Exploring the Impact of Under Canopy LED Lighting on Cultivation Quality & Business Profitability

Enhancing Commercial Cannabis Cultivation Through Strategic Supplemental Sub-canopy Photon Delivery in Indoor and Greenhouse Facilities

Technical White Paper

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Backed by Growgenics LLC

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Commercial Horticultural Lighting Solutions

Executive Summary

Key Findings and Strategic Value of Under Canopy Lighting Technology

Based on combined findings of independent third-party testing of 120W and 240W Under Canopy Fixtures in commercial legal cannabis cultivation environments in concert with expert level horticultural research.

Core Value Proposition

Yield Enhancement

Average dry trimmed flower yield increases by 21% using Under Canopy lighting, rising to as much as 43% when paired with optimized above canopy lighting, converting lower B/C grade buds into dense A-grade flower.

Quality & Potency

Observed THC improvements of approximately +4.1% in lower canopy zones and +2.1% in upper canopy zones, while also improving overall flower size consistency across canopy layers.

Rapid ROI

Estimated payback period is approximately 2.2 months at a 21% yield increase; For a 1,000 sq. ft. facility this enhancement can add about $105,820 in annual revenue with minimal additional operational costs.

The Limitation of Commercial Cultivation: Vertical Light Distribution

In high-intensity commercial cultivation, vertical light distribution is a greater yield-limiting factor than total photon output, as lower canopy tissues remain photon-limited.

1

High-Density Canopy

High planting density increases leaf area index and creates shading within the canopy.

2

Light Penetration Challenges

Upper leaves intercept most photons[1], reducing light availability deeper in the canopy.

3

Lower Tissues Photon-Limited

Lower canopy tissues receive insufficient photons, limiting photosynthesis and yield potential.

Under Canopy Lighting: Core Function and Mechanism

How UC Lighting Expands Photosynthetic Productivity

1

Supplemental Photon Delivery

UC lighting delivers photons directly into shaded zones beneath the canopy.

2

Local Photosynthesis Boost

Increased photon availability boosts carbohydrate production in shaded tissues.

3

Increased Productive Yield

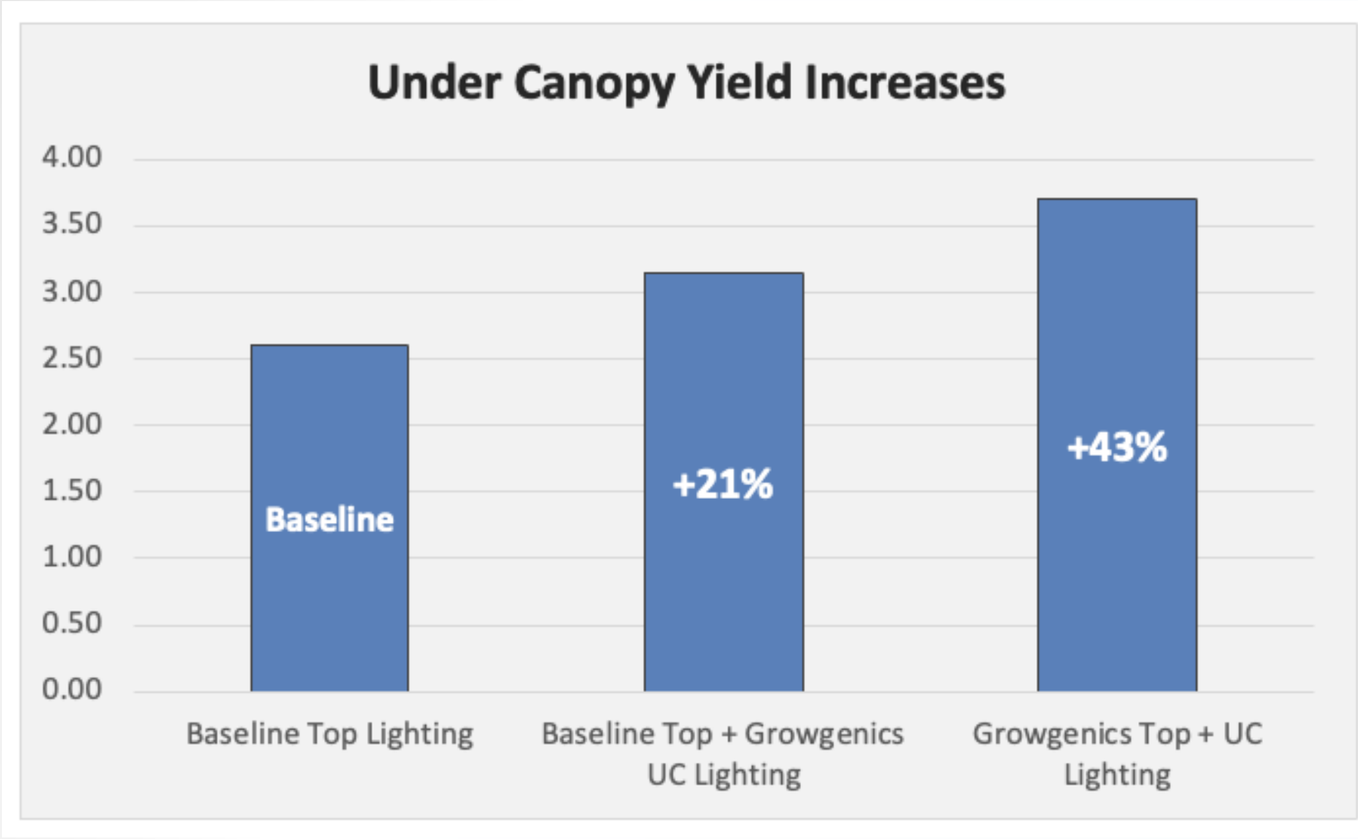
Increases photosynthetically driven crop yield without increasing existing canopy footprint.

