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Sustainable Practices in Organic Fenugreek (*Trigonella corniculata* L.) Cultivation

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Abstract

Sustainable agriculture places a high priority on environmental sustainability and community well-being, and organic fenugreek farming is one important aspect of this movement. This presentation highlights the benefits that organic fenugreek farmers make to social justice and ecological balance by examining the various sustainable strategies that they have embraced globally. Important sustainable farming approaches include crop rotation and composting to improve soil health, using natural pest management techniques, and avoiding synthetic chemical use in organic farming. These methods reduce greenhouse gas emissions, enhance biodiversity, and minimize environmental deterioration in addition to maintaining soil fertility. Additionally, through bolstering regional economies and enabling small-scale farmers, organic fenugreek growing incorporates social responsibility concepts. Fair trade methods guarantee just income distribution and foster community harmony among farming communities. Initiatives that support education and gender equality also strengthen the social cohesion of these rural areas. In conclusion, organic fenugreek growing is a prime example of a comprehensive strategy for sustainability that integrates socioeconomic growth with environmental preservation. Future studies should concentrate on improving these procedures and investigating their scalability and climate change resilience. Stakeholders may promote a more sustainable agricultural paradigm that satisfies the demands of global food security, protects natural resources, and improves rural livelihoods by supporting organic fenugreek growing.

Keywords: Organic farming, soil health, water conservation, biodiversity, community engagement.

Introduction

Trigonella corniculata L., also known as kasuri methi, is an annual spice crop that grows slowly and is mostly grown for its dried herbaceous and bushy texture. It belongs to the Fabaceae family of spices. It is mostly farmed in the plains of northern India as seeds and leafy vegetables. It has vital nutrients that the body needs for development and upkeep (Singh S *et al*., 2012). Its origins are in the countries of the Near East and Mediterranean region. The useful portion of this plant is its dried leaves. It is primarily grown in the northern Indian states of Punjab, Madhya Pradesh, Haryana, Uttar Pradesh, Rajasthan, and Maharashtra. Eighty percent of the nation's Kasuri methi is produced in Rajasthan. Kasuri methi is a crop with many uses. All of its components are beneficial and are used as food, fuel, medicine, and cosmetics in various forms. Fresh green leaves are used as a condiment.

Crop nutrients are essential for crop production because they affect the development, growth, and total productivity of plants. Nitrogen, phosphorus, potassium, sulfur, calcium,

magnesium, and a number of micronutrients are examples of important nutrients that are necessary for the production of proteins, enzymes, and other vital components in plants. Proper root development, vigorous vegetative growth, effective flowering, and successful reproduction are all made possible by adequate nutrient availability, which eventually results in increased yields and better crop quality (Aakash *et al.*, 2022).

India has the world's second-largest population. As the population grows, cultivable land becomes increasingly scarce. Improving agricultural land productivity and soil health is crucial to meeting the rising population's needs for food, fiber, fuel, and fodder. The Green Revolution has led to self-sufficiency in food for developing countries. However, sustaining agricultural production against limited natural resources requires a shift from "resource degrading" chemical agriculture to "resource protective" biological or organic agriculture.

Organic farming, particularly for vegetables, is gaining popularity worldwide and quickly becoming a desirable way to generate revenue in rural areas due to rising awareness of environmental and health hazards. Both in wealthy nations and India's largest cities, consumers are becoming more and more drawn to organic items. The market for organic food is expanding both domestically and internationally, with a 20–25% yearly growth rate. Consequently, there has been a constant increase in the area dedicated to organic farming. India has great potential for producing organic vegetables due to its diverse soil types and climate. India's broad range of products, year-round high production volume, strategic position, strong demand from abroad, plenty of sunshine, and reasonably priced labour make it an.

Nutrient management is crucial to organic farming because it's necessary to both maintain and increase soil fertility. Organic farming strictly prohibits the use of any synthetic fertilizers. The nutrition that crops receive comes from a healthy, biologically active soil. With good management practices and crop rotation, a live, healthy soil can maintain maximum productivity over time without losing fertility. Crop yield sustenance is correlated with the ability to cycle and manipulate vital nutrients. The plant's ability to generate useful biomass is dependent on the quantity and balance of macro- and micronutrients. Organic food sources are full of all the necessary nutrients (Singh *et al.*, 2024).

