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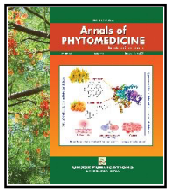

Invited Commentary : Open Access

Harnessing horticulture for nutritional security and public health in India

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Article Info

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Abstract

Horticulture plays a vital role in ensuring nutritional security in India by providing a diverse array of fruits, vegetables, and herbs, which are rich sources of essential nutrients, phytochemicals and therapeutic agents. Phytochemicals, including glucosinolates, carotenoids and flavonoids, present in horticultural crops such as broccoli, carrots and berries, demonstrate significant antioxidant and anticancer activities, contributing to the mitigation of chronic diseases. Bioactive compounds like allicin from garlic and curcumin from turmeric exhibit potent anti-inflammatory and immunomodulatory properties, offering therapeutic potential for managing prevalent health disorders. With challenges like growing population and malnutrition, promoting the cultivation and consumption of horticultural crops can significantly enhance dietary diversity, nutritional security and public health in India. Supportive policies coupled with dedicated scientists, innovative farmers and entrepreneurs pave the way for healthy India with sustainable development in horticulture sector. In conclusion, leveraging the rich phytochemical and nutritional profile of horticultural crops, along with strategic policy support and stakeholder collaboration, holds immense promise for building a healthier, nutritionally secure, and sustainably developed India.

1. Introduction

India, with its diverse agro-climatic zones, is the second-largest producer of fruits and vegetables globally. Horticulture encompasses a wide range of crops, including fruits, vegetables, flowers, spices, and medicinal plants. This sector not only contributes to food and nutritional security but also offers sustainable solutions to mitigate the impacts of climate change (Moran Zhang *et al*., 2024). Horticultural crops possess the capacity to function as carbon sinks, thereby contributing to the mitigation of greenhouse gas emissions. Perennial species, such as fruit trees, sequester atmospheric carbon dioxide through photosynthesis and store it in their biomass and soil, effectively lowering atmospheric carbon concentrations. Climate smart practices such as precision farming, soil and water conservation measures in horticulture reduce water usage and minimize the carbon footprint. Biodiversity conservation practices such as cultivating a variety of horticultural crops enhances biodiversity, which is crucial for ecosystem resilience against climate change.

Horticulture is integral in improving the nutritional status of the population. Fruits and vegetables have rich nutritional profile and are primary sources of vitamins, minerals, and dietary fiber, essential for combating malnutrition (Nazir Ahmed *et al*., 2024). A diverse range of horticultural products ensure a balanced diet, reducing dependency on staple crops. Growth of the horticulture sector boosts rural incomes, making nutritious food more accessible to economically weaker sections. Although, horticulture offers immense potential, it faces challenges such as: Erratic weather patterns affecting crop yields and quality. A significant portion of horticultural produce is wasted due to inadequate storage and transportation facilities. Strengthening the initiatives like the National Horticulture Mission will help to face these challenges. In summary, harnessing the full potential of India's horticulture sector through climate-smart practices, improved infrastructure, and supportive policies can play a pivotal role in enhancing nutritional security, fostering rural livelihoods, and building resilience against climate change for a sustainable future.

2. Impact of climate change on the nutritional quality of horticultural crops

Climate change significantly impacts the nutritional aspects of horticultural crops in various ways (Owino *et al*., 2022). Changes in temperature, CO_2 levels, and precipitation can affect the nutrient content of fruits and vegetables. For instance, elevated CO_2 levels may increase carbohydrate content but reduce protein, vitamin, and mineral concentrations. Extreme weather events, such as heatwaves and droughts, can lead to stress in plants, affecting their growth and reducing the quality of produce. Warmer temperatures and erratic rainfall patterns can increase the prevalence of pests and diseases, further impacting the nutritional value of crops (Table 1). Climate change can adversely impact soil quality through processes such as erosion, salinization, and depletion of organic matter, thereby reducing the bioavailability of essential nutrients to plants. Elevated temperatures may hasten plant developmental rates, resulting in shortened growing periods and diminished nutrient accumulation in horticultural produce. Adopting climate-smart agricultural practices, such as improved irrigation techniques, pest management, and soil conservation, can help to mitigate these effects and ensure the production of nutritious horticultural crops. Climate change has a profound impact on various horticultural crops, particularly those sensitive to temperature, precipitation, and other environmental factors. Horticulture stands at the intersection of agriculture, nutrition, and environmental sustainability. By adopting innovative practices and addressing existing challenges, India can leverage horticulture to combat climate change and ensure nutritional security for its population.