4

Enhanced Bud Development

Supports bud initiation, bulking, and quality across entire vertical profile of plants and significantly boosts lower bud maturity.

Yield Impact Analysis



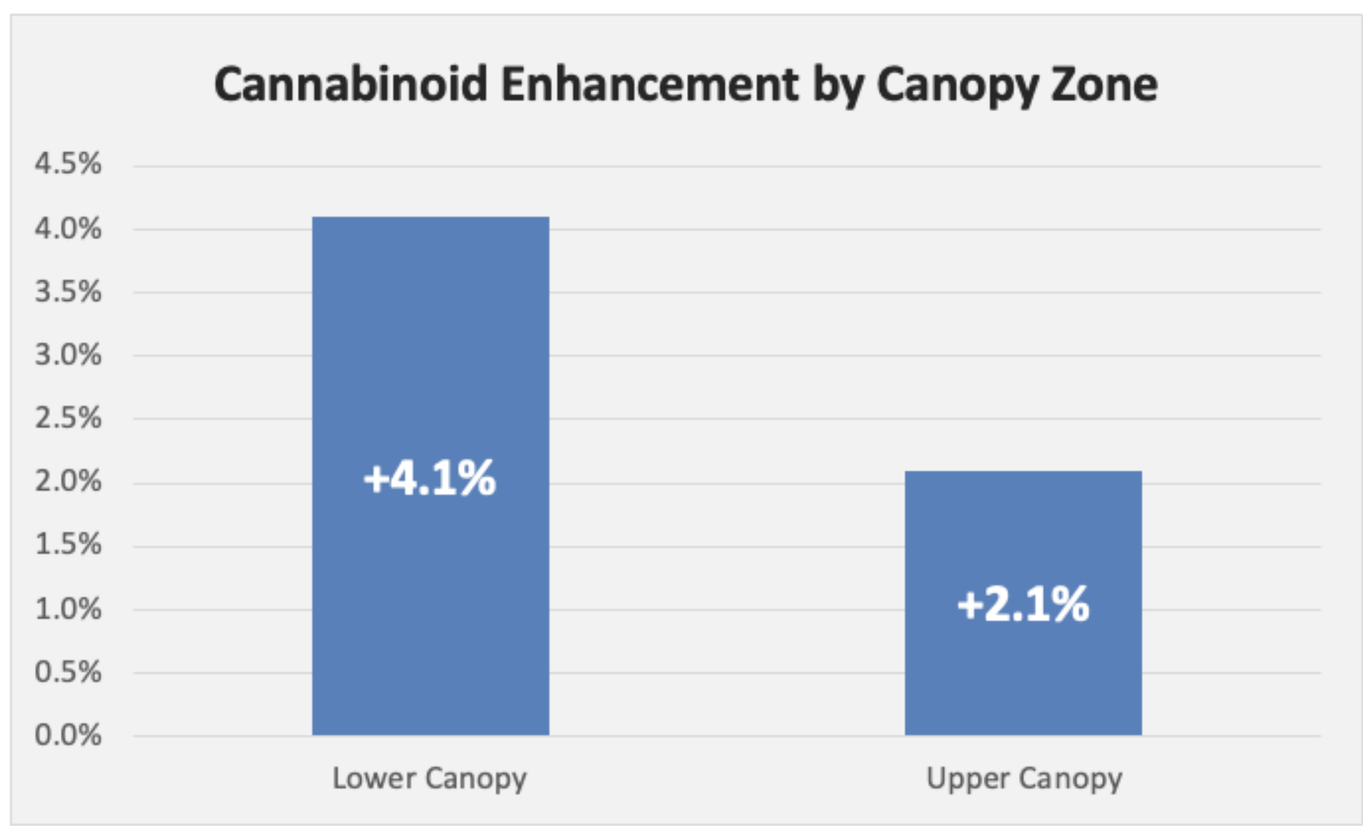
Standard UC Addition

By adding UC lighting to a commercial cultivation utilizing conventional top lighting, testing showed a 21% yield increase.

