion in arid and semi-arid regions. In the desert farms of Dubai (UAE), watermelon, pearl millet and zucchini have been grown using this technique. Currently, the application of liquid nanoclay costs around 2–5 USD per square meter. LNC has the potential to enhance seed germination rates also via diverse mechanisms: modulation of gene expression, enhancement of enzyme activity, generation of ROS (Reactive Oxygen Species), ultimately resulting in cell wall loosening and promotion of seedling growth (Salama et al., 2021).

Therefore, nanotechnology holds significant promise towards improving nutrient and water retention in desert soils.

5 Application of desert plant microbiome

Plants are known to harbor diverse microbial communities on their different parts: on aerial parts (phyllosphere), within plant (endosphere), on root surface (rhizoplane) and in zones around the roots (rhizosphere). Building up of appropriate symbiotic plant-microbe associations is crucial to desert plants' survival and fitness in harsh conditions. It is dependent on host plant genotype, geographical location and soil properties, and also requires the secretion of specific primary and secondary metabolites in the root exudates (Alsharif et al., 2020). Taxonomically, two major bacterial phyla have been found to dominate microbiomes in desert plants, namely, Proteobacteria and Actinobacteria. An important bacterial category, namely PGPR (Plant Growth Promoting Rhizobacteria), also assist these plants to thrive in extreme environmental conditions by enabling nutrient mobilization (such as nitrogen fixation and iron sequestration) and improving plant tolerance to abiotic and biotic stresses (via production of hydrolytic enzymes and VOCs). The desert plants can be useful sources of PGPRs that can help both native and non-native agricultural crops to thrive in conditions of extreme stresses such as drought and soil salinity, with a potential to alleviate food (in)security issues.

In one study, Zia et al. (2021) reported on the isolation of rhizobacteria from native weeds (*Aerva tomentosa* and *Panicum turgidum*) of Cholistan desert (a hot, hyper-arid sandy desert in Pakistan). These were found to improve wheat seed germination and growth under water deficit conditions. The functional characterization of the bacteria revealed indole acetic acid (IAA) production, phosphate solubilization, siderophore production, and nitrogen fixation. In another recent study, Marik et al. (2024) reported on the isolation and mechanistic characterization of a rhizobacterium, *Peribacillus frigoritolerans* T7-IITJ, isolated from the rhizosphere of the wild indigo plant *Tephrosia purpurea* occurring in the Thar desert of India. In the model plant *Arabidopsis thaliana*, upon inoculation with the bacterial isolate, 445 plant genes were found to be induced (for photosynthesis and secondary metabolite biosynthesis, for example). The isolate was also seen to promote germination and seedling growth of plants such as *Triticum aestivum* (wheat) under drought conditions, besides inhibition of pathogenic fungi.

In brief, such bacteria (i.e. the desert plant microbiome) have the potential of acting as chemical-free and environment-friendly biofertilizer to promote the sustainable growth of crops in arid regions.

6 Application of organic farming

The basis of organic farming is maximizing reliance on renewable resources derived directly from the farm and effectively managing ecological and biological processes (Gamage et al., 2023). Organic farming seeks to achieve optimal levels of crop and livestock production, enhance human nutrition, and protect against pests and diseases while ensuring an appropriate return on investment in human and natural resources by focusing on these principles.

This approach offers many long-term benefits, such as improvement in environmental quality, biodiversity conservation, and healthy ecosystems.

The key focus areas of organic farming include: maximizing biological activity in soils, long-term soil health and reduction of soil erosion, genetic and biological system enhancement, recycling of plant and animal-origin materials and reducing the usage of non-renewable resources. Through these principles, organic farming develops a symbiotic relation between agriculture and the environment, which ensures a brighter future for generations.