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Table 1: Climate change and its effects on horticultural crops

Crop category	Effect	Climate change component
Temperate fruits	Apples, peaches, cherries, and apricots are highly affected due to disrupted dormancy	Reduced chilling hours
Vegetables	Crops like tomatoes and peppers face challenges such as flower drop and reduced fruit setting	Early temperature rises
Leafy greens	Lettuce and spinach are vulnerable	Higher temperatures and increased water demand
Plantation crops	Tea and coconut are impacted	Reduced precipitation and higher temperatures.
Tropical fruits	Bananas, pineapples, and papayas	Increased disease incidence and severity
Root crops	Cassava and other root crops may benefit	Increased CO_2 but face challenges like erratic rainfall

Source: Saqib *et al*., 2022.

3. Horticulture for nutritional security in India

India's nutritional challenges are many, *viz*., malnutrition, micronutrient deficiencies and imbalanced diets affecting millions. Horticulture focused on cultivating fruits, vegetables, nuts, spices, and medicinal plants has emerged as a powerful tool to enhance nutritional security. Packed with vitamins, minerals, and antioxidants, they are vital for combating deficiencies like anemia (iron), scurvy (vitamin C) and night blindness (vitamin A) provide essential fatty acids, proteins, and other nutrients that improve overall health and immunity (Venkatesh *et al.,* 2021).

A mix of fruits, vegetables, and nuts ensures a more balanced and nutritious meal. Horticultural produce, such as leafy greens and citrus fruits, are critical for children's growth and cognitive development. Nutrient-dense foods contribute to better health outcomes for vulnerable groups. Horticulture creates livelihoods for millions of farmers, particularly smallholders and women, enhancing their ability to afford nutritious food. Initiatives like rooftop gardening and kitchen gardens in urban areas improve access to fresh produce, reducing dependency on markets.

Programs like the National Horticulture Mission (NHM) and Mission for Integrated Development of Horticulture (MIDH) aim to promote sustainable cultivation, reduce post-harvest losses, and improve the supply chain for horticultural products, ensuring affordability and availability. Horticulture is a cornerstone of India's strategy for achieving nutritional security. By boosting production, promoting diversity, and ensuring equitable access to nutrient-rich crops, horticulture has the potential to transform the nutritional landscape of the nation.

India faces significant challenges in achieving nutritional security, despite being a major producer of food. India ranked very low in the Global Hunger Index (2024), highlighting serious hunger situations. India has the highest number of "zero-food" children globally, with 6.7 million children not consuming any solid, semi-solid, or animal milk in a day. India achieved record food grain production of 315.72 million tonnes in 2021-22, and horticulture production reached 341.63 million tons (Pandey, 2022). The Comprehensive National Nutrition Survey (2016-18) revealed widespread micronutrient malnutrition across states. These statistics underscore the need for transformative changes in agriculture and nutrition policies to ensure equitable access to nutritious food (Karlsson *et al*., 2024).

3.1 Nutritional security and fruits

Fruits play a crucial role in ensuring nutritional security in India, as they are rich sources of essential vitamins, minerals, and antioxidants. Fruits like mangoes, guavas and oranges are high in vitamin C, which boosts immunity and prevents scurvy. Bananas and papayas provide potassium and dietary fiber, aiding in digestion and heart health (Slavin *et al*., 2012). Seasonal fruits like lychees and pomegranates contribute to a balanced diet and help combat micronutrient deficiencies. India is one of the largest producers of fruits globally, with a diverse range of tropical and temperate fruits. Government initiatives like the National Horticulture Mission aim to increase fruit production and improve supply chains, making fruits more accessible. Programs such as the mid-day meal scheme and Integrated Child Development Services (ICDS) incorporate fruits to enhance the nutritional intake of children and pregnant women. Efforts to promote fruit consumption through awareness campaigns and subsidies have been instrumental in addressing malnutrition. Fruits are not just a source of nutrition but also a means to improve livelihoods and ensure food security.