Optimized System Synergy

Combining high-performance top lighting with UC systems achieved a 43% total yield increase over baseline configurations.

Cannabinoid Enhancement by Canopy Zone



Lower Canopy Impact

Most dramatic potency improvement occurred in lower canopy zones with increases up to +4.1% THC where light limitation was most severe.

Upper Canopy Benefit

Even the well-lit upper canopy showed increases of up to +2.1% THC, indicating whole-plant metabolic enhancement from improved resource allocation.

Technical Specifications

System Architecture and Configuration Parameters

Typical Under Canopy Configuration Ranges

Standard operating parameters for commercial UC lighting deployments across various facility types and cultivation protocols. These ranges represent field-validated configurations. Note: Outcomes may be strain dependent.

Parameter	Typical Range / Specification
Power Density	15 W/ft² of canopy
Mounting Height	12-14” above bench/base of plant
Row Placement	2 rows of UC fixtures per bench (Typical Setup: 3 plants across)
Fixture Length	4 ft modules (120W fixtures) or 8 ft modules (240W fixtures)
Photoperiod	Same as flower photoperiod or reduced hours (typically 11-12 hours per day)
Spectrum	Slight blue, broad white + heavy deep red (high-red dominant)
Target Zone	Lower and interior canopy
Electrical Power Setup	Dedicated UC circuits and power cords
Dimming / Control	On/Off or 0–10 V dimming capability

Technical Specifications of Measured Deployments

Detailed specifications of the UC luminaire systems used in the field trials and commercial deployments that generated the performance data presented in this white paper.

Specification	Detail
Luminaire Power	120W per 4 ft fixture / 240W per 8 ft fixture
Configurations	Two 4-ft luminaires per 16 sq. ft. (240W) or Two 8-ft per 32 sq. ft. (480W)
Field Input Voltage	277 VAC
Ingress Protection	IP66 (Wet-location UL/ETL certified)
Control Interface	0–10 V Dimming
Spectrum Focus	High-red dominant spectrum
Operating Protocol	Activated Day 12–14 of flowering at 100% output
Typical Photoperiod	12 hours on, flowering cycle (same as overhead)
Environmental Rating	Tolerates sanitation/washdown procedures

System Architecture and Power Density

Standard Power Density

Typical application results in approximately 15 W/ft² of canopy. Two 4ft 120W luminaires per 16 sq. ft. (or two 8ft 240W luminaires per 32 sq. ft.) of cultivation area provides optimal photon delivery to lower canopy

