

STUDY / RESEARCH · ARUNPATIL LABS

From Vine to Raisin

The Full Grape Growth Cycle & Raisin Formation

A comprehensive 173-day viticulture systems research record documenting pruning, bud-break, phenological stages, and precision shade-drying on a commercial overhead trellis vineyard at Basavana Bagevadi & Sindagi Taluk, Vijayapura, Karnataka.

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Official Web Archive: arunpatillabs.com



AGROTECH FIELD RECORD · 2025–26 SEASON

From Vine to Raisin

The full grape growth cycle and raisin formation, documented in our vineyard at Basavana Bagevadi, Vijayapura, Karnataka.

October 2025 – April 2026

Built from 29 field photos, videos and CCTV clips



The season at a glance

Tractor (Tarzan)

GPS Map telemetry logged: 1 Nov 2025

586208, Karnataka, India

Location: Basavana Bagevadi, Vijayapura district, Karnataka. India's premier raisin belt, offering a dry winter ideal for shade drying.

Crop: Green seedless table/raisin grapes on an overhead trellis with drip irrigation (Thompson Seedless clone).

147

days from the post-pruning spray (18 Oct) to harvest (14 Mar)

27

days from that spray to full flowering (14 Nov)

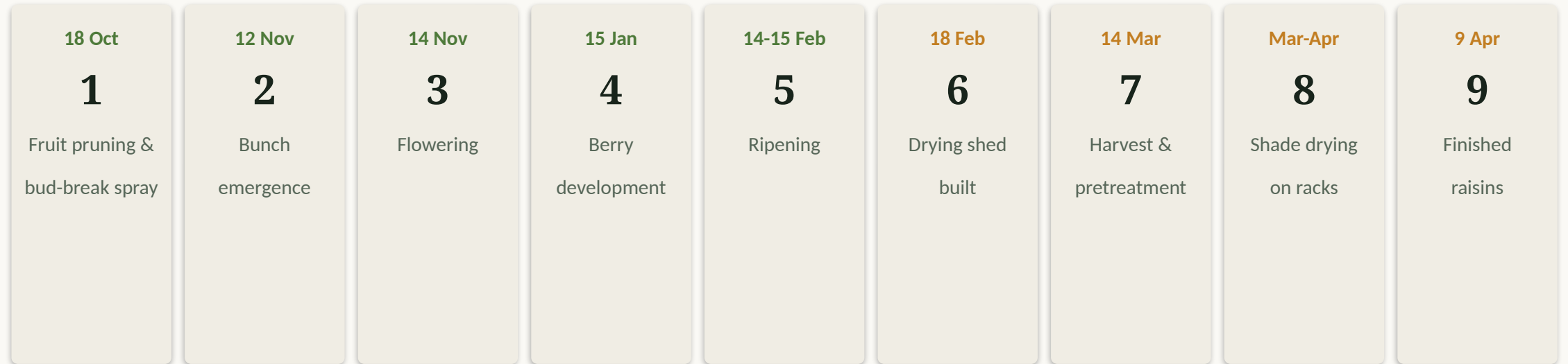
~4 : 1

kg of fresh grapes needed for 1 kg of raisins (typical)

173

days from the spray to finished golden raisins (9 Apr)

Nine stages, one season



Growth cycle: About 4 months from fruit pruning to ripe bunches, all completed within one dry winter season.

Raisin formation: About 4 weeks from vine harvest to finished, sorted, and packed raisins in the shade shed.

PART 1

The growth cycle

From a pruned, leafless vine to ripe, sugar-rich bunches in about 150 days.



A vineyard pruned twice a year

Overhead Trellis & Canopy Management

- Rows with drip lines and green inter-row cover hold soil moisture in the semi-arid Deccan plateau.
- Vines are trained overhead (bower system) to maximize solar interception while shading ripening bunches below.
- Two distinct pruning passes govern the annual cycle: foundation vegetative growth and fruit bud activation.

A April: foundation pruning

Canes are cut back hard after harvest. New vegetative canes grow vigorously through the summer monsoon to establish fruit buds for the coming season.

B October: fruit pruning

Mature canes are pruned back to fruitful node positions. This initiates the commercial fruiting cycle that culminates in the March harvest documented in this deck.

Fruit pruning and bud-break spray

- **Bare canes**

The vine has no leaves. Each cane is precision-cut to the fruitful buds that will carry this season's bunches.