Numerous factors influence this crop's productivity, but irrigation and mineral nutrition are the most crucial ones. It is farmed nearly entirely without fertilizers and with restricted irrigation in northern India. A valuable resource that is essential to the success of agricultural production is water. Given the scarcity and high expense of irrigation water, it is critical to use it economically, scientifically, and optimally among the various crops that are farmed. During the flowering and pod-filling stages, fenugreek is extremely sensitive to water stress; nevertheless, overwatering can result in excessive vegetative growth, shorten the reproductive time, and eventually reduce output. As a result, the timing of irrigation intervals and the combination of chemical and organic fertilizers are necessary to maintain crop yield and land productivity (Sharma *et al*., 2016).

Biological pest management, crop rotation, and the application of biofertilizers are examples of sustainable natural resource-based practices used in organic agriculture. Since typical agriculture uses synthetic fertilizers and insecticides. An agricultural practice known as "organic agriculture" is one that makes use of renewable natural resources and techniques like crop rotation, biological pest management, and the use of biofertilizers. In contrast to conventional agriculture, which uses synthetic fertilizers, insecticides, and growth regulators to increase crop yields, organic farmers employ natural fertilizers and pesticides (Duran-Lara *et al*., 2020).

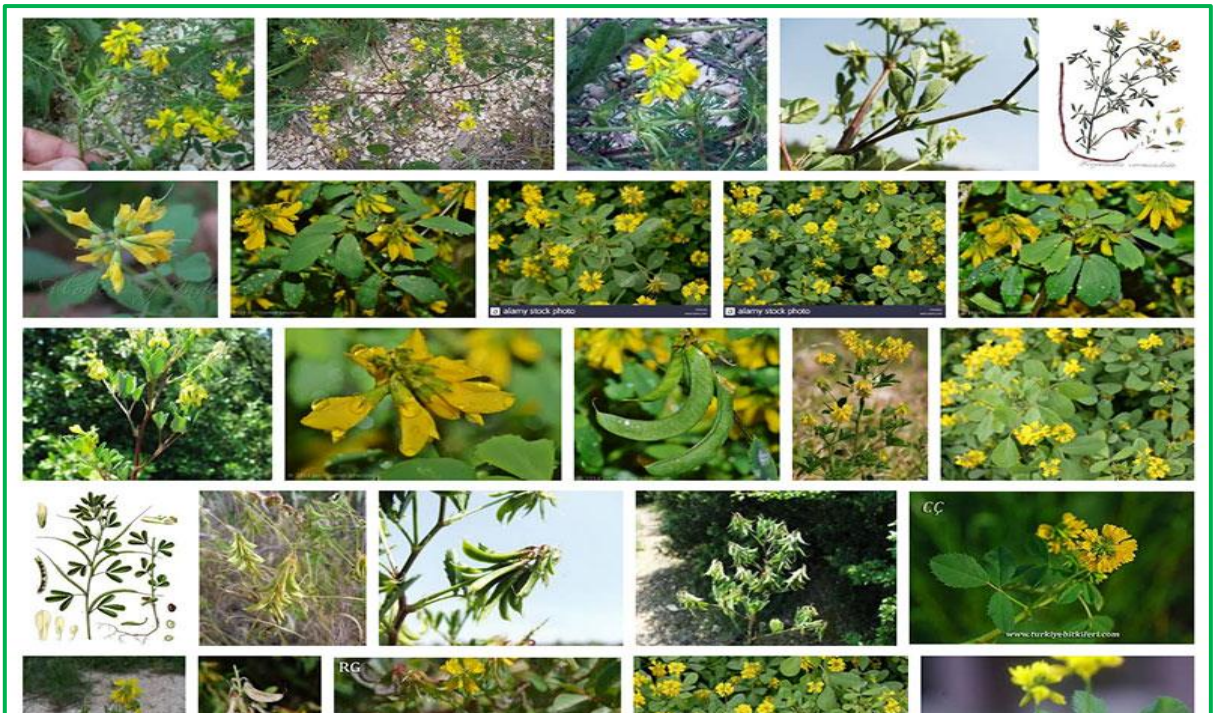

Image source: google.com/search?q=Trigonella+corniculata&tbm=isch

Conversion period of Organic Farming

It takes at least two to three years to convert to organic farming and go through the certification process with the recognized organization. It is necessary to abide by the general rules for choosing farm property, buffer zones, certification, etc.