3.2 Nutritional security and vegetables

Vegetables are essential for achieving nutritional security in India, as they provide vital nutrients, improve dietary diversity, and support overall health. Vegetables like spinach, carrots, and tomatoes are rich in vitamins (A, C, K) and minerals (iron, calcium, potassium), which are crucial for preventing deficiencies (Slavin *et al*., 2012). Vegetables such as beans and broccoli aid digestion and help in preventing lifestyle diseases like diabetes and obesity. Many vegetables contain antioxidants that protect against chronic diseases and boost immunity. Vegetables are integral to combat stunting in children by providing essential nutrients for growth. Leafy vegetables and other vegetables are vital for pregnant and lactating women to ensure healthy pregnancies and reduce anemia. Vegetables are relatively inexpensive sources of nutrition, making them accessible to low-income families. Initiatives like rooftop gardens and community farming in urban areas improve access to fresh vegetables. Programs such as the national food security act (NFSA) and PM POSHAN Scheme incorporate vegetables into meals provided to vulnerable populations, ensuring better nutrition (Priyadarshini and Abhilash, 2021). Vegetables are not just a source of nutrition but also a means to improve health outcomes and livelihoods.

3.3 Nutritional security and nuts

Nuts are a vital component of nutritional security in India, offering a rich source of essential nutrients and contributing to health and well-being. Nuts like almonds, walnuts, and cashews are packed with healthy fats, proteins, vitamins (E, B-complex), and minerals (magnesium, zinc, iron), which are crucial for overall health (Gonçalves *et al*., 2023). Regular consumption of nuts reduce cholesterol levels and supports cardiovascular health. Nuts are calorie-dense, making them an excellent source of energy, especially for children and athletes. Nuts address nutrientdeficiencies such as iron and zinc, which are common in India. Including nuts in diets can improve cognitive development and overall growth in children. Nuts like groundnuts and cashews are widely cultivated in India, providing livelihoods to farmers and ensuring availability. Programs like the National Food Security Mission and Integrated Child Development Services (ICDS) promote the inclusion of nutrient-rich foods in diets to combat malnutrition. Nuts are not only a source of nutrition but also a means to improve health and support sustainable agriculture.

3.4 Nutritional security and spices

Spices are not only flavor enhancers but also play a significant role in nutritional security in India. Spices like turmeric, cumin, and coriander are packed with essential nutrients, including iron, magnesium, and vitamins. Many spices, such as turmeric and ginger, have anti-inflammatory and antioxidant properties that support overall health (Gidwani *et al*., 2022). Spices like fennel and black pepper improve digestion and nutrient absorption. Regular consumption of spices strengthens immunity, reducing susceptibility to diseases. Spices are widely available and relatively inexpensive, making them accessible to all sections of society. Spice cultivation provides income to farmers, especially in regions like Kerala and Andhra Pradesh. Programs like the National Horticulture Mission promote the cultivation and use of spices to enhance nutritional security and support sustainable agriculture. Spices are not just culinary ingredients but also vital contributors to health and nutrition.

Medicinal and aromatic plants play a vital role in nutritional security and health**,** offering bioactive compounds that enhance immunity, prevent diseases, and support overall well-being. These plants, including turmeric, tulsi, mint, and ashwagandha, are rich in antioxidants, vitamins, and minerals that contribute to a balanced diet and holistic health. MAPs are widely used in traditional medicine and modern healthcare for their therapeutic properties, addressing ailments such as inflammation, digestive disorders, and stress-related conditions. Additionally, their cultivation promotes sustainable agriculture and economic growth, particularly in regions with a strong herbal medicine heritage. The increasing global recognition of MAPs highlights their potential in functional foods, pharmaceuticals, and cosmetics, making them essential for a healthier future (Kumari and Prakash, 2024).