- **Bud-break spray**

A growth regulator (hydrogen cyanamide) is applied immediately so all dormant buds sprout simultaneously and evenly.

- **Why it matters**

Even sprouting lines up subsequent flowering, berry sizing, and ripening so the entire block can be harvested together.

- **Ground cover**

Green ground cover and weeds between rows help hold soil moisture and buffer against intense solar heating.

Tech on the farm

01

Tractor GPS

Maps each pass and marks the farm block boundary across all 51 vineyard rows.

02

Tractor Camera

Mounted action camera records spray and tillage passes row by row to build baseline visual logs.

03

Fixed CCTV

Time-stamped cameras cover the vineyard rows and drying shed yard 24/7.

04

Dated Visual Log

Synchronized imagery, GPS coordinates, and CCTV feeds form the empirical ground-truth dataset for this study.

Bunch emergence

- **~25 Days Post-Spray**

Each new cane shoot carries one or two compact flower clusters (inflorescences) with curling tendrils.

- **Hundreds of Flower Buds**

Each emerging cluster holds hundreds of closed flower buds, which will pollinate and develop into individual berries.

- **Canopy Thinning Work**

Extra vegetative shoots are manually thinned so sunlight and air circulation reach the developing clusters.

Flowering and berry set

- **Full Bloom (~27 Days)**

Flower caps (calyptras) fall off and pollen is shed, approximately 27 days after the bud-break spray.

- **Berry Set**

Fertilised flowers swell into tiny green berries (2–3 mm), establishing the cluster's potential crop load.

- **Bunch Shaping & GA3**

Growers apply gibberellic acid (GA3) to elongate the cluster rachis and thin berries, ensuring loose bunches that dry evenly.

Berry development

- **Rapid Cell Division & Water Fill**

Berries swell rapidly—first by cell division, then by cells expanding and filling with water and tartaric acid.

- **Green & Firm Physiology**

Berries remain deep green, firm, and acidic with minimal soluble sugars during this vegetative sizing window.

- **Canopy Shade Protection**

Bunches hang under the overhead leaf canopy, preventing direct solar sunburn while drip lines maintain soil tension.

Ripening: sugar builds, acid falls

- **Veraison (Translucence)**

Berries soften and turn from opaque deep green to a translucent golden yellow-green.

- **Biochemical Transition**

Soluble sugars accumulate rapidly while titratable acids drop precipitously.

- **Harvest Trigger (°Brix)**

Harvest timing is governed strictly by sugar concentration, tracked via refractometer (°Brix) toward the 22–24° target.

PART 2

Raisin formation

From ripe grapes to golden raisins in about four weeks, by pretreatment and shade drying.



Building the drying shed

- **Steel Frame Construction:** Built directly adjacent to the vineyard, engineered to support multiple tiers of high-tension wire-mesh racks.
- **Green Shade-Netting:** Shade-net walls and roof block direct UV radiation while permitting free air circulation.
- **Why Shade Drying?:** Direct sunlight browns grapes into dark raisins. Shade drying preserves the lucrative golden-green hue that fetches top market prices.
- **Airflow Dynamics:** Continuous air movement through permeable net walls carries away the 70–80% moisture that berries release.
- **Construction Timing:** Erected ~4 weeks prior to harvest so the facility is cured and ready when grapes reach optimal Brix.

Harvest and pretreatment

STEP 01

Harvested at Full Sugar

Picked carefully by hand directly into plastic crates once Brix readings confirm target sweetness.

STEP 02

Chemical Emulsion Dip

Bunches are dipped in a potassium carbonate (K_2CO_3) and ethyl oleate emulsion (dipping oil).

STEP 03

Skin Wax Degradation

The alkaline dipping oil dissolves the natural hydrophobic waxy cuticular bloom, allowing internal moisture to escape 2–3× faster.

Checking sugar before drying

22–24 °Brix

Typical target sugar level for premium golden raisin grapes at harvest.

Refractometer Measurement Protocol

- **Optical Hand Refractometer:** A single drop of extracted grape juice placed on the prism refracts light to instantly display soluble sugar percentage.
- **Economic Recovery Multiplier:** Every additional degree of Brix substantially increases final dried raisin weight, improving the fresh-to-dried recovery ratio closer to ~4:1.