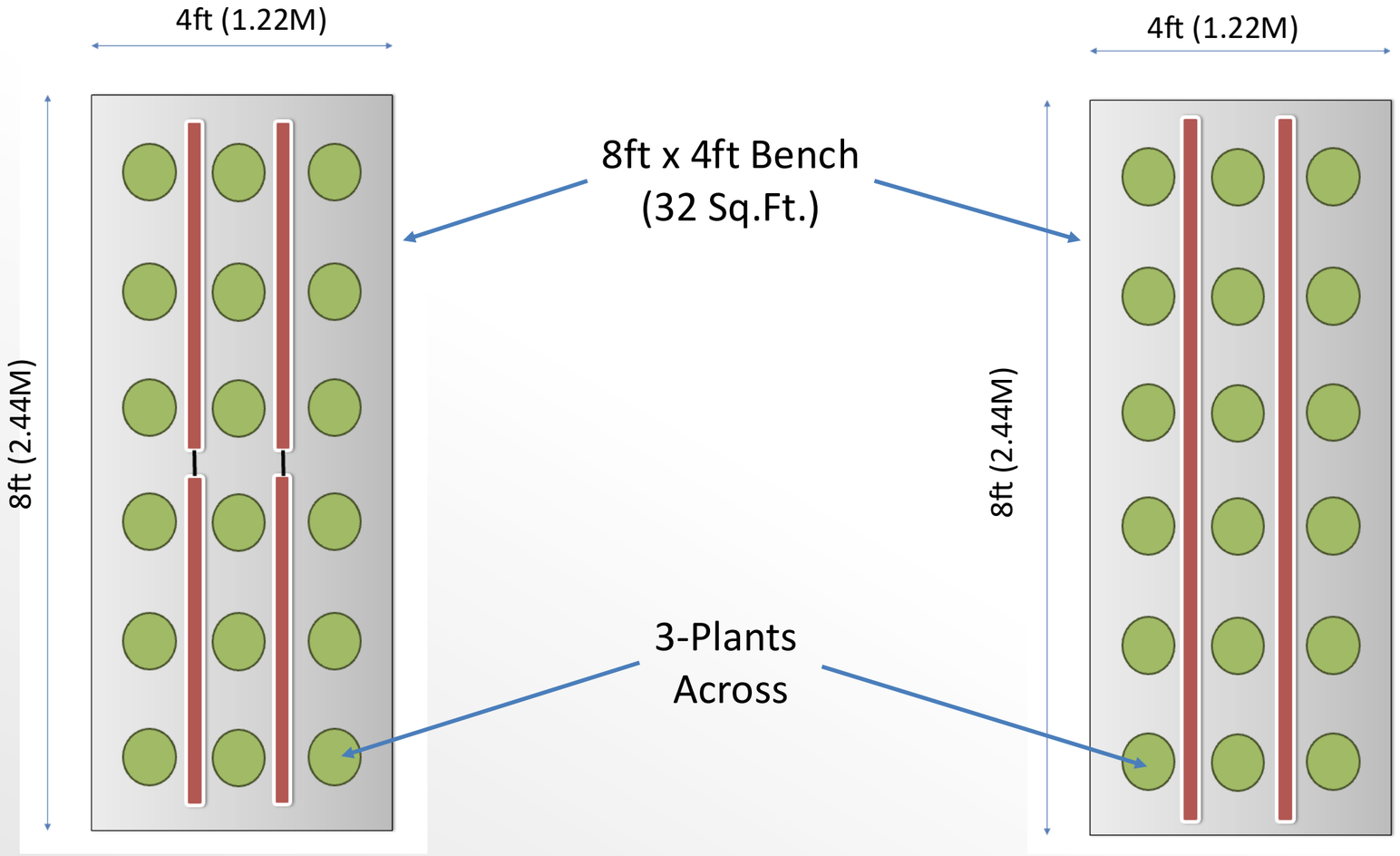
Mounting Configuration

Fixtures mounted 12–14 inches above floor/bench via basic triangular configuration light stands. Recommended plant configuration: 3 across light bars between the two internal pant gaps.

Environmental Design

IP66 wet-location rating essential for sanitation compliance. Safe surface temperatures maintained to prevent plant tissue damage & lean design to maintain airflow.

Typical Under Canopy Layout Configurations



Configuration-1
Qty=4, 120watt 4ft Light Bars
(15 watts/Sq.Ft.)

Configuration-2
Qty=2, 240watt 8ft Light Bars
(15 watts/Sq.Ft.)

Economic Analysis

Financial Impact and Return on Investment

Economic Impact Summary - 1,000 sq. ft. Facility

Comprehensive financial analysis for a 1,000 square foot commercial cultivation facility implementing Under Canopy lighting. Analysis based on baseline yield of 2.5 lb per 16 sq. ft. and field-validated performance data.

Financial Metric	Value / Specification
Added Annual Revenue	$105,820
Added Energy Cost (Annual)	Included in $12,973
Added Cooling Cost (Annual)	Included in $4,057
Total Added Operating Cost (Energy + Cooling)	$17,030 per year
Typical Lighting Cost	~$20 per square foot
Payback Period (21% yield)	~2.2 months
Payback Period (15% yield)	~3.3 months
Baseline Yield Reference	~2.6 lb per 16 sq. ft. before Under Canopy installation
ROI Insight on a Cost per Yield Basis	Highest-ROI yield enhancement strategy with zero canopy increase

