

Strawberry production technology for high altitudes of Tawang, Arunachal Pradesh

Farm income in the high mountain border state of Arunachal Pradesh is below the national average due to fragmented landholdings, lack of quality planting material, and reliance on traditional cropping systems. Furthermore, this fragile ecosystem experiences significant yield losses and economic distress due to harsh climatic conditions and the menace of wild animals. Therefore, to enhance farm income per unit area, interventions such as protected cultivation and the introduction of high-value crops offer a viable solution. Notably, about one-third of the geographical area of the Tawang district has a temperate climate suitable for strawberry cultivation. However, the use of protected structures covered with 6 mm polycarbonate sheets or 200 μ polythene is essential to safeguard the crop from high-altitude weather extremes. Protected cultivation of strawberry in the Tawang is economically viable, with a return of ₹1.74 and ₹3.26 per rupee invested during the first and second years, respectively, under polythene mulch. Similarly, the use of organic mulch, such as abundantly available red oak leaves, yields a benefit-cost (B:C) ratio of 1.31 and 2.16 during the first and second years, respectively, under high-altitude conditions.

Keywords: Cultivation practices, Mulching, Protected cultivation, Strawberry, Yield

STRAWBERRY (*Fragaria × ananassa*) is an aggregate fruit grown worldwide for its pleasant aroma, sweet-sour taste, and juicy, bright red fruits rich in essential nutrients, vitamin C, flavonoids, and antioxidants. It matures within a short period, requires a moderate cost of cultivation, and fetches premium prices, especially in tourist destinations like Tawang district, where market demand is high. Hence, its introduction can be a highly profitable agribusiness opportunity.

Its growth and development are favoured by temperate climates; therefore, protected cultivation can be successfully practiced throughout the year in the high mountainous and cold climate conditions of Tawang, with the potential to significantly enhance the income of frontier farmers.

Encouraging results from strawberry feasibility trials conducted at the Defence Research Laboratory Research and Development Centre, Tawang, Arunachal Pradesh, for its introduction in greenhouses at strategic locations have led to the development of the following agronomic practices for economical cultivation.

Ambient conditions

The optimum temperature for the growth and development of strawberries is 20–25°C during the day and 10–12°C at night. In high-altitude areas of Tawang, however, daytime temperatures range between 15–20°C, while night temperatures fluctuate between 5–8°C and

may occasionally drop to near freezing even during summer nights.

The experimental site in Tawang receives an annual rainfall of 500–895 mm, characterized by highly irregular distribution throughout the growing season, which further accentuates temperature variability. However, the desired temperature range can be effectively maintained using a naturally ventilated polyhouse constructed with 6 mm thick polycarbonate cladding, even during peak winters at altitudes of 7,500–9,500 feet.

Construction of low-cost polyhouse

High initial investment costs, even with government subsidies, constrain small and marginal farmers in the Tawang district from adopting polycarbonate greenhouse structures. Except for a few holdings of approximately 0.5 acre, most cultivable land in the region is highly undulating with steep slopes, resulting in fragmented landholdings. Under these combined constraints of harsh climatic conditions and limited, uneven land availability, strawberry cultivation can be made feasible and economically viable through the adoption of low-cost polyhouses.

A low-cost polyhouse measuring 10 × 5 × 3 m (length × width × central height) has been found to be economically suitable and can be conveniently established at sites receiving adequate sunshine throughout the year. The structure utilizes 200 μ m polyethylene as cladding

material (11 × 4 m) and locally available wood for framing, along with provisions for efficient drainage. The side flaps of the polythene covering can be rolled up during midday hours to prevent excessive heat build-up inside the polyhouse through adequate ventilation.

Soil

The soils of most cultivable fields in the Tawang are acidic (pH ~5.0) and loamy in texture, comprising approximately 45% sand, 35% silt, and 19% clay. The balanced addition of organic manures can make these soils suitable for strawberry cultivation, which prefers slightly acidic conditions.

Soil preparation

The soils of the Tawang are sandy and gravelly; therefore, ploughing is primarily carried out to remove boulders and perennial weeds. This is usually done using a spade and hand hoe to achieve a fine tilth up to 20 cm depth.

A minimum application of vermicompost at 5 kg/m² during final land preparation, followed by levelling, is recommended along with the appropriate dose of chemical fertilizers. It helps in moderating soil acidity and improving nutrient availability in the leached soils of the region. Preparation of raised beds measuring 2.7 × 1.2 × 0.15 m is advisable, even under protected structures, to prevent seepage and waterlogging during heavy rainfall.