Shade drying on racks

12–15

days in the shade drying shed (typical duration)

~15%

final dried raisin moisture, down from ~80% in fresh grapes

Drying Rack Management

- **Thin Layer Loading:** Bunches are spread thinly across wire-mesh tiers so air circulates over every individual berry.
- **Manual Loosening:** Workers gently turn and loosen drying bunches periodically to prevent clumped moisture pockets.
- **Microclimate Monitoring:** Shed temperature and relative humidity determine drying rate and prevent mold formation during humid spells.

How a grape becomes a raisin

STEP 1

Skin opened

Dipping oil dissolves the hydrophobic waxy bloom, creating microscopic moisture evacuation pathways.

STEP 2

Water leaves

Warm, dry circulating shade air draws water vapor out. Berries shrink and develop characteristic wrinkles.

STEP 3

Sugar concentrates

Sugars remain trapped inside while water evaporates, concentrating to ~70% total sugar by dry weight.

STEP 4

Colour preserved

Shade canopy and alkaline dipping chemistry limit enzymatic browning, securing prized golden-green colour.

The finished product

1. Remove Stems

Dried bunches are mechanically rubbed or shaken over coarse mesh to cleanly detach individual berries from stalks.

2. Clean & Grade

Berries pass through pneumatic separators to remove dust, broken skin, and dark or undersized fruit.

3. Pack & Cold Store

Sorted golden raisins are sealed into airtight cartons and moved into cold storage to preserve colour until market dispatch.

Closing the loop: back to the soil

- **Organic Matter Return**

Post-harvest vineyard biomass, prunings, and composted manure are returned to the soil to rebuild organic carbon.

- **April Foundation Pruning**

A hard cut-back of canes in April restarts the annual cycle, growing vigorous fruiting canes for next season.

- **Permanent Infrastructure**

The multi-tier shade shed remains preserved on site, ready for immediate deployment next harvest.

- **Sensorized Next Season**

Planned deployment of camera carts, GPS tracking, and IoT sensors to link per-block soil treatment with final raisin recovery.

Season takeaways

1. ~150 Days

From October fruit pruning to a March harvest, with flowering starting ~4 weeks after pruning.

2. Even Start, Even Finish

A bud-break spray right after pruning lines up sprouting, bloom, and ripening across the entire block.

3. Sugar Decides Harvest

Pick strictly at full °Brix; higher initial sugar yields heavier, sweeter raisins and superior dried weight.

4. Shade + Dip = Golden

Alkaline pretreatment and shade-net drying turn fresh grapes into premium golden raisins in ~2 weeks.

PART 3

What tech can do

Options for our 4.5-acre Thompson Seedless farm on a ₹3 lakh budget. Everything here is an option; nothing is decided yet.



Our farm and goals

4.5

acres, Thompson Seedless

4,100

vines ($\approx 4.4 \text{ m}^2$ each)

51

rows, ~ 80 vines & $\sim 120\text{m}$

$\sim 6 \text{ km}$

per full camera pass ($\sim 1.5\text{h}$)

Already In Place

- Fyllo agricultural microclimate field station
- Kubota B2741S orchard tractor
- Tractor GPS speed and pass logging
- 4G outdoor CCTV perimeter cameras
- Mounted Action Camera
- Wi-Fi at drying shed (4G SIM backhaul)

Strategic Priorities

- P1. Grape Yield:** Bunch count per vine, berry sizing curves, row yield maps
- P2. Raisin Quality:** Brix at harvest, drying shed temperature/humidity, recovery
- P3. Protect Crop:** Early mildew alerts via Fyllo, yard theft alerts via CCTV
- P4. Optimize Inputs:** Variable-rate GA3, fertiliser, and water guided by row data

Ideas we reviewed: reality check

Idea	What the evidence says	Verdict
Fixed cameras: theft	Person detection on CCTV is mature, reliable and cheap.	Do now
Labour headcount	Easy at the gate; simple disclosure to workers required (DPDP Act).	Do now
Labour heat map	Needs worker tracking via active GPS tags or dense high-angle cameras.	Hold
Per-plant yield (camera + GPS)	Bunch detection ~13% error per vine; $R^2 \sim 0.81$ on bunch counts.	Best first project
Sugar per bunch (hyperspectral)	Living Optics R^2 0.71, ± 1.24 °Brix in lab; La Rioja R^2 0.92 at single site.	Research-grade
Robot cart scanning every grape	YouTube Short labelled 'AI'; research prototypes exist, none to buy.	Inspiration only