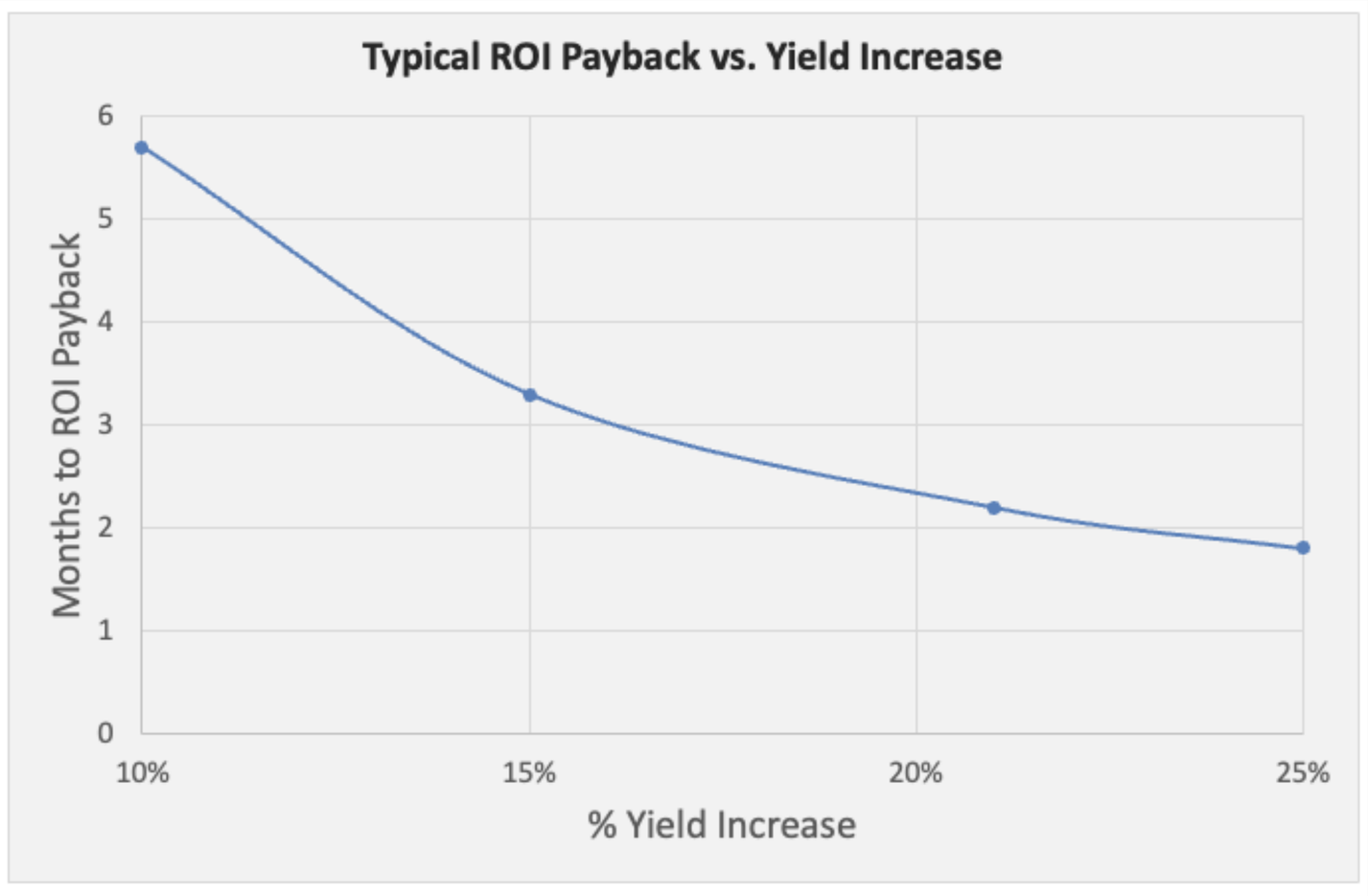
Payback Period Sensitivity Analysis

Investment Recovery Timeline

Even under conservative yield improvement scenarios of only 15%, the UC lighting system demonstrates exceptional economic efficiency with payback in 3 -4 months. At the field-validated 21% yield increase, investment recovery occurred in just over 2 months, making this one of the fastest-returning capital investments in commercial cultivation without increasing canopy.

2.2

Months to Full ROI



Cost-Benefit Analysis Breakdown for 1,000 sq. ft. Facility

Initial Investment

$20,000–$30,000 for 1,000 sq. ft. facility. Includes fixtures, electrical infrastructure, and installation labor

Incremental Operating Costs

$17,030 annually in added energy and cooling costs. Minimal maintenance requirements with long-life LED technology

Revenue Enhancement

$122,850 additional annual revenue at 21% yield increase. Quality improvements command premium pricing for A-grade flower

Net Annual Benefit

$105,820 net annual profit increase. Extreme rapid payback enables reinvestment in facility expansion or additional optimization

Operational Protocols

Implementation and Operating Procedures

Operating Protocol and Timing

Vegetative Stage

UC only recommended during flower cycles. During vegetative stage, UC lights remain off or not installed in vegetative areas.

Activation Point Day ~14

UC lights activated at 60-100% output. This activation coincides with the active bud development phase and maximizes density during early flower expansion.

Final Flush Period

Continue UC lighting at 100% through harvest. Maintain a consistent light environment until crop termination to stabilize final cannabinoid and terpene development.

Early Flowering Days 1-14

UC lights remain OFF. Allow initial flower site establishment and early reproductive structures to form without supplemental UC lighting during this period.[2]

Mid-Late Flowering Days 21-56

UC lights at 80-100% power and maintain a 12/12 photoperiod matching overhead lighting. Ensure full photon delivery of high red photosynthetic frequencies to the lower canopy to support uniform flower maturation.

Cultivation Conditions for Optimal Performance

CO_2 Enrichment

Data derived from environments using CO_2 at approximately 1200 ppm during key flower weeks. Elevated CO_2 levels maximize photosynthetic response to increased photon availability and support enhanced metabolic activity.

Top-Canopy PPFD

Baseline top-canopy PPFD of 800–1000 µmol/m²/s. UC lighting supplements rather than replaces overhead illumination. Integrated approach ensures full vertical canopy optimization combatting photon stratification.

Environmental Control

Standard commercial cultivation parameters maintained. Temperature, humidity, and airflow protocols remain unchanged. UC fixtures designed to integrate seamlessly with existing climate control systems.

Application Scenarios

Indoor and Greenhouse Facility Implementation

Commercial Indoor Facilities

Primary application for high-density cultivation operations. UC lighting addresses inherent light penetration challenges in multi-tier and dense single-tier canopy systems. Maximizes yield per square foot in space-constrained environments. Essential for facilities targeting premium A-grade flower production at scale

Implementation Advantages

Controlled environment allows precise integration with existing lighting control systems. No seasonal variation concerns. Ideal for facilities with automated fertigation and climate control seeking to optimize all growth factors. Plants are receiving additional photonic energy and therefore will typically consume nutrients and water at higher rates.