3.5 Nutritional security and nutraceutical vegetables

Nutraceutical vegetables are a cornerstone of nutritional security, offering health benefits beyond basic nutrition. Vegetables like tomatoes (lycopene), carrots (carotenoids), and broccoli (glucosinolates) contain bioactive compounds that prevent chronic diseases. Nutraceutical vegetables provide antioxidants, vitamins, and minerals that support immunity and reduce the risk of cardiovascular diseases (AlAli *et al*., 2021). Vegetables such as spinach and beans improve digestion and help to manage lifestyle diseases like diabetes. Nutraceutical vegetables address deficiencies in essential nutrients, such as iron, zinc, and vitamin A. Vegetables are an essential part of a balanced diet, packed with nutraceutical components that promote health and prevent disease. They are rich in vitamins (like A, C, and K), minerals (such as potassium and magnesium), dietary fiber, and antioxidants like carotenoids and polyphenols. Many vegetables also contain phytochemicals like glucosinolates in cruciferous vegetables and allicin in garlic, which have been shown to reduce the risk of chronic diseases. These components collectively offer numerous benefits, including improved digestion, stronger immunity, better heart health, and even cancer prevention. For example, spinach is a powerhouse of iron and magnesium, carrots are loaded with beta-carotene for eye and skin health, and garlic supports the immune system with its anti-inflammatory properties (Table 2). Including nutraceutical vegetables in diets can enhance cognitive development and overall growth in children. Nutraceutical vegetables are accessible to low-income families, making them a cost-effective source of health-promoting nutrients. Programs like the National Horticulture Mission and Mission for Integrated Development of Horticulture (MIDH) promote the cultivation and use of nutraceutical vegetables to enhance nutritional security. Nutraceutical vegetables are not just a source of nutrition but also a means to improve health outcomes and support sustainable agriculture (Priyadarshini and Abhilash, 2021). Nutraceutical vegetables such as spinach, carrots, broccoli, tomatoes, garlic, onions, sweet potatoes, cabbage are well appreciatedand have many associated health benefits (AlAli *et al*., 2021). These vegetables not only provide essential nutrients but also offer therapeutic benefits, making them integral to a healthy diet.

Table 2: List of vegetables, their nutraceutical components and their benefits

Vegetable	Nutraceutical component	Health benefits
Spinach	Iron, folate, carotenoids	Improves blood health, supports vision, boosts immunity
Carrots	Beta-carotene	Enhances vision, supports skin health, acts as an antioxidant
Broccoli	Glucosinolates, sulforaphane	Reduces cancer risk, supports detoxification, boosts immunity
Tomatoes	Lycopene, vitamin C	Protects against cardiovascular diseases, acts as an antioxidant
Garlic	Allicin	Lowers cholesterol, supports heart health, has antimicrobial properties
Onions	Quercetin	Acts as an anti-inflammatory, supports cardiovascular health
Sweet potatoes	Beta-carotene, dietary fiber	Supports digestion, boosts immunity, improves skin health
Cabbage	Glucosinolates, vitamin K	Supports bone health, reduces cancer risk

Dietary requirements vary significantly based on an individual's age and activity level (Table 3). Children and teenagers need nutrient-dense foods to support growth and development, including proteins, calcium, and essential vitamins like D and C. Adults with sedentary lifestyles should focus on balanced diets with moderate calorie intake to maintain healthy weight and energy levels, while physically active individuals require higher caloric intake alongside increased carbohydrates and proteins to fuel and repair muscles. For older adults, nutrient-rich diets with an emphasis on calcium, vitamin D, and fiber are crucial for bone health, digestion, and overall well-being. Additionally, hydration plays a vital role across all age groups and activity levels to support bodily functions effectively. Tailoring dietary plans to meet these specific needs ensures optimal health and performance at every stage of life (Patel *et al*., 2015).

Table 3: Dietary requirements for individuals based on age and activity level

Category	Energy (kcal/day)	Protein (g/day)	Fat (g/day)	Carbohydrates (g/day)
Infants (0-6 months)	500-700	9-11	30-35	60-70
Children (1-3 years)	1000-1200	16-20	35-40	130-150
Adolescents (14-18 years)	2200-2800	50-60	50-70	300-350
Adults (Sedentary)	2000-2400	50-60	50-70	300-350
Adults (Active)	2500-3000	60-70	70-90	350-400
Pregnant Women	2200-2500	60-70	50-70	300-350
Lactating Women	2400-2700	65-75	60-80	350-400

4. Phytochemicals in vegetable crops

Common vegetables are rich in key phytochemicals that offer a range of health benefits. For example, cruciferous vegetables like broccoli and cauliflower contain glucosinolates, which have anti-cancer properties. Garlic and onions are packed with allicin, known for its anti-inflammatory and immune-boosting effects. Tomatoes are abundant in lycopene, a powerful antioxidant that supports heart health and reduces the risk of certain cancers (Aðagündüz *et al*., 2022). Spinach and kale are excellent sources of lutein and zeaxanthin, which promote eye health (Table 4). Including a variety of vegetables in your diet ensures a diverse intake of these beneficial compounds, supporting overall wellness.