Where tech fits in the season

Stage	Decision	Measure	Low-cost option	Upgrade
Pruning (Oct)	Even spray, every row covered?	Tractor path	Tractor GPS + camera (have)	Sprayer flow log
Shoots, bloom (Nov)	Shoots to keep? Disease risk?	Shoot count, wetness	Fyllo alerts (have)	Multispectral vigour
Full bloom (Nov)	How much fertiliser?	Petiole nutrients	Petiole lab test	—
★ Berry sizing (Nov–Dec)	GA3 / girdle? Which blocks?	Berry diameter curve	Scale card + camera	Global-shutter rig
Berry growth (Dec–Jan)	Crop load, thinning, yield	Bunches per vine	Action-camera pod	Depth camera
Ripening (Feb)	Pick order by row?	°Brix trend	Refractometer, tagged vines	Handheld NIR meter
Harvest (Mar)	Pick date, labour, theft	Brix, crates per row	Crate log + CCTV	AI person alerts
Drying (Mar–Apr)	Turn, vent, done?	Temp, humidity, weight	Shed sensors	Colour camera

Berry-sizing window options

Option	Effect	Timing	Cost / Risk
GA3 sprays	Standard practice for bigger berries	Berry set, ~3–5 mm	Late sprays give less return
GA3 + CPPU	+5–20% berry size on Thompson Seedless	Same window	High dose can delay ripening ~3 weeks
Girdling	+10–30% berry weight, no chemical	From ~3 mm, done by 6–8 mm	Labour intensive; can kill cane if done badly
Thinning	Fewer berries, each bigger and sweeter	Early berry set	High manual labour requirement
Water	Stress now permanently limits berry size	Whole sizing phase	Fyllo soil tension sensors (have)
Fertiliser	Dose potash guided by petiole test (NHB)	Full bloom	Lab test cost < one wasted dose

Tech's job here: Measure berry diameter growth curves per block row-by-row, so growth regulator sprays and girdling are applied only to lagging blocks while still inside the narrow physiological sizing window.

How data flows: five layers

1. Capture

- Action-camera pod
- Fyllo station
- CCTV cameras
- Shed sensors
- Refractometer

2. Identify

- Row-end number boards
- Trunk counting
- Date + GPS stamps
- Canopy flank ID
- Unique vine tags

3. Store

- Season folders
- Phenology stage blocks
- One row per measurement
- Raw footage archive
- Sync manifest

4. Analyse

- Bunch count AI
- Berry diameter sizing
- Vigour (NDVI / green)
- Shed drying curve
- Security person alerts

5. Act

- Spray / irrigate by block
- Selective pick order
- Shed ventilation alerts
- Weekly grower report
- Post-season review

Layer 2 is the foundation: Without a verifiable vine ID on every image, photos are just disconnected photos. At 4,100 vines across 51 rows, simple row boards plus trunk counting do the job accurately without needing costly RTK GPS base stations.

Camera pod: two action cameras

Must-Have Specifications

- Auto-start on power: 100% no-touch operation
- Linear lens mode: zero fish-eye barrel distortion
- Fast locked shutter: $\geq 1/1500$ s to kill motion blur
- External 12V power tapped from tractor ignition
- Interval photos: 1–2 raw frames per second
- Integrated LED light bars to penetrate dense canopy shade

Camera at ~1.4 m	mm / px	3–7 mm berry	12–18 mm berry
Dashcam, 1080p wide	~4	1–2 px (No)	3–5 px (No)
Action cam, 4K linear	~0.7	4–10 px (Weak)	16–25 px (Yes)
Industrial narrow lens	~0.3–0.4	10–20 px (Yes)	30–50 px (Yes)

Operational Recommendation: For the early 3–7 mm GA3 sizing window, pair action camera passes with close-up smartphone photos of tagged clusters against scale cards, upgrading to industrial global-shutter pods in Year 2.

One pod, five platforms

Platform	Cost / pass	Operator	How often	Image quality	Main risk
P1 Tractor, spray passes	₹0	Farmer	Spray schedule	Mist, diesel shake	Dirty lenses
P2 Tractor, camera-only	₹500	Farmer	On request	No mist, low shake	Cost adds up
P3 Suzuki Access scooter	Fuel	You	Weekly	Less shake	Balance, bumps
P4 Push trolley	₹0	You / worker	On request	Best, steady frames	1.5–2 h walk
P5 Hybrid Mix	Varies	Both	Weekly in windows	Good	Keep consistent

Likely Strategy (P5): Scooter or light push cart every week during late Nov–Dec (berry sizing) and around veraison ripening; free opportunistic spray passes during the remainder of the season. Tractor mount clamps to front frame, powered via ignition 12V.