Greenhouse Cultivation Facilities

Highly effective as supplemental light in greenhouse operations. Addresses light distribution challenges during low-angle sun conditions and overcast periods. Complements natural sunlight by filling shaded zones that overhead sun cannot reach. Extends productive growing season in northern latitudes

Greenhouse-Specific Benefits

Reduces dependency on seasonal light variations. Maintains consistent production quality year-round. Lower cooling burden compared to indoor-only facilities. UC lighting provides targeted supplementation exactly where natural light is deficient without over-lighting upper canopy zones

Quality and Grade Improvement

Converting Lower Canopy Production to Premium Flower

Flower Grade Transformation and Market Value

1

Baseline Scenario

Without UC lighting, lower canopy levels produces smaller, less dense B/C grade buds with lower cannabinoid content and larf

2

Under Canopy Implementation

Supplemental photons delivered directly to lower canopy tissues during critical flowering phase

3

Density & Size Improvement

More lower buds develop increased density, size, and trichome production matching A-grade characteristics

4

Revenue Impact

Higher percentage of total yield qualifies as premium A-grade flower commanding top market pricing

Consistency and Uniformity Benefits

> UC lighting improves overall flower size consistency across the entire vertical canopy profile, reducing variation between upper and lower zones and simplifying post-harvest processing and grading operations.

Uniform Development

Reduced differential between top and bottom canopy reduces sorting complexity

Processing Efficiency

More consistent flower sizes streamline trimming, drying, and packaging workflows

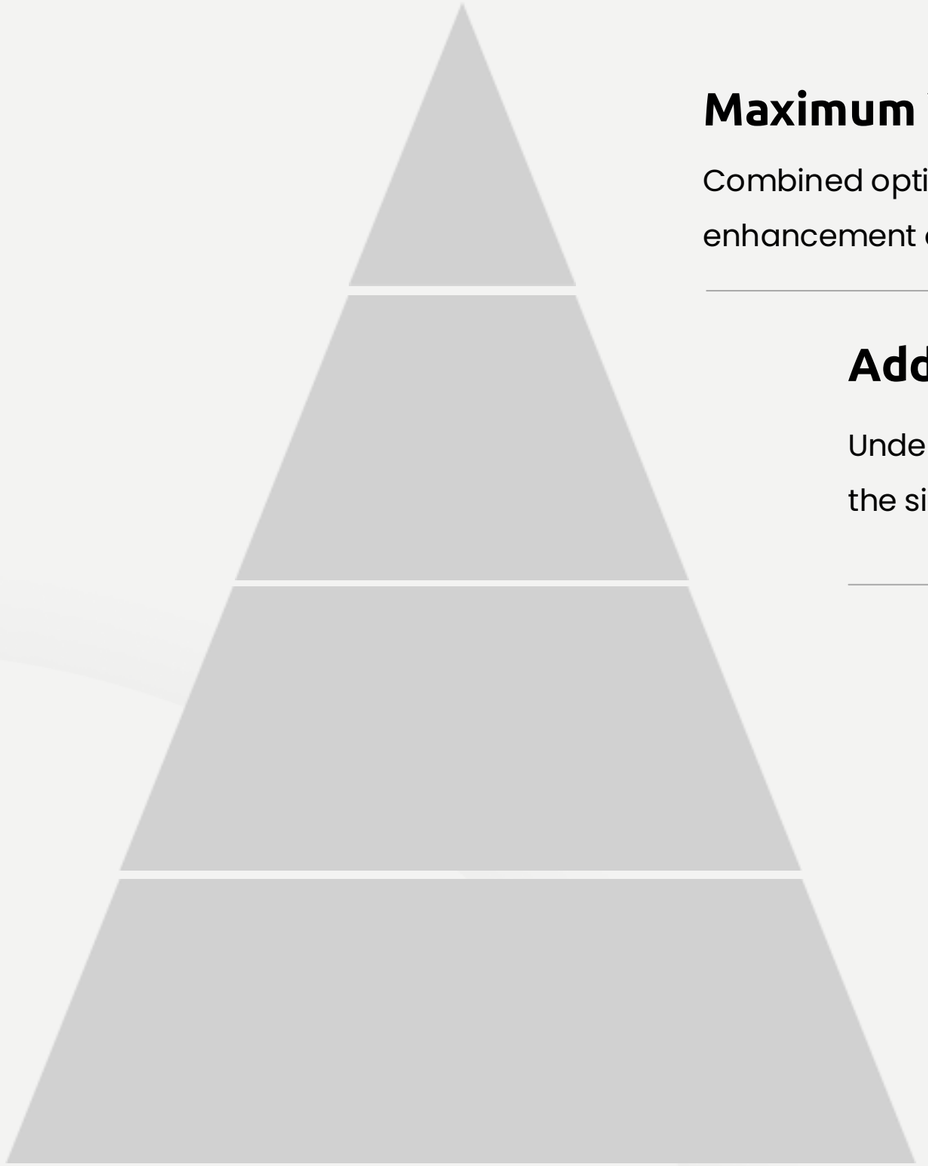
Quality Assurance

Narrower quality distribution improves brand consistency and customer satisfaction