The procurement management involves operationalizing the processes for producing organic seed spices crops, establishing a favourable environment for the necessary kind and quantity of products by implementing pre- and post-harvest procedures, and selecting an appropriate marketing strategy. The information provided here will eventually serve as a guide for the grower, processor, and exporter in organizing the production and supply of organic seed spices for export.

Soil Preparation

Soil Testing: Conduct soil tests to determine pH and nutrient levels. Fenugreek prefers slightly acidic to neutral soils (pH 6.0-7.0).

Organic Matter: Incorporate well-decomposed organic matter, such as compost or farmyard manure (10-15 tons/ha), into the soil to improve soil structure and fertility.

Green Manure: Use green manure crops like cowpea or sunhemp in the previous season to enhance soil fertility and organic matter content.

Seed Selection and Sowing

Certified Organic Seeds: Use certified organic fenugreek seeds to ensure high germination rates and disease-free crops.

Seed Treatment: Treat seeds with Trichoderma or Pseudomonas to protect against soil-borne diseases.

Sowing Time: Sow seeds at the right time, generally in the cooler months (October-November in most regions), to avoid high temperatures that can affect germination and growth.

Spacing: Maintain proper spacing (20-25 cm between rows and 10 cm within rows) to ensure good air circulation and reduce disease incidence.

Cultivated varieties

State	Varities
Haryana	HISAR SONALI HISAR SUVARNA (HM-103) HISAR MUKTA (HM-346) HISAR MADHAVI (HM-350)
Rajasthan	RMT-1 RMT-143 RMT-305 NRCSS-AM 1 NRCSS-AM 2
Gujarat	GM 1
Bihar	RAJENDR A KRANT
Andhra pradesh	LAM SELECTIO N-1
Uttar Pradesh and Uttrancal	Pant Ragini
Madhya pradesh	PUSA EARLY BUNCHIN G PUSA KASURI (Other kasuri type)
Tamil nadu	CO-1

Seed treatment

To improve symbiotic nitrogen fixation, it's recommended to inoculate seeds with Rhizobium culture before sowing, especially in virgin fields. Establishing a connection between a certain legume and a Rhizobium strain can improve this process.

Nutrient management

Prioritizing organic sources such as farmyard manure, compost, vermicompost, sheep and goat dung, as well as liquid organic manures such as cow pee, panchagavya, Verm wash, bio-digested liquid, and jeevamrut, is crucial for sustainable production and efficient resource usage on farms. This review examines how organic nutrients affect vegetable growth, production, quality, nutrient uptake, soil qualities, and accessible nutrients.

By applying 4 t ha-1 vermicompost, the plant height at the first, second, and harvesting cuttings, the number of nodules at 60 and 90 DAS, the fresh and dry weight of the roots at the pre-flowering stage, the herbage yield and the dry weight of the leaves at the first and second cuttings, and the number of branches plant-1 during both years (Deora *et al*., 2011). Vermicompost is a rich source of micronutrients and functions as a chelating agent, regulating the availability of metallic micronutrients to plants. This promotes plant growth and yield by giving nutrients in the appropriate form dependent on crop demand.

Additionally, on applying FYM (16 t/ha) + Vermicompost (4 t/ha) + Rhizobium (10 ml/kg) seed) + PSB (10 ml/kg seed) + KSB (10 ml/kg seed), T15 - Rhizobium (10 ml/kg seed) + PSB (10 ml/kg seed) + KSB (10 ml/kg seed) maximum fresh leaf yield of 96.26 q/ha was reported (Dongre *et al*., 2023).