Soil treatment

Soil solarization, which involves trapping solar heat by covering moist, well-prepared soil with transparent polythene mulch, is an effective non-chemical method for managing soil-borne pathogens, insects, and nematodes under the agro-climatic conditions of Tawang.

The soil should be thoroughly ploughed, made clod-free, levelled, and shaped into beds to eliminate air pockets and ensure uniform heat transfer. Adequate moisture (about 50% of field capacity) should be maintained prior to mulching. A 50 µm LDPE transparent sheet is tightly laid and sealed at the edges, and solarization is carried out for about 48 hours during periods of high ambient temperature in August.

Suitable cultivars

Varietal evaluation trials conducted over two years at the ICAR-DRL, R&D Centre, Tawang, indicate that the strawberry cultivars *Sweet Charlie* and *Winter Dawn*, both short-day types, are suitable for protected cultivation under the prevailing temperate climate.

Planting time

Strawberry runners can be planted throughout the year in Tawang. However, two main planting windows have been identified at altitudes of 7,500–9,500 ft AMSL: March–April (summer) and September–October (winter).

Winter planting is considered most suitable, as it coincides with receding rainfall and stable temperatures. In contrast, July planting promotes excessive vegetative growth and runner production, which reduces fruit yield and quality.

Plant spacing

Limited arable land is a major constraint in the Tawang district. Therefore, closer spacing of 30–35 cm between plants and rows ensures optimal utilization of space under protected conditions. However, a spacing of 50 × 25 cm may be adopted in soils with low to medium fertility.

A raised bed of 2.7 × 1.2 × 0.15 m accommodates four rows and approximately 36 plants, facilitating efficient cultural operations and maintaining optimal plant density.

Mulching

Polythene mulching is an essential practice in strawberry cultivation to ensure high-quality fruit production. Planting runners in holes of 5–7.5 cm diameter made in black–silver polythene mulch (30–50 µm) protects fruits from direct soil contact, conserves moisture, and maintains a favourable microclimate by suppressing weeds.

The mulch should be laid just before planting, with the silver surface facing outward. Although polythene mulch is most effective, organic mulching using locally available oak leaves at 5 kg/m² can serve as a partial alternative.

Nutrient management

In the absence of chemical fertilizers, raised beds should be enriched with vermicompost at 10–15 kg/m², applied 15–20 days before planting during the initial years. The soils in Tawang are generally medium in nitrogen, low in phosphorus, and high in potassium.

An optimum dose of N, P₂O₅, and K₂O (10 g, 12.5 g, and 8 g/m², respectively), preferably based on soil test results, along with 2.5 kg/m² vermicompost, is recommended. Due to heavy rainfall and sloping terrain, higher doses of vermicompost are advisable to ensure a balanced supply of secondary and micronutrients.

Nitrogen should be applied in two equal splits—at establishment and before flowering—using the band placement method. Phosphorus and potassium should be applied during final land preparation. Fertigation of nitrogen and potassium is recommended throughout flowering and fruiting.

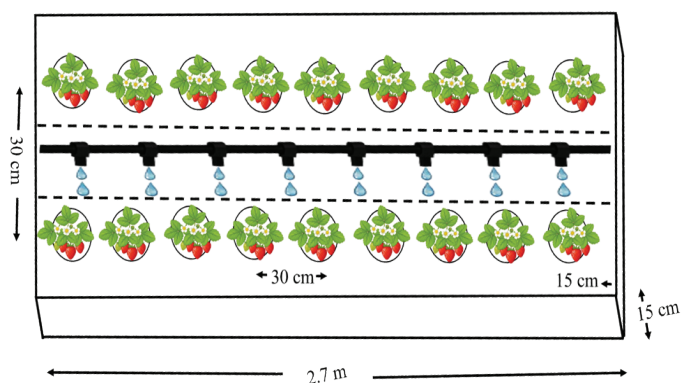
Foliar spray of N:P:K (19:19:19 or 20:20:20) at 3–5 g/l, applied twice a week during flowering and fruit set, enhances plant vigour and fruit quality.

Water management

Maintaining optimal humidity and adequate soil moisture (around 50% field capacity), particularly during critical stages such as establishment, budding, flowering, and fruit set, is essential under polyhouse conditions to prevent grey mould incidence.

Instead of conventional furrow irrigation using water with total dissolved solids (TDS) below 450 ppm, the integration of a double-row planting system with a centrally placed drip line significantly improves water and nutrient use efficiency. The drip line is positioned between two rows under the polythene mulch, minimizing direct moisture contact with plant stems and reducing the risk of fungal diseases.

Irrigation should be scheduled during morning hours, avoiding the warmest part of the day and evening periods.



