

#### Use of Protected Cultivation Structures

The protected cultivation technique is the mainstay of the off-season vegetable crop, as it allows the farmer to manipulate the microclimate around the crop. Polyhouses, net houses, low tunnels, walk-in tunnels, and shade nets are some of the structures used, depending on the crop to be grown and the budget available to the farmer. These structures provide the ideal conditions for the growth of the crop, irrespective of the prevailing weather conditions. These structures protect the crop from heavy rains, frost, strong winds, and extreme temperatures, which could otherwise limit the growth of the crop. The advantage is also the reduced incidence of pests and diseases, which is not the case in open-field conditions. The crops grown in these structures grow faster, flower early, and give higher yields with better quality than the crops grown in the open fields. The technology is also becoming popular, with the government providing the necessary impetus in the form of subsidies, training, and awareness. Variety Selection

The choice of the right variety or hybrid of vegetables is of paramount importance in the production of vegetables during the off-season. Some varieties or hybrids are specifically designed for production in the protected environment or in a more challenging environment. They have a definite advantage over the regular varieties or hybrids used for production in the open field. The choice of the right variety or hybrid should take into consideration the characteristics of the variety or hybrid, such as its maturity period, tolerance to extreme temperatures, resistance to pests and diseases, and the ability of the variety or hybrid to produce fruits of uniform size, color, and shelf life. Hybrids have a definite advantage over other varieties or hybrids because of the presence of hybrid vigor. They have a higher potential for yield, a steady growth pattern, and a better ability to adapt to the environment. In addition, the fruits of the hybrid varieties or hybrids are of a better appearance and flavor, thus fetching a premium price in the market.

#### Nursery Raising

The raising of a healthy nursery is of paramount importance in the production of vegetables during the off-season. A healthy nursery provides the momentum for the production of a healthy crop. The nursery should be raised in a manner that provides a healthy seedling. The choice of the growing medium for the nursery should be a mix of soil, sand, and farm yard manure in the ratio of 1:1:1. The medium should be properly sterilized to kill all the weed seeds, pathogens, and nematodes. The medium can be properly sterilized by solarization, steaming, or bio-fumigation. The seeds should be treated with the right bioagents or the appropriate fungicide to protect the seedling from diseases such as damping-off. The seeds should then be sown in trays with sterile medium or directly in raised nursery beds, depending upon the available facilities. The seedlings should then be hardened before transplanting them in the field. The seedlings should be hardened by gradually introducing them to the outdoor conditions. The seedlings should be exposed to the natural conditions of the environment, i.e., full sunlight, less moisture, and a gradual change in the temperature. The seedlings should then be transplanted in the field. The result of a healthy nursery will be a healthy crop with a high yield.

#### Temperature and Humidity Management

Maintaining optimum microclimate is crucial.

Crop	Temperature Range	Relative Humidity
Tomato	18-28°C	60-70%
Capsicum	20-30°C	65-75%
Cucumber	22-32°C	70-80%

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#### INTRODUCTION

Vegetable production off-season refers to the cultivation of vegetables outside of their natural growing season. It entails the use of advanced farming techniques, climate modification, and the use of protection. The technique helps farmers evade harsh weather conditions, including high or low temperatures, frost, or excessive rainfall. It also helps maintain a consistent supply of fresh vegetables to the market. In recent times, the demand for fresh vegetables among the urban population, coupled with the nutritional benefits of a balanced diet, has created a lucrative off-season vegetable farming industry. The Indian Council of Agricultural Research encourages the use of this technique through training programs, research, and extension services.



#### Importance of Off-Season Vegetable Production

Off-season cultivation has numerous economic, agronomic, and social advantages. The farmers can demand high prices due to the rarity of the product in the market. It is an efficient use of resources, as the land, labor, water, and resources are used throughout the year, without allowing them to remain idle. The practice also provides employment in the rural areas, especially for skilled labor in the development of the nursery, protected cultivation, and the harvest operations. Price stabilization is another important advantage of off-season cultivation, as it has a positive impact on the producers and the consumers. In addition, the practice can ensure nutritional security, as the availability of vegetables in the off-season can meet the demand for balanced diets and healthy food for the people.