Organic Fertilizers: Utilizing animal manure, green manure, like vermicompost, bone meal, or neem cake to provide essential nutrients. and other organic fertilizers enriches the soil without synthetic chemicals.

Biofertilizers: Microbial inoculants like Rhizobium can enhance nutrient availability and uptake.

Weed Management

Manual Weeding: Perform manual weeding or use mechanical weeders to control weeds.

Cover Crops: Grow cover crops like clover between fenugreek crops to suppress weeds and enhance soil health.

Water conservation

Since fenugreek is mostly an irrigated crop, it grows quickly with light irrigation applied often. However, in some regions of the nation, it may also be grown in rain-fed circumstances. The timing of the irrigations varies from seven to ten days, based on the kind of soil, the season, the amount of rainfall, and other sporadic weather. For rapid foliage growth, light irrigations should be applied often. As a general rule, every cutting should be followed by a light watering. The important times for the need for watering are during the early growth phase and seed planting. Since excessive moisture in any form and at any stage increases the frequency of powdery mildew and root rot, too much irrigation is just as hazardous as not enough moisture. The overall advice for achieving increased production was determined to be the use of seven irrigations at a ratio of 1.0 IW to CPE. It was discovered that sprinkler irrigation in Gujarat performed best with an IW/CPE ratio of 0.75 (Malhotra *et al.*, 2008). Throughout the whole cropping season, irrigation was applied every four to five days, depending on the soil's moisture content. 32–37 irrigations were administered (Babaleshwar *et al.*, 2017).

Water Management

Irrigation: Use efficient irrigation methods like drip or sprinkler systems to conserve water. Avoid waterlogging, as fenugreek is sensitive to excessive moisture.

Mulching: Mulch helps retain soil moisture, suppress weeds, and add organic matter to the soil as it decomposes.

Rainwater Harvesting: Collecting and storing rainwater for irrigation can reduce dependency on groundwater.

Pest and disease management

To increasing the yield of fenugreek, pest and disease management module effectively controlled pests and diseases. The module consisting of soil application of neem cake at 2 q/ha, seed treatment with Trichoderma at 8g/kg, and foliar spray with neem formulation (Azadirachtin) at 5ml/lit at 45, 60, and 90 DAS was shown to be successful. At 70 and 100 DAS, respectively, this treatment demonstrated the lowest incidence of root rot (5.73 and 9.53 %) (Chhata et al.,2010).

Integrated Pest Management (IPM): Combining biological control, cultural practices, and mechanical methods can effectively manage pests with minimal chemical use.

Natural Predators: Encouraging beneficial insects like ladybugs and lacewings can help control pest populations.

Neem Oil and Other Organic Pesticides: Using natural pesticides can manage pests without harming the environment.

Crop Rotation: Rotate fenugreek with non-leguminous crops to break pest and disease cycles. If all other crops are cultivated using organic farming practices, fenugreek can be planted as an intercrop or mixed crop. Since they are leguminous, they work well as a component crop in intercropping systems with winter vegetable crops, ajowan, coriander, and fennel. Similarly, crops that are cultivated in rotation ought to be grown using organic agricultural practices.

Other farming systems that have been proposed include

(i) Fenugreek - Pearl millet – Maize
(ii) Fenugreek – Sesame
(iii) Sesame - Fenugreek - Summer Maize (Malhotra *et at.*, 2008).

Harvest and yield

Maximum yields of fresh herbs (1.88 t/ha), dried herbs (1.13 t/ha), number of pods per plant (620.17), length of pods (2.14 cm), seed yield (465.31 kg/ha), and crude protein content (13.31%) were recorded. Better vegetative growth in terms of plant height, number of branches, and spread may be the cause of increased fresh herb yield and dry herb yield. Better photosynthetic activity is promoted by the application of balanced nutrients in integrated sources, which in turn leads to better plant growth and increased carbohydrate synthesis (Sunanda *et al.*, 2014).

Timely Harvesting: Harvest fenugreek when pods turn yellow-brown, and seeds are fully developed but not overripe.