Data handling: two options

~60–130 GB per full vineyard pass (two cameras, photos or 4K video) — far too massive for rural 4G SIM upload.

D1 Weekly SD swap + laptop

- Hardware: 4 high-endurance SD cards, reader, 2–4 TB drive
- On farm: swap cards weekly (~5 min); farmer does nothing
- Software: Python ingestion script, row finder, vine counter
- Pros: cheapest, 100% reliable, full raw resolution preserved
- Cons: requires weekly physical visit; analysis delayed by days

D2 On-board computer, Wi-Fi sync

- Hardware: Jetson Orin Nano / RPi 5, global-shutter cams, SSD (~₹50k–1L)
- On farm: fully automated; uploads lightweight MB metrics via shed Wi-Fi
- Software: on-device inference, automated health checks, telemetry daemon
- Pros: fully no-touch, near-real-time row alerts
- Cons: higher initial cost, software complexity, field vibration risk

What multispectral can do

Capabilities & Limits

- Vine vigour & stress map: **YES**
- Weak patches, nutrient diffs: **YES**
- Stress before visible disease: **YES**
- Berry size & bunch count: **NO** (needs standard RGB)
- Sugar (Brix) / raisin quality: **NO** (needs hyperspectral)

M1 Survey3 on our cart pod (~₹50–70k)

Side view under canopy suits bower trellis; provides NDVI vigour matched directly to per-vine bunch counts.

Status: Fits budget

M2 Hired drone survey service (Quote per flight)

1–2 flights per season; inspects top of canopy only, cannot image bunches hanging underneath.

Status: Fits budget

M3 Own pro drone + RedEdge-P (₹11.5 lakh + drone)

Calibrated 5-band research payload; far beyond realistic 4.5-acre budget.

Status: Over budget

Macro + micro + ground truth

Macro: Fyllo Station

1 point, hourly

Tracks heat units (GDD), leaf wetness, relative humidity, soil moisture at 8"/16", rainfall, and light intensity.

Micro: Camera Cart

4,100 vines, weekly

Measures bunch counts per vine, berry sizing progression, canopy density (NDVI), and visual leaf symptoms.

Ground Truth: Manual

~20 tagged vines, key dates

Hand vernier caliper berry measurements, hand refractometer Brix curves, crates per row, and raisin recovery.

Macro predicts EXPECTED growth → Micro shows OBSERVED per vine → DEVIATION is what we act on

Where It Works: Heat units predict expected berry curve; farm-wide vs local slows distinguish irrigation deficits from vine pests; wet spells trigger targeted visual mildew inspection.

Limits: Single weather point cannot explain row-level soil variance; periodic hand sampling remains essential to calibrate cameras.

Raisin shed and security options

Raisin Shed Quality Instrumentation

- Temp + humidity (3 tiers) (ESP32 + SHT31):
Humid spells trigger mold & dark browning
- Sample rack weight (Load cell):
Continuously tracks drying curve and true recovery ratio
- Berry colour tracking (Time-lapse camera):
Quantifies golden vs brown colour progression
- Pretreatment log (Log sheet / photo):
Links field harvest Brix directly to final market grade

Security Architecture (No Fixed IP)

- S1 Solar 4G Cameras (AI on device):
Detect people at camera level; sends alerts via vendor app. Plugs perimeter border gaps cheaply.
- S2 Small Shed Computer:
Reads existing cameras locally via RTSP, runs person detector, dispatches push alerts over 4G.
- S3 Private Mesh VPN (Tailscale):
ZeroTier / Tailscale deployed on S2 to stream camera feeds remotely without static public IP.

Budget options within ₹3 lakh

Item	Cost Range	Need Tier
2 × 4K action cameras (locked shutter)	₹60–90k	Core
MAPIR Survey3 + calibration panel (M1)	₹50–70k	Option
Pod: clamps, dampers, sealed case, 2 LED bars, 12V	₹15–25k	Core
GPS logger, row boards, scale cards, tags	₹5–10k	Core
Shed: 3-tier sensors, load cell, time-lapse	₹15–25k	Core
CCTV gaps: 2 solar 4G AI cameras (S1)	₹25–40k	Option
SD cards + portable SSD (D1)	₹8–12k	Core
Weather, soil, disease (Fyllo station)	₹0	Have
Contingency or D2 on-board upgrade later	₹30–50k	Reserve

₹2.1–3 L

total project capital required, depending on optional modules selected.