#### Suitable Crops for Off-Season Cultivation

To ensure the success of off-season veg cultivation, the right crop has to be selected, as all the vegetables may not thrive in different environmental conditions. In the case of summer off-season cultivation, cucumber, capsicum, tomato, and bitter gourd are the crops that are cultivated in winter under protected cultivation, as these plants need the warmth and protection from cold stress. In the case of winter off-season cultivation, cauliflower, cabbage, pea, and carrot are the crops cultivated in the hot summer under shade or cooling conditions to reduce the stress due to high temperatures. The selection of the right crop is the foundation for the success of off-season veg cultivation, and the selection has to be made on the basis of regional climate, availability of resources, and the facilities available to the farmers.

#### Site Selection and Soil Preparation

The selection of the right site for the off-season vegetable crop is the first major step towards good yields. Soil should be well drained, fertile, and rich in organic matter to encourage the growth of strong root systems, which are essential for good nutrient uptake. The pH should be around 6.0 to 7.5, which is ideal for the majority of vegetables, maintaining the availability of nutrients and the activity of the microorganisms in the soil. It is also best to avoid low-lying areas where waterlogging or frost may occur, as this could reduce the productivity of the crop. Soil preparation is also very important, so plowing should be done to loosen the soil beneath the surface, followed by harrowing to provide a fine till to encourage the growth of the crop. Adding 20-25 tonnes per hectare of farm yard manure or compost also enhances the growth of the crop. Raised beds also provide the advantage of good drainage, good circulation of air, and uniform growth.

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कोटा, राजस्थान



### Package of Practices for Off-Season Vegetable Production

संकलन

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Control measures include ventilation, shading, fogging, and mulching.

#### **Planting Time and Spacing**

The planting time is one factor to be considered in the cultivation of vegetables during the off-season, since the crop must be planted at the right time to ensure that the critical stages of growth do not coincide with extreme weather conditions. For this purpose, the planting or transplanting time is adjusted according to the regional climate, the duration of the crop, and the type of protective structures employed. For example, the early planting of vegetables under protected conditions can provide the crop with insurance against frost or heat stress, so that the crop is ready for the market when the price is high.

Spacing is another factor to be considered in the cultivation of vegetables, since it affects the plant population, growth, and utilization of resources. Spacing is also essential in the prevention of fungal diseases, since it promotes better air circulation, sunlight penetration, and nutrient uptake, all of which result in the production of better-quality fruit. For example, the spacing recommended for tomato is 60 × 45 cm, capsicum 45 × 45 cm, and cucumber 1.5 × 0.5 m, but the actual spacing adopted may vary depending on the variety and the system of cultivation. Spacing is essential to ensure the best growth, facilitate easy operations, and obtain the highest yield per unit area.

#### **Nutrient Management**

Balanced nutrient management is critical for attaining high yields and quality in off-season vegetables since vegetables produced under intensive cultivation methods require more nutrients. Organic manure like FYM or compost @ 20–25 tonnes/ha is beneficial for maintaining soil health by improving soil structure and microbial activity, besides providing required nutrients in a slow and continuous manner. Along with this, required doses of macronutrients like NPK (nitrogen, phosphorus, and potassium) in the ratio of 100-150-60-80-60-80 kg/ha would support vegetative growth, root development, flowering, and subsequent fruit set.

Fertilizers should be applied in split doses to match crop demand at different growth stages, thereby minimizing nutrient losses and improving uptake efficiency. In protected cultivation, fertigation through drip irrigation systems is widely practiced because it delivers nutrients directly to the root zone, ensuring precise and efficient fertilizer use. Foliar feeding of micronutrients is also beneficial, particularly when deficiency symptoms appear or rapid correction is required. Micronutrients such as calcium, boron, and zinc play vital roles in cell wall formation, pollen viability, and enzyme activation, ultimately improving fruit quality, shelf life, and yield. Proper nutrient management not only enhances productivity but also maintains soil fertility and sustainability.

#### **Irrigation Management**

Irrigation management is an important factor in off-season vegetable cultivation since excess and deficit moisture can impair the growth and development of vegetables. Crops that are cultivated in protected structures require careful irrigation management since the environment minimizes the chances of rainfall and alters the rate of evaporation. Drip irrigation and micro-sprinklers are highly recommended irrigation systems since they supply water directly to the roots of the plants in controlled quantities.

Drip irrigation and micro-sprinklers are advantageous in vegetable irrigation since they reduce water consumption by 40–60 percent, ensure uniform moisture distribution in the soil, reduce weed growth, and minimize leaf diseases due to reduced leaf wetting. Soils should also be kept moist, especially during flower and fruit development stages, since water stress during these periods can lead to flower drop, poor fruit set, and reduced fruit size. These factors are essential in ensuring optimal growth and development of the vegetables, and their application will lead to increased and efficient vegetable production.