In desert regions, one benefit of organic farming seems to be an increase in the diversity of arbuscular mycorrhizal fungi (AMF), with potential to enhance sustainable food production in resource-limited soils. Kutty Mullath et al. (2019) reported that organically farmed native plants of Arabian desert peninsula harbored 21 AMF species, compared to 14 species on conventional sites. AMF are known to benefit crops by improving crop nutrition (such as enhanced phosphorus uptake from soil) and better protection against soil-borne pests and diseases. Water uptake is also better in such plants, therefore having utility in drought tolerance or desert conditions.

Therefore, organic farming can be beneficial to desert farmlands by enhancing AMF and water uptake by crops.

7 Vertical farming on desert lands

The reduction in arable lands all over the world has given rise to the concept of vertical farming (VF), in which the crops are grown in vertically stacked layers (Van Gerrewey et al., 2022). Indoor vertical farms allow for precise regulation of temperature, moisture and light intensity; higher water use efficiency and year-round agro-food production. These are important parameters in arid land agriculture too, water being a highly precious commodity in those areas. When installed on meagre agricultural lands in urban areas, VF helps to reduce transportation costs of the agricultural products to the market.

Khalaf et al. (2023) employed a form of renewable energy (Concentrating Solar Power, CSP) to enable vertical farming in Iraq's arid regions. In comparison to conventional farming, 63- to 104-fold increase in the yields of Romaine lettuce (not a conventional arid zone plant) was observed when VF was employed, coupled with artificial lighting and temperature regulation. In comparison to a single winter harvest in the Anbar region of Iraq, VF could achieve multiple harvest cycles (every 30 days per year). However, it required 83 times greater energy (owing to enhanced electricity consumption) to achieve this yield, with possible mitigation through integration of renewable energy sources such as use of CSP.

In brief, CSP-powered vertical farming can be used to ensure sustainable food production in the desert regions of the world.

8 Application of AI/ML/DL to reduce losses and boost agricultural yield on desert farms

Artificial Intelligence (AI) technologies are being visualized as groundbreaking technology, with potential to boost agricultural productivity and reduce crop losses. In a recently published report (Joshi et al., 2024), we have discussed the potential of AI/ML/DL to enable the cultivation of mainstream food crops on desert soils; ensure food safety, quality and traceability in desert food production; discovery of bioactive metabolites/metabolic biomarkers/quality indicators in desert plants. Some of the barriers in successful use and expansion of AI/ML in the domain of agriculture have recently been emphasized as: high cost; extreme climate; requirement of high accuracy and precision in parameter prediction; lack of skilled workforce/computational resources/necessary infrastructure/willingness to embrace a new technology, etc (Hasteer et al., 2024).

The right crop cultivar (high yielding/disease resistant) of the desert plant needs to be identified for large scale cultivation in farms. AI can also assist in the breeding experiments to develop improved plant varieties through combination of high-throughput genomics and phenomics; and, development of stress-tolerant and climate-resilient crops (Khan et al., 2022).

In brief, AI can help in sustainable agriculture by quickly analyzing large amounts of data, deriving connections among variables, and offering useful insights on prediction of a specific parameter under study (e.g. a disease infecting a desert crop), which may not be manually possible.

9 Potential for commercialization

The technologies discussed above have met with commercial success when applied on a local scale. A few case studies are highlighted below to analyze their performance and sustainability under rising demands.

In one instance, the implementation of low tunnel technology resulted in greater crop production and revenue generation (e.g. 30–60% boost in harvest and two to three times revenue), early production (e.g. crop maturation 15–20 days ahead of open-field crops), improved germination and plant survival (e.g. germination increase by more than 80%), water use efficiency (e.g. via drip irrigation), and women empowerment (e.g. achieving better nutrition and incomes through formation of women self-help groups). The exponential spread of this technology has enabled the meeting of rising demands in the hot arid regions of Rajasthan to an extent. For example, the net sown area under low tunnel technology was about 1,015 hectares in Bikaner District of Rajasthan (India) during 2011 which increased by 1378% and reached to 15,000 hectares during 2021 (Rani et al., 2022).

