Kula Bio®

# Strawberry Technical Training

Nitrogen-Fixing Biology for California & Florida Growers

# Overview


01 **Strawberry Root Architecture**
*How roots drive nitrogen uptake*

02 **Nitrogen Demand by Crop Stage**
*Establishment → Peak Production → Late Season*

03 **The Kula Bio Difference**
*Xanthobacter autotrophicus*

04 **Trial Results**
*California (Santa Maria) & Florida (Thonotosassa)*

05 **ROI & Commercial Summary**
*What this means for your growers*

# 01 | STRAWBERRY ROOT ARCHITECTURE

## Shallow, Dense Root Zone

80–90% of roots confined to top 6–12 inches of soil — critical zone for N uptake and biological activity.

## Fibrous Root System

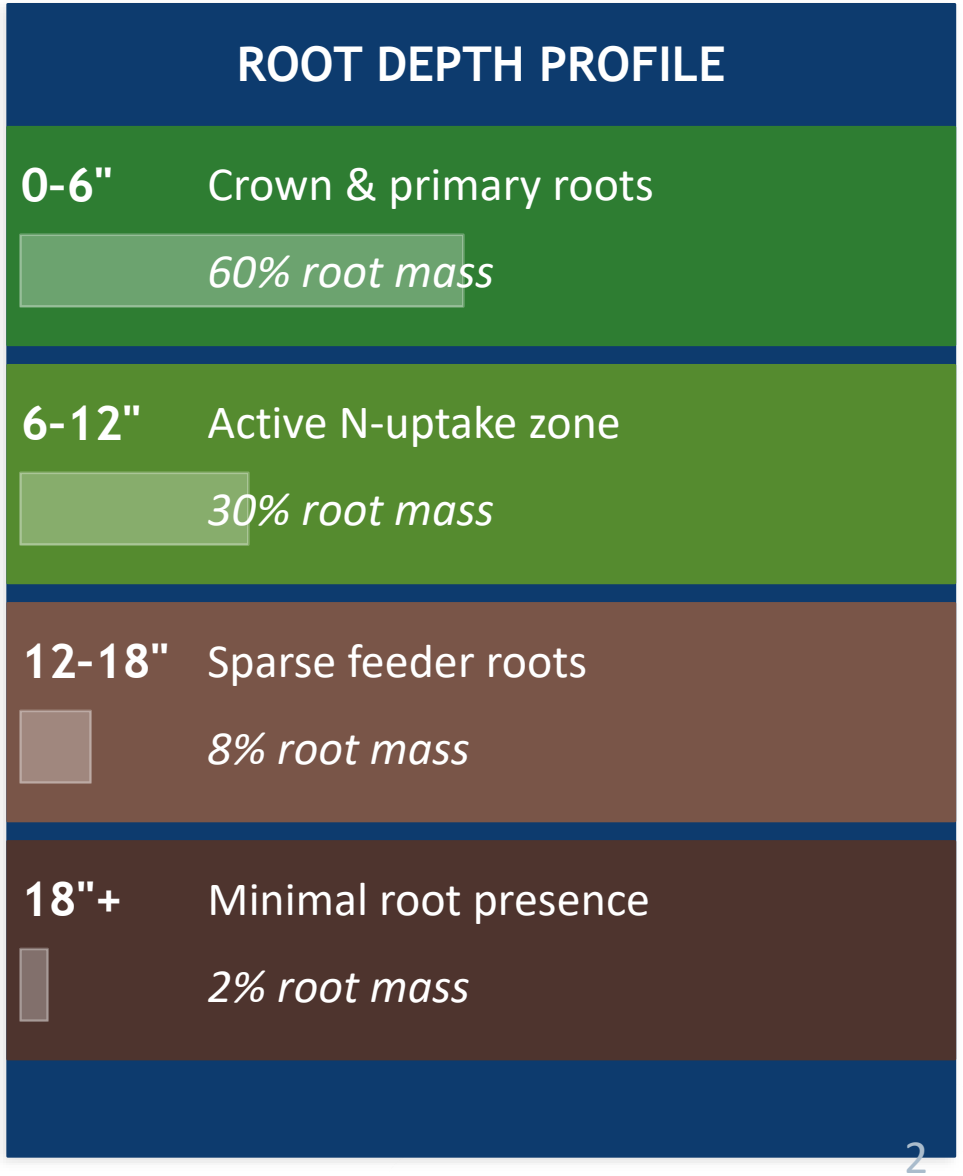
Lateral roots spread 8–12 inches from crown. Highly dependent on consistent moisture and fertility delivered directly to the root zone.