Table 4: Common vegetables, their key phytochemicals, and associated health benefits

Vegetable	Phytochemical constituent	Health benefits
Spinach	Lutein, zeaxanthin	Supports eye health, reduces risk of macular degeneration
Carrots	Beta-carotene	Enhances vision, acts as an antioxidant, supports skin health
Broccoli	Sulforaphane, glucosinolates	Reduces cancer risk, supports detoxification, boosts immunity
Tomatoes	Lycopene	Protects against cardiovascular diseases, acts as an antioxidant
Garlic	Allicin	Lowers cholesterol, supports heart health, has antimicrobial properties
Onions	Quercetin	Acts as an anti-inflammatory, supports cardiovascular health
Sweet Potatoes	Beta-carotene	Supports digestion, boosts immunity, improves skin health
Cabbage	Glucosinolates	Supports bone health, reduces cancer risk

Table 5: Therapeutic agents found in vegetables, their associated health benefits, and examples of vegetables containing them

Therapeutic agent	Health benefits	Vegetables
Lycopene	Antioxidant, reduces risk of cardiovascular diseases	Tomatoes
Beta-carotene	Enhances vision, supports skin health, acts as antioxidant	Carrots, Sweet potatoes
Sulforaphane	Reduces cancer risk, supports detoxification	Broccoli, Cabbage
Allicin	Lowers cholesterol, antimicrobial properties	Garlic
Quercetin	Anti-inflammatory, supports cardiovascular health	Onions
Lutein	Supports eye health, reduces macular degeneration risk	Spinach, Kale
Glucosinolates	Cancer prevention, supports liver detoxification	Broccoli, Brussels sprouts
Anthocyanins	Antioxidant, anti-inflammatory properties	Eggplants, Red chabbage

5. Vegetables as therapeutic agents

Vegetables are rich sources of therapeutic agents that offer profound health benefits (Rashmi and Negi, 2020). Phytochemicals like glucosinolates in broccoli and cauliflower exhibit anticancer properties, while allicin in garlic provides anti-inflammatory and antimicrobial effects. Lycopene in tomatoes serves as a powerful antioxidant that supports heart health and reduces cancer risk (Ifrah Usman *et al*., 2025). Additionally, lutein and zeaxanthin in leafy greens like spinach and kale promote eye health and combat oxidative stress (Table 5). Incorporating these vegetables into daily meals not only enhances flavor but also contributes to disease prevention and overall well-being. These therapeutic agents not only enhance the nutritional value of vegetables but also contribute to preventing and managing various health conditions.

6. Future thrust

The future thrust for horticulture in achieving nutritional security in India lies in adopting innovative approaches and fostering sustainable practices. Prioritizing research on the biofortification of horticultural crops can enhance their nutritional profile, focusing on increasing the presence of vital phytochemicals and therapeutic agents. Promoting organic farming and reducing chemical inputs will ensure the production of high-quality, nutrient-dense vegetables, fruits, and herbs. Advanced technologies like precision agriculture, vertical farming, and hydroponics can optimize yield and make horticulture accessible even in urban and resource-constrained areas. Strengthening supply chain systems, improving cold storage facilities, and ensuring market accessibility can reduce post-harvest losses and increase the availability of nutritious produce. Additionally, nationwide campaigns emphasizing the importance of horticultural crops in diets, coupled with education programs, can encourage greater consumption.Policy-makers, farmers and researchers are instrumental in transforming India's horticulture sector into a robust pillar of nutritional security for generations to come.

7. Conclusion

In conclusion, horticulture stands as a cornerstone for achieving nutritional security in India, offering a sustainable solution to combat malnutrition and prevent chronic diseases. By cultivating a variety of fruits, vegetables and herbs rich in phytochemicals and therapeutic agents, India can enhance dietary diversity and public health outcomes. The integration of nutrient-rich horticultural produce into daily diets addresses vital nutritional gaps while reducing the burden of non-communicable diseases. With supportive policies, dedicated scientists and innovative farmers, entrepreneurs India can pave the way for a healthier and more resilient population, through fostering sustainable development in horticulture sector.

I elated to place on record that **Annals of Phytomedicine: An International Journal** reaching wider scholars and academicians with very prompt, timely, updated scientific data sets with error free assessment of research investigation outcomes across the world.The journal covers almost all the methods, and approaches applied in medicinal, aromatic, plantation and aromatic plants. Annals of Phytomedicine undoubtedly an excellent scientific foundation in herbal medicinal products, including clinical medicine and Indian System of medicines in therapy. I feel it privileged in offering my warmest regards and best wishes for further prosperity of **Annals of Phytomedicine: An International Journal**.

Conflict of interest

The author declares no conflicts of interest relevant to this article.