In a relevant study, Gautam et al. (2024) showed that in comparison to ground-mounted solar power plant, the agrivoltaics system had 55% lesser cost of energy (electricity). Their study involved a 209 kWp solar farm (0.512 hectare land area) at Dayalbagh Educational Institute's Dairy Campus in Agra, India. The reproducibility of this approach needs to be seen in other/larger areas.

Since environment regulation is important to the success of Vertical Farming (VF), its high energy demand poses a challenge and can offset the advantages associated with VF. Additionally, agriculture contributes significantly to the greenhouse gas emissions in the atmosphere. Considering the negative impact of climate change, future food production systems would require reducing the dependence on fossil fuels, while enhancing that on clean, renewable energy. However, the leachates releasing from solar cell devices and elements like lead, cadmium and copper, often present in their ingredients, can cause health and environmental problems, if not managed properly, and therefore compromise on sustainability of the technology.

There have been instances where rising demand for a particular technology (e.g. panel installation for solar energy) has led to felling of trees (e.g. *Prosopis cineraria* in cultivable lands of Rajasthan (India)), resulting in debate surrounding sustainability (Down to Earth, 2025). Environmentalists have proposed the shifting of solar panels to more arid regions rather than cultivation-friendly semi-arid zones.

With changing agricultural priorities shifting from subsistence to profitable farming, the risks associated with mono-cropping in the arid zones have also increased. The unpredictable nature of Indian monsoon rains (too sparse or very heavy at times), coupled with the environmental constraints of hot arid regions, highlights the need for multidimensional interventions, before success is achieved on a more global scale.

10 Challenges and insights

The technologies discussed above could ensure future food security by supporting large scale farming on desert lands. Similarly, the right cultivar of a sustainable, arid zone plant (like the thornless 'Thar Shobha' variety for *Prosopis cineraria*, developed through grafting techniques) can be considered for more mainstream agricultural practices. However, these would need to be validated through implementing small scale, and possibly long-term, pilot projects first, in which manpower training (in appropriate technology) would be essential. Such an approach would also ensure that the success of a particular technology gets replicated in another region or when implemented on a larger scale. In the same context, multiple factors, other than those already highlighted in relevant sections above, merit scientific discussion and research.

- Tree legumes such as of the *Prosopis* genus are crucial to the agroforestry system in desert regions, as they are able to fix nitrogen and sequester carbon at high temperature, high salinity and low moisture conditions. However, genome

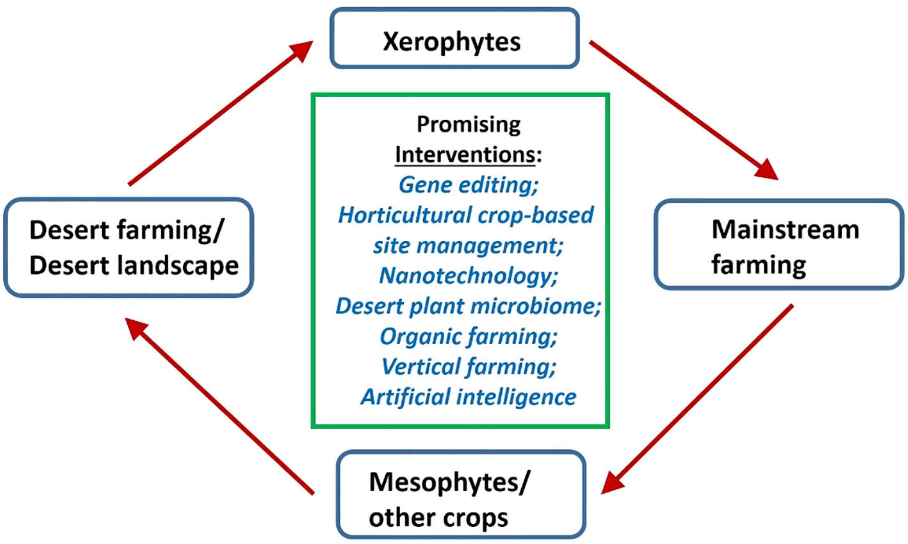

FIGURE 2
Promising interventions using desert plants and desert landscapes towards enhanced agricultural and food security.

assembly and identification of genes corresponding to such traits in these legumes would be crucial.