Strategic Value Proposition

Positioning UC Lighting in Facility Optimization

Highest-ROI Yield Enhancement Strategy Available



Maximum Yield Potential

Combined optimization of all factors achieves up to 43% yield enhancement over conventional systems

Addition of Yield-Specific Spectrum Under Canopy Lighting

Under Canopy Lighting Integration - Strategic supplemental lighting addresses the single greatest remaining yield limitation: Photon Stratification

Integration of Yield-Specific Spectrum Above Canopy Lighting

Above-Canopy Lighting Optimization - High-efficiency LED top lighting with optimized photosynthesis-specific spectrum and intensity provides primary photon delivery

Foundations: Basic Environmental Requirements

Optimized Cultivation Protocols - Genetics, nutrients, climate control, integrated pest management, and standard cultivation practices establish baseline performance

Competitive Advantages for Early Adopters

Market Differentiation

Consistent premium-grade flower production establishes brand reputation. Higher quality product commands premium pricing and builds customer loyalty in competitive markets

Operational Efficiency

Maximize revenue per square foot of cultivation space. Extremely rapid ROI enables aggressive expansion or additional facility optimization investments without extended capital recovery periods

Risk Mitigation

Diversified lighting approach reduces single-point failure risk. Proven technology with field-validated performance data minimizes implementation uncertainty and provides confidence in projected returns

Technical Considerations

Design Requirements and Integration Factors

Electrical Infrastructure Requirements

Power Recommendations

Standard 277V input voltage. Typical 15 W/ft² power density requires dedicated circuits or integration with existing flower lighting circuits. Load calculations must account for simultaneous operation with overhead lighting

Control Integration

0–10 V dimming interface allows integration with facility management systems. Can be tied to same photoperiod controllers as overhead lighting or operated independently for specialized protocols

Installation Considerations

Professional electrical installation required for code compliance. Wet-location rated components throughout. Mounting hardware should maintain fixture stability and UC height of ~12 to 14” above bench floor

Environmental and Safety Requirements

Sanitation Compliance

Minimum IP66 ingress protection rating essential for wet-location compliance. Fixtures must withstand regular washdown and sanitation protocols. Sealed construction prevents moisture intrusion and maintains electrical safety in high-humidity cultivation environments

Thermal Management

Surface temperatures must not damage plant tissue at minimum spacing distances. Passive or active cooling maintains safe operating temperatures. Heat output must be factored into facility HVAC load calculations

Airflow Preservation

Fixture design and mounting configuration must maintain unobstructed airflow patterns. Root-zone ventilation cannot be compromised. Proper spacing prevents stagnant air pockets that promote pathogen development

Spectral Design

Optimized Wavelength Distribution for Lower Canopy

High-Red Dominant Spectrum Strategy

UC lighting employs a broad white plus deep red spectrum with high-red dominance, optimized for photosynthetic efficiency and flowering response in lower canopy tissues.

Broad White Foundation

Provides full spectrum support for photosynthesis and maintains color rendering for crop monitoring and quality assessment

Deep Red Enhancement

660-670nm red wavelengths maximize photosynthetic photon efficiency and drive flowering responses. Key red frequencies are absorbed quickly, and thus are key for UC supplementation

Lower Canopy Optimization

UC spectrum designed for canopy adapted to shaded conditions. Delivers photons in wavelengths most efficiently captured by lower canopy chlorophyll configurations

Mechanistic Basis

Photobiological Principles of UC Lighting Efficacy

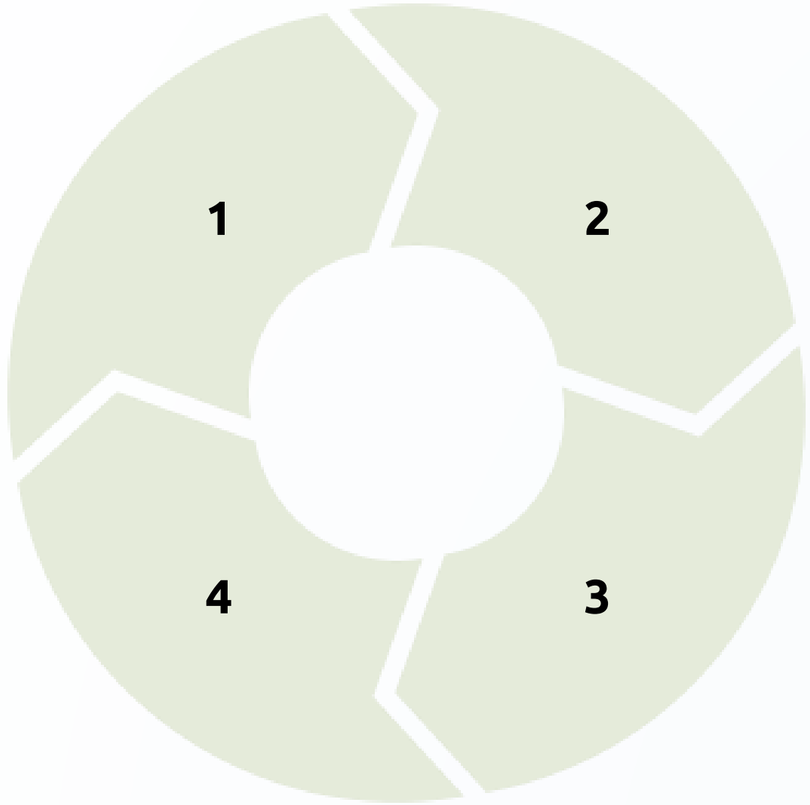
Photosynthesis and Carbohydrate Production