Drying and Storage: Dry the harvested seeds properly to reduce moisture content and store them in cool, dry conditions to prevent spoilage.

Post-Harvest Practices

Sustainable Packaging: Using biodegradable or reusable packaging materials reduces environmental impact.

Local Markets: Selling locally reduces transportation emissions and supports the local economy.

Certification and Standards

Organic Certification: Following the guidelines set by organic certification bodies ensures that the cultivation practices meet sustainability standards.

Continuous Learning: Staying updated with the latest sustainable farming practices and technologies can improve efficiency and sustainability.

Biodiversity and community

One of the most extensively researched groups of organisms is plants, and they are most impacted by organic farming. This is most likely because conventional farming uses herbicides, which has a direct impact on plants. The impacts of this can spread to higher trophic levels in the food chain. Different organism groups are affected differently by organic farming; for example, plants, pollinators, and potentially even predators and birds benefit from it, but microorganisms, herbivores, and decomposers are less affected, and less is known about amphibians and mammals. (Tuck SL *et al.*, 2014).

Compared to the conventional farming community, the organic farming community generally had a higher status of social capital. Although the social capital of the organic farming community was much higher in the "generalized" and "institutional" network structures, no equivalent conclusion could be drawn for the "informal" network's constituent pieces. This suggests that long-term organic agricultural practices foster reciprocity and general trust among practitioners in their various social network structures. In intimately connected informal social networks, their social capital may not be impacted by their organic agricultural practices. (Rahman *et al.*, 2007).

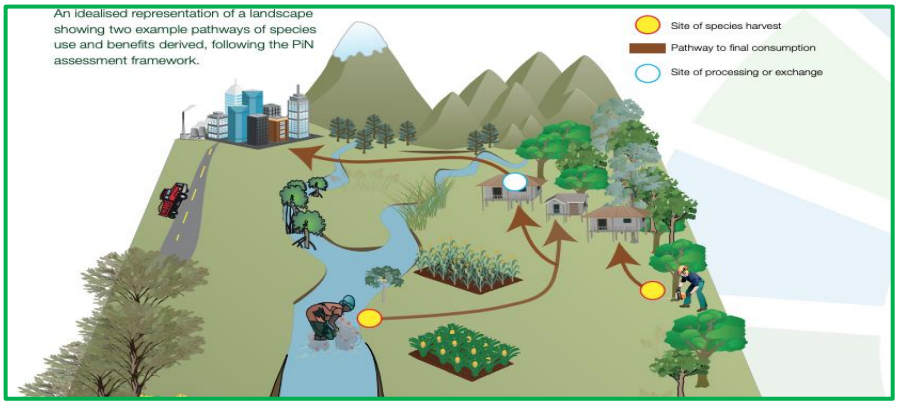

Image source: https://www.iucn.org/news/commission-environmental-economic-and-social-policy/202106/people-nature-understanding-how-communities-use-biodiversity

Conclusion

Sustainable practices in organic fenugreek cultivation are crucial for ensuring long-term agricultural productivity and environmental health. Key strategies include maintaining soil health through regular testing, incorporating organic matter, and practicing crop rotation. Certified organic seeds and bio-control agents help establish healthy crops, while optimal sowing times and proper spacing reduce disease pressure.

Efficient water management using drip or sprinkler systems, combined with organic mulching, conserves water and regulates soil moisture. Organic fertilizers and biofertilizers enrich the soil, promoting robust plant growth. Pest and disease management through biological controls, resistant varieties, and sanitation practices minimize chemical use and environmental impact.

Manual weeding and cover cropping suppress weeds and enhance soil health. Timely harvesting and proper post-harvest handling maintain seed quality and reduce losses. Detailed record-keeping and adherence to organic certification standards ensure transparency and continuous improvement in farming practices.

These sustainable methods not only enhance fenugreek yields but also support ecological balance, resource conservation, and soil fertility, ultimately contributing to a resilient and productive agricultural system. Adopting these practices ensures that organic fenugreek cultivation remains viable and beneficial for both farmers and the environment.

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