Diagrammatical illustration of raised bed with central drip system (dashed line showing drip line under the silver mulch)

Intercultural operation

Clean cultivation with soil solarization and polythene mulching in the protected structure does not require interculture operations. However, the removal of sand eaves (lower most senescing leaves) once in 15 days helps in reducing the incidences of insects and diseases (fruit rot).

Insect pest and disease management

Two-spotted mites (*Tetranychus urticae* Koch), aphids (*Chaetosiphon fragaefolii* Cockerell), white flies (*Bemisia tabaci*) and thrips (*Scirtothrips dorsalis* Hood) are the major insect pests of strawberry. However, in Tawang region, the attack of aphids and thrips is periodic while white flies are sporadic under protected conditions. The preventive measures such as the use of yellow, blue and white sticky traps are desirable in this region. A prophylactic spray of 0.5% neem seed kernel extract (NSKE) at 15 days interval is suggested when the incidence of insects is more than 10/plants.

Gray mould (*Botrytis cinerea*) is a major disease of

strawberry under protected conditions, however, in Tawang its outbreak is not a serious concern in winter crop because of the cold temperature during fruit set. In the summer season, maintaining ventilation during mid-day along with ensuring nil contact of fruits with soil through polythene mulching is the most efficient preventive measure for the disease.

Picking and yield

September planted crop started to set flowers in the last week of December and fruit in the first week of January coinciding with light snowfall incidences in Tawang region. Early (May or July) planting favours more vegetative growth and late planting (November-December) take more than 100 days to set flowers and fruits due to the increased establishment phase. Three pickings can be taken from a timely planted crop with an average of 500 to 600 g fruits per plant under optimally managed protected conditions.

Special care

- The temperature inside greenhouses in the Tawang region may rise up to 40°C, leading to mid-day depression and high humidity levels. Therefore, proper ventilation should be ensured at noon, while vents and double doors should be closed before evening to prevent a sudden drop in temperature.
- Runner formation coincides with the fruiting stage and may adversely affect fruit production; hence, runners should be removed regularly.
- Once planted, strawberry remains productive for up to three years; however, yield declines after the third year. Therefore, to optimize the cost of protected structures, fresh runners should be planted every alternate year.
- Vermicompost and FYM can substitute up to 50% of the inorganic fertilizer requirement. Hence, fertigation and foliar application during critical growth stages are essential for economical strawberry production in Tawang region.

Economics of strawberry cultivation under greenhouse in Tawang (9,300 feet AMSL)

Particulars	Polythene mulching		Organic mulching	
	I year	II year	I year	II year
Average yield (g/m ² /picking) [#]	1,150.0		1,050.0	
No. of pickings/season ¹	03			
Final yield (g/m ²)	3,450.0		3,150.0	
Gross return (INR/m ²)	1,725.0		1,575.0	
Gross return (INR/50m ²)	86,250.0		78,750.0	
Cost of cultivation (INR/50m ²)	31,477.5	20,227.5*	31,102.5	19,852.5*
Net returns (INR)	54,772.5	66,022.5	40,647.5	51,857.5
B:C ratio	1.74	3.26	1.31	2.61

[#]Average yield of 3 picking/year pooled over 2 years; ¹Only 3 pickings were taken considering fruit quality; *Cost of strawberry runners at 25/plant is deducted during II year; Market price of strawberry fruit (INR/g): 0.50 considering initial introduction of the strawberry in local market of Tawang, transportation cost and break-even point of demand and supply.

Although the benefit-cost (B:C) ratio may be lower during the first year, it improves from the second year onwards as returns increase. The B:C ratio can be further enhanced through efficient utilization of the vertical space within the polyhouse.



Training and demonstration (9,300 ft.)



Training and demonstration (9,300 ft.)



Successful production of strawberry in strategic location (10,800 ft.)



SUMMARY

The farming sector in high-altitude regions faces several challenges, including limited availability of quality planting material, harsh climatic conditions, and traditional farming practices. Despite these constraints, there is significant potential to enhance productivity and farm income through the adoption of protected strawberry cultivation in Tawang.

Cultivation following the recommended package of practices under protected conditions is both economically viable and environmentally sustainable, as evidenced by favourable net returns under prevailing climatic conditions. Large-scale frontline demonstrations, along with regular

hands-on training and financial support for establishing low-cost protected structures, are essential. A coordinated effort by researchers, extension workers, and policymakers will facilitate wider adoption of this technology, enabling farmers to utilize the lean, snow-bound winter period effectively and improve their livelihoods.

For further information, please write to:

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