- Techniques like HBCPSMA, which have been successful for *Prosopis cineraria*, need to be optimized for other desert plants, as the required microclimate will vary from plant to plant.
- Challenges like high electricity consumption and energy demand for vertical farming could limit their successful implementation and would need to be addressed for their long-term sustainability. Although used for leafy vegetable cultivation, their potential to replace conventional agriculture for staple food crops like wheat looks limited as of now.
- Technologies related to solar panel installation/agrivoltaics in fields require higher initial investment. So, economic considerations of the technologies discussed would be important for their success. There are success stories here, propelled by government subsidies. However, rising episodes of extreme heatwave conditions and dust/sand-storms might impose higher maintenance costs on the renewable energy devices like solar panels and windmills in the arid ecosystems.
- Due to their high reactivity and ability to stimulate an oxidative burst inside plants, nanoparticles (at higher dosages) can also have effects other than the intended ones. Therefore, toxicity to the plant, effects on human health and environmental impact of nanoformulations would also need to be studied.
- It should be kept in mind that variability in soil composition (like calcium carbonate levels), pH and organic matter content in different desert regions of the world could impose a bottleneck for nanoclay technology. So, customized nanoclay might be needed for ensuring suitability of application for a particular soil type.
- Even though organic farming has been popular for some time now due to apparent environmental benefits, there are debates surrounding its ability to enhance crop yield in fields. Therefore, more land would be needed to compensate for the initial lower crop yields on organic farms, potentially leading to deforestation as an environmental cost.
- The key insights from lab studies with plant growth potential of desert microbiota need to be validated under field conditions, including combination of stresses like salinity and drought, and ecological safety. However, as many PGPRs are known to carry genes for antibiotic resistance, the potential for trait transfer to other soil/environmental microbiota remains. As per Ramakrishna et al. (2019), an alternative approach could be to utilize the bioactive compounds from the bacteria, and developing these into bioformulations for agricultural applications.
- It is important to note that since the anatomy and physiology of desert plants is different from other plants (small/spiny leaves and waxy cuticles, for instance), robust datasets are needed and specific AI/ML models need to be developed to predict desirable parameters in them, for instance yield, quality and disease.

Figure 2 summarizes the ideas presented in this article.

11 Conclusions

Desert plants hold tremendous potential as sources of nutrient-dense, antioxidant rich, sustainable and healthy diets. The agricultural propagation of desert plant diversity can further benefit significantly from integration with advanced solar power (via the CSP technology, for example) and rainwater harvesting technologies. Also, every agricultural/horticultural crop requires its own specific set of ecological conditions to thrive and produce fruit with maximum efficiency (as exemplified by cucurbits, benefiting from the application of low tunnel technology). Connecting different technologies towards a common goal could be envisaged in near future. For example, Meena et al. (2023) discussed on utilizing plant/microbial/mycorrhizal extracts for green synthesis of nanomaterials (nanofertilizers and nanopesticides) for possible application in organic farming. If implemented timely and carefully, such interventions hold a possibility to enhance the agricultural potential of desert lands, boost food production therein and also create new farming-based jobs in these areas, benefiting the farmers in a holistic manner. For a desert legume like *Prosopis cineraria*, the indigenous farming communities further stand to gain economically and legally, owing to its edible pods recently receiving the GI (Geographical Indication) tag. Using specific and appropriate tools to farm suitable genotypes/cultivars of selected arid zone plants for harvesting bioactive phytochemicals/nutraceuticals could be another, industrially relevant outcome.

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MB: Conceptualization, Writing – original draft, Writing – review & editing. PD: Conceptualization, Writing – original draft, Writing – review & editing. PS: Conceptualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

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