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Integrated use of organic and inorganic fertilizers for coping with current climate change and profitable tomato cultivation in Pakistan

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The agricultural sector is facing challenges due to climate change, which has led to a delicate balance in crop production. Scientists, policymakers, and governments are aware of the climate change effects on crops and are making efforts to mitigate these impacts. However, there is still a significant loss in crop production and quality. It is crucial to take action now to address these challenges before it's too late. Implementing climate resilient agricultural practices and sustainable farming methods based on climate change principles, along with continuous research

and long-term enforcement, is essential for ensuring food security and protecting nutrition.

Tomato: Importance and Utility

Who can deny the importance and utility of tomatoes in the world? It is a very popular vegetable in many countries, providing farmers with an additional source of income and contributing to the development of communities through traditional cultivation practices. However, in Pakistan, tomato production faces a significant threat due to changing seasonal conditions. It is crucial to take urgent steps to ensure the productivity capacity of this important crop in the face of climate change.

Tomato farming can provide various benefits to farmers. Relying solely on one crop of income can be risky, so diversifying with vegetables such as tomatoes can help mitigate this risk. By not being dependent on just one crop, farmers can reduce the dangers associated with crop failure. Additionally, tomato farming can help address nutrition shortages as tomatoes are rich in vitamins A and C, potassium, and other essential minerals that are necessary for human health.

Pakistan ranks 35^{th} globally in tomato production, with a total of 3.8 million tons produced last year. Punjab is the leading tomato-producing province, followed by Sindh, Khyber

Pakhtunkhwa, and Baluchistan. Despite challenges such as insects, diseases, limited access to modern technology, and unpredictable climatic conditions, Pakistan is adopting modern techniques like drip irrigation, tunnel farming, and tomato hybrids to improve production. However, per-acre tomato production in Pakistan is lower than that of other tomato producers. The low per-acre tomato production in Pakistan ranks the country 11th in production area globally. Despite efforts to introduce hybrid varieties and tunnel farming, Pakistan's tomato production per capita, yield per acre, and average acreage are significantly lower compared to India, with figures at 79%, 97%, and 92% respectively. This underscores the need for Pakistan to rely on annual tomato imports.

The root cause of this poor yield is soil health issues, availability of good quality seeds, poor nutrient management, and poor tomato quality. Pakistani soils are deficient in most essential nutrients due to alkalinity, low organic matter, calcareousness, and monocropping pattern, which hinder nutrient absorption by plants. Factors like reliance on chemical fertilizers, limited crop rotation, weather-related challenges, and inadequate awareness of modern productivity techniques have exacerbated the issue, and poor nutrient management has contributed significantly to lower productivity.

By incorporating a balanced mix of organic and chemical fertilizers, farmers can provide a wide range of necessary nutrients to plants, promote soil health, and reduce dependence on expensive chemical fertilizers. This approach not only benefits the environment but also leads to long-term cost savings and improved productivity. Pakistan's reduced reliance on annual tomato imports is crucial for meeting the country's domestic demand.

Research findings emphasize the significance of combining organic and inorganic nutrients to improve tomato fruit yield and quality. Sole reliance on chemical fertilizers can lead to nutrient deficiencies and soil degradation, posing challenges for tomato farmers. In Pakistan, the lack of emphasis on organic sources in tomato nutrition plans has exacerbated nutrient depletion and soil degradation due to unpredictable weather patterns. Incorporating organic manures can help address these issues by enriching the soil with essential nutrients and enhancing fertility. Organic manures aid in retaining nutrients in the soil and preventing losses over time. To maximize the benefits of organic manure in tomato cultivation, it is crucial to choose the right type of manure and apply it correctly, at the appropriate time and in the correct amounts. The integration of organic and inorganic sources is vital for sustainable production and environmental protection, as soil health should not be compromised for higher crop yields. While organic manure alone may not suffice to meet the projected food demand for 2030, a combination of farming practices and

technologies will be necessary to meet the food needs of the growing population. Prioritizing sustainable agricultural practices and reducing the environmental impact of food production are essential to preserve soil health, water resources, and ecosystems for future generations.

Research trials conducted at the Department of Soil and Environmental Sciences of MNS University of Agriculture Multan from 2020 to 2023, funded by the Higher Education Commission (HEC) Pakistan, focused on formulating eight types of organic fertilizers through composting processes. These included Farmyard-based compost, enriched poultry manure compost, press-mud compost, berseem compost, kitchen waste compost, biochar-enriched compost, wheat-straw compost, and value-added compost. The impact of these composts on soil health parameters and their effectiveness in improving tomato yield and quality were studied. Integrated nutrient management using various combinations of organic and inorganic sources significantly influenced agronomic parameters and quality of tomato fruit, with higher levels of nutrients like vitamin C, total soluble solids, and lycopene observed in organic manure treatments enriched in potassium.

Economic analyses of various combinations of organic and chemical fertilizers indicate that organic tomato farming may not be viable for farmers if the tomato price falls below Rs. 120/kg, based on market projections for 2023-24. Sole reliance on chemical fertilizers can harm soil

health, diminish microbial activity, induce salinity, and create environmental issues. To address these concerns, farmers are advised to combine chemical fertilizers with organic manures like farmyard manure and poultry manure to achieve higher tomato yields and quality while preserving soil health and the environment. For vegetable cultivation in Pakistan, a balanced approach utilizing both chemical fertilizers and organic manures is recommended to enhance soil health, improve nutrient availability, and increase yields sustainably. This integrated approach optimizes nutrient uptake by plants, reduces dependence on chemical fertilizers, and promotes sustainable agricultural practices.