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#### **Weed Management**

The management of weeds is an important aspect of off-season vegetable cultivation because weeds compete with vegetables for nutrients, water, light, and space. One of the most effective methods of weed management is mulching. Mulching can be done with plastic sheets or organic materials like straw, dry leaves, crop residues, etc. Mulching prevents weeds from coming up because weeds require light to germinate. Apart from weed control, mulching is also beneficial because it saves water, reduces evaporation, and prevents fluctuations in soil temperature. These are advantageous to the crop because they are grown under protective conditions.

Hand-weeding is also an effective method of weed control, especially in the initial stages of growth because the crop is tender. In large-scale cultivation, herbicides can be employed to control weeds before they appear. However, they need to be compatible with the crop and the soil type.

#### **Pest and Disease Management**

Pest and disease management is one of the important factors in off-season vegetable production, as controlled environments may encourage rapid growth of pests if not managed properly. As a sustainable management practice, Integrated Pest Management (IPM) is highly recommended for maintaining pest populations at or below economic thresholds.

Selection of varieties that are resistant or tolerant is one of the first steps in integrated management for vegetable production. Insect-proof nets for ventilation and other openings are important for preventing entry into the protected environment by pests like aphids, thrips, and whiteflies that cause viral diseases. Yellow and blue sticky traps are important for control and detection of flying pests. They are used for early detection of infestations. In eco-friendly management strategies for pests, biological control agents like parasitoids, predators, and microbial pesticides are important. Chemical pesticides are used when required in appropriate quantities for avoiding resistance and residue problems. As in protected cultivation, risk of pests is minimized, but crop monitoring is important for maintaining healthy growth.

#### **Harvesting and Post-Harvest Handling**

Harvesting and post-harvest handling are essential in ensuring that vegetables are of high quality and in minimizing losses. For instance, vegetables should be harvested when ripe, and the timing depends on the type and intended market. For vegetables meant for long-distance transport, harvesting should be done before the expected harvesting period to ensure that they reach the market before they deteriorate. Sharp and clean tools should also be used in harvesting to avoid mechanical damage and infection of vegetables.

Vegetables should also be classified according to their sizes, color, and quality to ensure that they meet the required standards and are sold at premium prices. After harvesting, vegetables should be stored in cool and shaded places to slow down their respiration and subsequent spoilage. For instance, vegetables should be stored in clean and airy containers to avoid heat buildup and mechanical damage during transportation. Effective post-harvest handling results in reduced losses in terms of quantity and quality, which in turn increases farm income.

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#### **Yield Potential**

Scientific management of vegetables in seasons and under protected conditions can lead to increased yields compared to conventional practices in open fields. For instance, under protected conditions, tomato yields are expected to reach between 80–120 tonnes/ha, cucumber between 100–150 tonnes/ha, and capsicum between 60–100 tonnes/ha.

These productivity gains are evidence of the economic benefits that off-season farming offers and have been promoted all over the world. Organizations like the Food and Agriculture Organization provide training and technical support for protected vegetable farming and encourage horticultural technology for improved food security.

#### **Constraints**

Although off-season vegetable farming has several benefits for vegetable producers, it is not without a few challenges that may slow its adoption, especially for small and marginal vegetable farmers. For example, off-season farming in protected environments like polyhouses, which require irrigation systems and climate control systems, may be expensive for small-scale vegetable farmers. In addition, successful off-season farming in controlled environments requires knowledge in crop physiology and management.

Another challenge that off-season vegetable farming may present is that vegetables in controlled environments may be more susceptible to pests and diseases if not properly managed. For off-season farming in controlled environments to be successful, vegetable producers need high-quality vegetable seeds, fertilizers, and pesticides. All these factors may increase the cost of production.

#### **CONCLUSION**

Off-season vegetable cultivation is an economically viable, resource-friendly, and tech-savvy form of cultivation in the present-day world of horticulture. Cultivating vegetables on a regular basis is not only beneficial for farmers in terms of income generation but also for people in terms of nutrition. Embracing scientific cultivation practices like protected cultivation, fertigation, irrigation practices, and pest control is not only beneficial in achieving high productivity and quality in vegetables but also in minimizing the risk of crop production.

Off-season cultivation of vegetables is likely to play an important role in sustainable vegetable cultivation in the coming days due to the progress of new technologies in the field.

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