Increased Photon Availability

UC lighting delivers supplemental photons to previously photon-limited lower canopy tissues.

Yield & Quality Enhancement

Improved resource availability results in larger, denser buds with enhanced cannabinoid production throughout vertical profile.



Enhanced Local Photosynthesis

Elevated photosynthetic rates in lower leaves increase local carbohydrate production and energy availability[3].

Resource Allocation to Buds

Additional carbohydrates support bud initiation, cell division, and biomass accumulation in flower sites.

Whole-Plant Metabolic Effects

Lower Canopy Primary Benefits

Direct photon delivery to shaded tissues eliminates the primary limiting factor for lower bud development. Increased local photosynthesis provides carbohydrates directly adjacent to developing flower sites.[4] This proximity advantage maximizes efficiency of resource allocation to bud growth and secondary metabolite production including cannabinoids and terpenes.

Upper Canopy Secondary Benefits

Enhanced lower canopy productivity improves whole-plant resource availability. Better distributed photosynthetic capacity reduces stress on upper canopy as sole carbohydrate source. Observed THC increases in upper canopy (+2.1%) indicate systemic metabolic improvements beyond direct light effects, suggesting improved plant vigor and resource allocation efficiency.

Implementation Planning

Facility Assessment and Deployment Strategy

Pre-Implementation Assessment Checklist

Facility Evaluation

Measure canopy dimensions and mounting space availability. Assess electrical capacity and circuit availability. Evaluate HVAC capacity for additional heat load. Determine optimal fixture placement based on cultivation layout and plant training methods.

Financial Analysis

Calculate expected yield increase based on current production metrics. Project revenue enhancement using current market pricing. Determine payback period at conservative and optimistic yield scenarios. Budget for installation, incremental energy, and cooling costs.

Operational Planning

Develop activation protocol timeline and staff training procedures. Integrate UC lighting into facility SOPs and crop scheduling. Plan for fixture maintenance and cleaning within sanitation protocols. Establish monitoring procedures for performance validation.

Phased Deployment Strategy

Pilot Zone Implementation

Install UC lighting in single grow room or zone. Document baseline yield and quality metrics. Monitor performance through complete flowering cycle. Validate financial projections with actual data

Performance Validation

Compare pilot zone results to control areas. Analyze yield increase, grade distribution, and quality metrics. Calculate actual ROI and payback period. Identify any operational adjustments needed

Facility-Wide Rollout

Deploy UC lighting across all flowering zones based on validated pilot success. Leverage lessons learned for efficient installation. Train all cultivation staff on operation and maintenance

Continuous Optimization

Fine-tune activation timing and intensity for specific cultivars. Integrate learnings into SOPs and best practices. Monitor long-term performance and system reliability. Plan for technology upgrades and expansion

Conclusions

Key Takeaways and Strategic Recommendations

Summary of Key Findings

Proven Performance

21% average yield increase validated across commercial deployments. Up to 43% enhancement with optimized system integration

Quality Enhancement

THC increases of +4.1% in lower canopy. Conversion of B/C grade to premium A-grade flower

Exceptional ROI

2.1 month payback period at standard performance. Highest-ROI yield enhancement strategy available

Broad Applicability

Effective in both indoor and greenhouse cultivation environments. Scalable from small operations to large commercial facilities

Low Risk Implementation

Field-validated technology with proven performance data. Minimal operational disruption and rapid deployment possible

The Competitive Imperative

> In increasingly competitive cannabis markets, Under Canopy lighting represents a proven, low-risk strategy to maximize yield, enhance quality, protect margin, and achieve rapid return on investment. Operators who integrate this technology gain immediate competitive advantages in production efficiency, product quality, and operational profitability.

The question is not whether to implement UC lighting, but how quickly you can test, measure, and deploy it to capture the strategic and financial benefits.

Thank You

For questions or implementation support, please contact Growgenics to discuss how Under Canopy lighting can optimize your facility's performance.

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www.growgenics.com/under-canopy-pro

Sources

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