

**TECHNOLOGY FOR CULTIVATING CALENDULA (MARIGOLD) UNDER
PROTECTED GROUND CONDITIONS (IN GREENHOUSES)**

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Abstract: This article highlights the key aspects of cultivating calendula plants under protected ground conditions, i.e., in greenhouses. The biological characteristics of the plant, agrotechnical measures, microclimate requirements, and scientific-practical approaches to creating optimal conditions for high yield are analyzed. The possibility of cultivating quality flower products year-round under protected ground conditions and the economic efficiency of this process are substantiated.

Keywords: Calendula, protected ground, greenhouse, agrotechnology, microclimate, floriculture, yield, ecological balance

Introduction

Nowadays, plant cultivation technologies under protected ground — in greenhouses — are considered one of the promising directions in the agricultural sector. In particular, the possibility of cultivating calendula, which has medicinal and decorative value, year-round plays an important role in industrializing floriculture and increasing export potential. Due to calendula's sensitivity to light, temperature, moisture, and soil conditions, it can only be grown during certain seasons in open fields. However, in greenhouses, these limitations are eliminated, and an optimal environment suitable for the plant is created.

Modern greenhouses are based on systems that are environmentally safe, resource-saving, and highly efficient. Cultivating calendula under such conditions ensures not only flower production but also the preservation of its medicinal properties. This article thoroughly examines technological approaches, practical methods, and scientific foundations in this field.

Calendula is one of the crops well-suited for moderate and controlled greenhouse conditions. In greenhouses, this plant can be successfully cultivated during any season, even in cold weather. The cultivation technology consists of several main stages:

1. Seed preparation and planting:

Calendula seeds used in greenhouses must be clean, healthy, and viable. Seeds are sown in special substrates or well-structured, nutrient-rich loamy soil that meets agrotechnical standards. The sowing depth must be appropriate, with layers that retain moisture and ensure air circulation.

2. Creating microclimate conditions:

For calendula, optimal greenhouse temperature should be warm during the day and relatively cooler at night. Temperature must be constantly monitored and controlled to prevent overheating or chilling. Sufficient light intensity is essential, especially during the vegetation period. If needed, artificial lighting systems (LED lamps) provide supplementary light.

3. Irrigation and humidity control:

Drip irrigation is the most efficient method as it delivers water economically and maintains optimal moisture around the roots. Soil moisture is regularly monitored using agro-technical moisture sensors. Excess moisture leads to root rot, while insufficient moisture slows growth.

4. Fertilization and nutrition:

Nitrogen, phosphorus, and potassium are crucial for calendula's growth. Additionally, microelements such as iron, magnesium, zinc, and boron in optimal quantities ensure high-quality

flower formation. The use of biohumus, compost, and other organic fertilizers helps preserve the plant's medicinal qualities.

5. Disease and pest control:

In greenhouses, soil disinfection, ensuring natural air circulation, and using biological agents (such as *Trichoderma* or beneficial insects) help maintain calendula health. Chemical pesticides are used minimally as they can negatively impact the ecological purity of the plant.

6. Flowering and harvesting:

Calendula blooms by the end of the first month after sowing. During the flowering period, healthy flowers are harvested daily or weekly. Flowers are picked in the morning when humidity is low. Drying and storage are also carried out under controlled conditions.

Compared to open fields, calendula grown in greenhouses develops faster and produces more and better-quality flowers. Such products are suitable for export and for use in medicinal and cosmetic applications. The use of reusable soil, efficient irrigation, and energy-saving measures make calendula cultivation under protected ground economically viable.

Key to success in greenhouse calendula cultivation:

Modern agrotechnologies and integrated management systems are crucial for success. All plant growth and development processes must be carefully planned.

- **Temperature and Microclimate Control:**

To support calendula growth, daytime temperature should be maintained between 20–25 °C and nighttime between 15–18 °C. Automatic ventilation and heating systems protect plants from cold and overheating. Stable temperatures reduce stress reactions in plants.

- **Lighting Regime:**

The correct quantity and quality of light significantly affect growth and flowering quality. When natural light is insufficient, especially in short-day conditions, LED lighting is used. These systems provide red and blue light wavelengths essential for photosynthesis. A lighting duration of 12–16 hours per day is recommended to ensure effective flowering.

- **Irrigation and Water Management:**

Water is essential for calendula growth. Irrigation schedules must match the plant's phenological stages. Drip systems deliver water efficiently and support healthy root development. After irrigation, soil moisture is regularly measured to prevent excess humidity and ensure proper air exchange.

- **Soil and fertilization:**

Soil mixtures in greenhouses must fully meet the plant's nutritional needs. Organic and mineral fertilizers should be balanced. Nitrogen promotes growth, phosphorus strengthens the root system, and potassium enhances flowering and disease resistance. Microelements are also essential for cell division and metabolism. Foliar feeding methods are used for rapid nutrient delivery.

- **Disease and pest monitoring:**

Modern diagnostics, including visual inspections, biological sensors, and mobile apps, detect early signs of disease and pests. This enables timely intervention. Biological control agents, beneficial insects, and natural phytocides are used to reduce pesticide use and improve product quality.

Innovations to increase yield:

Recent years have seen the development of high-yield calendula varieties through genetic selection and cloning. These varieties are well-adapted to protected ground and more disease-resistant. They are quickly grown in large quantities. Hydroponic and aeroponic methods are also

being researched, offering soil-independent cultivation with precisely managed water and nutrients.

Environmental impact and sustainability:

Calendula cultivation in protected ground is considered an environmentally sustainable method. This technology prevents soil erosion and degradation, manages water resources efficiently, and reduces waste. Efforts include using solar energy, improving greenhouse insulation, and optimizing ventilation systems.

Recent agro-technological innovations are being widely implemented in protected calendula cultivation. Automated systems for controlling temperature, humidity, lighting, and air exchange significantly improve efficiency. These systems align with the plant's biological rhythms, prevent stress, and ensure consistently high yields.

Automated irrigation systems, especially drip irrigation, conserve water and maintain optimal root zone moisture. This reduces the risk of root diseases and accelerates growth. Additionally, automatic nutrition systems deliver precise fertilizer doses, helping maintain nutrient balance.

Biological methods dominate disease and pest control. Beneficial microorganisms like *Trichoderma* and *Bacillus* species, as well as natural phytocides, are used. These are more eco-friendly than chemical treatments and improve plant health. Proper ventilation also prevents excess moisture and improves air circulation.

Future prospects:

The integration of IoT (Internet of Things) and artificial intelligence into greenhouse calendula cultivation will enable real-time monitoring and control of plant growth parameters. This will increase production efficiency, reduce costs, and ensure consistent quality.

Conclusion:

Cultivating calendula in protected ground brings high results through thorough analysis of agrotechnical approaches and the implementation of modern methods. Optimal management of temperature, light, humidity, and nutrition creates a foundation for stable development. This method has evolved through years of experience, scientific research, and practical observation. In the future, the use of automated greenhouse systems and agrobiotechnologies will further enhance the effectiveness of calendula production.

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