₹25–65k

saved upfront because Fyllo IoT already covers weather, soil moisture, and microclimate.

This season, step by step



Go / No-Go Gate at Each Step: Did this intervention save money or improve quality compared with last season? This empirical discipline requires establishing last season's farm records as the definitive operational baseline.

Decisions and inputs still needed

1. Decide Strategy

- Platform mix: P1–P5 balance
- Data ingestion: D1 SD swap now, D2 on-board later?
- Multispectral: M1 Survey3, M2 drone, or standard RGB only
- Security: S1 cameras, S2 shed computer, or both

2. Request from Fyllo

- Full CSV historical sensor export
- REST API or automated webhook access
- Disease risk mathematical scores as raw data
- Service repair for air pressure sensor
- Exact GPS coordinate of soil moisture probe

3. Dig Out Farm Records

- Past spray & GA3 chemical application dates
- Fertiliser and input vendor purchase bills
- Labour muster days by operation
- Historical harvest crate counts by row
- Final dried raisin recovery weight, grade, and sale price

Appendix: source media used

Slide Reference	Media File(s)	Timestamp Date
Slide 2	IMG_0650.PNG (tractor GPS screenshot)	1 Nov 2025
Slide 5	VIDEO-2025-11-02-10-27-20.mp4	2 Nov 2025*
Slide 6	f35cd164-....MP4 (CCTV camera)	18 Oct 2025
Slide 7	IMG_0653 / 0654 / 0655.HEIC	2 Nov 2025
Slide 8	PHOTO-2025-11-12-07-40-08.jpg (×2)	12 Nov 2025
Slide 9	IMG_0694-0707.HEIC, 200C36AD / A85AAFF.F.JPG	14 Nov 2025
Slide 10	VIDEO-2026-01-15-13-48-46.mp4	15 Jan 2026*
Slide 11	VIDEO-2026-02-14-..., VIDEO-2026-02-15-....mp4	14–15 Feb 2026*
Slide 13	20260218102201.MP4 (CCTV camera)	18 Feb 2026
Slide 14–15, 17	VIDEO-2026-03-14-12-11-52 / 13-00-19.mp4	14 Mar 2026*
Slide 16	IMG_1316.MOV, IMG_1324.MOV	~Apr 2026 (inferred)
Slide 18	IMG_1313.HEIC	9 Apr 2026
Slide 19	20260408080701.MP4 (CCTV camera)	7 Apr 2026

** Date from WhatsApp filename timestamp (transmission date). Practices designated 'typical' represent regional horticultural standards.*

Appendix: Part 3 sources

Media Hardware References

- Slide 21, 22: Tractor photos (Kubota B2741S)
- Slide 23: AI-labelled Short screenshots
- Slide 25: PHOTO-2025-11-12-07-40-08.jpg
- Slide 27: IMG_0653.HEIC (tractor camera mount)
- Concept: Living Optics hyperspectral study
- Telemetry: Tractor & Fyllo app dashboards

Research Literature Sources

- Gutiérrez et al., on-the-go hyperspectral TSS, La Rioja (digibug.ugr.es/handle/10481/89025)
- Living Optics, Picking the Perfect Grape case study
- Santos et al., grape detection and tracking, WGSD (arXiv 1907.11819)
- YOLO bunch counting, Agronomy 2022; occlusion-robust detection, 2024
- Fairtrade Nashik weather app; Fyllo shared-unit model
- UC / NMSU / eXtension guides on GA3, CPPU, and cane girdling
- NHB (National Horticulture Board) grape nutrient guide (petiole testing)
- MAPIR Survey3 (seesense.eu); RedEdge-P India listing (xboom.in)
- WineOz SmartGrape berry-size app (Wine Australia)
- DPDP Act 2023 legal commentary (KS&K, EY)

Prices are rough budgetary ranges from public listings. Accuracy metrics originate from published scientific literature, not farm trials.

STUDY & RESEARCH COMPLETED

ArunPatil Labs

Applied AI, Systems ML & Viticulture Intelligence

Bengaluru & Sindagi Taluk, Vijayapura, Karnataka

Explore models, field protocols and datasets: arunpatillabs.com