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Biography

Dr. Raji Reddy Danda is the Vice Chancellor of Sri Konda Laxman Telangana State Horticultural University, Telangana from 19-10-2024 to till date.

Dr. Raji Reddy Danda did his Masters in Agronomy from Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra and Ph.D. in Agrometeorology from Gujarat Agricultural University, Anand, Gujarat. His journey started in APAU in 1992 as Assistant Agronomist, Jagtial, and served University in different capacities like Senior, Principal Scientist, Director of Agro Climate Research Centre, Agricultural Research Institute and Director of Extension, ANGRAU. During his tenure, he has initiated research related to agro-meteorology in the university. Developed multi-scale adaptation strategies for climate change, decision aid tools, methods and data products for translating climatology and climate forecasts into information required to support agricultural and natural resources management. Established 21 Automatic Weather Stations in different districts of Telangana and A.P. and scientifically advised and trained the Disaster Management Department and other line departments in understanding the climate information, adaptation mitigation options in the state of unified Andhra Pradesh. Dr. Raji Reddy Danda developed several tools for disseminating timely contextual climate information to farmers. He assumed charge as Director of Research, PJTSAU in 2014 and continued his service as Director of Research and Director of Extension for more than 5 years and improved infrastructure facilities including laboratories and sophisticated equipment. Thirteen improved varieties of different crops were released and popularized, which include Telangana sona during his tenure. He developed extensive international collaborations with partners nationally and internationally. He worked as World Bank consultant for Afghanistan Agromet services project from Jan 2020 to May 2022.

He has handled several projects worth of Rs. 14 crores funded by different funding agencies like DBT, DST, ANTP, IMD, ISRO, Dept. of Space, GoI. Dr. Raji Reddy has published 130 research papers/ extended abstracts, out of which 58 in reputed National and International Journals like Springer, *etc*. He also contributed to publish 35 research papers in various national and international conference proceedings, 6 book chapters, 3 policy briefs, 30 paper presentations in seminars/symposia in the fields of weather forecast, yield forecast, remote sensing, crop modeling, *etc*. He has delivered talks as resource person in various conferences and seminars at National and International Level. He has visited many countries, *viz*., United States of America, Switzerland, Australia, Sri Lanka, Cambodia, Tanzania, Indonesia, Nepal, Afghanistan and Lao PDR.

He is life member of various professional bodies and Reviewer for Journal of Agrometeorology, Journal of Research ANGRAU, Andhra Agricultural Journal, Agricultural Water Management. He is the President for Indian Meteorological Society, Hyderabad chapter, Vice President for Society of Agrometerologists- A.P. Chapter, Zonal Representative of Central Zone for Journal of Agrometereology. He has received many awards, *viz*., Jawaharlal Nehru Memorial fund award, Janna Venkat Reddy memorial award and international recognition by CCAFs & CSIRO.

Dr. Raji Reddy is the recipient of Jawaharlal Nehru Memorial fund award for securing First rank at University level in M. Sc (Ag).; Janna Reddy Venkat Reddy memorial prize in 2003 by Farmers Welfare Trust, Hyderabad; Meritorious Research Scientist Award in 2001 by ANGR Agricultural University.

The university has recognized team work and its significant contributions to scientific and farming community and upgraded the center as Directorate from 01.05.2012 and renamed as Agro Climate Research Centre (ACRC).

India Meteorological Department, New Delhi has identified ACRC as a core centre for its excellent research in crop modeling and development of mitigation strategies for climate change scenarios. Received seeds men Association annual award 2015.

One of the significant impacts of work on agro advisories was well appreciated by various national and international agencies.

He was honored with International recognition for scientific and technical relationship between India and Australia Research institutes

in 2011 by University of Southern Queensland, Australia; Received three best presentation awards and one best poster award in various national and International workshops.

He is visiting scientist, IFDC, Muscle Shoals, Alabama, USA. International recognition for excellent research, demonstration work and solid Leadership in 2012 by IRI, Earth Institute, Columbia University, New York, USA. International recognition for Best Integrated Agromet Advisory Services in 2012 by CCAFS, Group of CGIAR. International recognition for excellent research, demonstration work by CSIRO as International Centre of Excellence, in 2013 by CSIRO-ACIAR, Australia.

At the international workshop organized by CCAFS at Dakar, Senegal, Africa in 2012, the process of preparing and disseminating Agromet advisories by ACRC, ANGRAU was very much appreciated and selected among the six states studied, ACRC, ANGRAU, A.P. as the flagship case.