## Crown = Control Center

The crown drives both vegetative growth and fruit set. Root health directly determines canopy size and yield potential.

## Nitrogen Uptake Pathway

N absorbed primarily as $NO_3^-$ via roots. Biological N fixation at the root zone delivers N exactly where the plant needs it — without leaching.

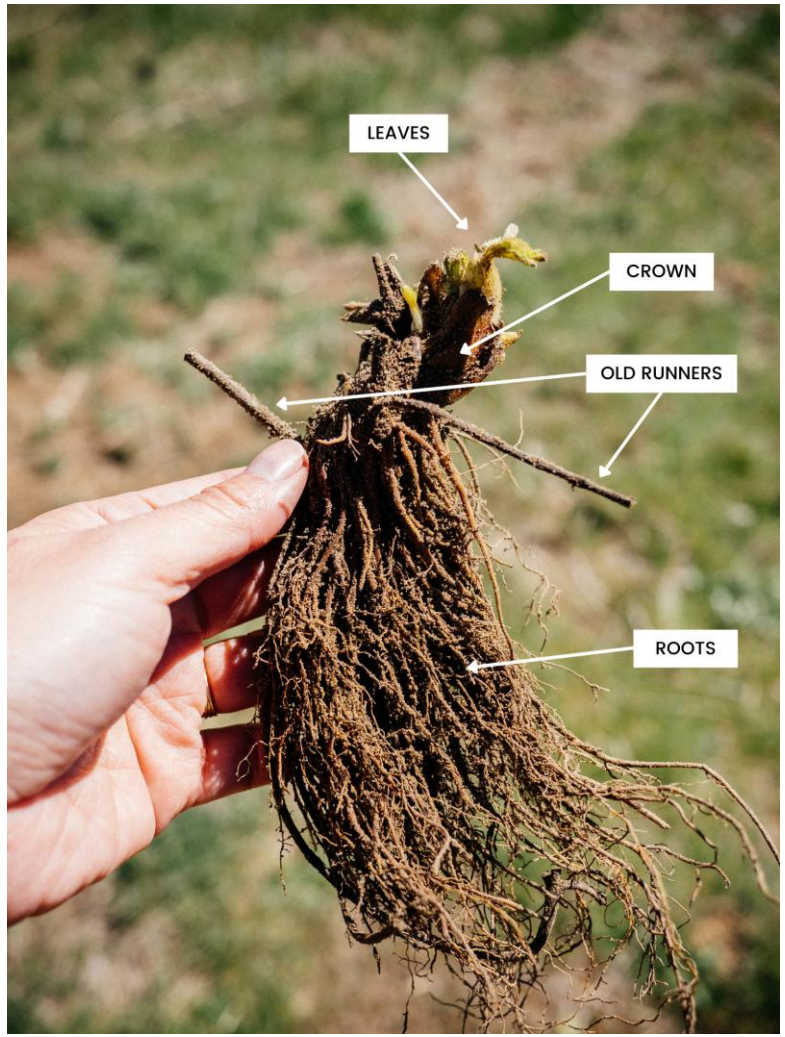





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Hancock, J.F. (1999). *Strawberries*. CAB International, Wallingford, UK. — root depth, crown structure, fibrous root system

# 01 | STRAWBERRY ROOT ARCHITECTURE

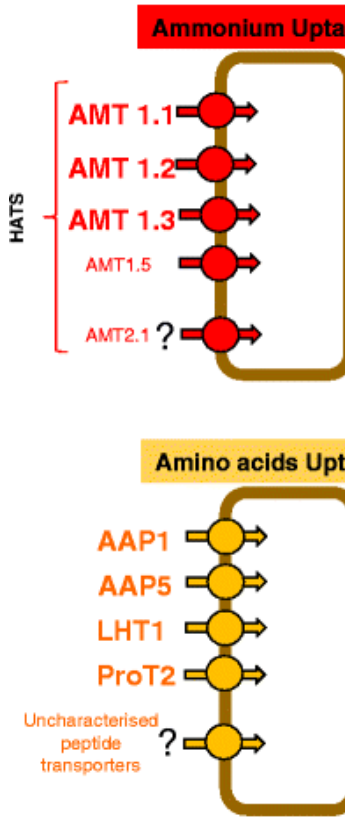



**N absorption in strawberry is concentrated in the fine root fraction**, specifically the root hair zone just behind the root tip.

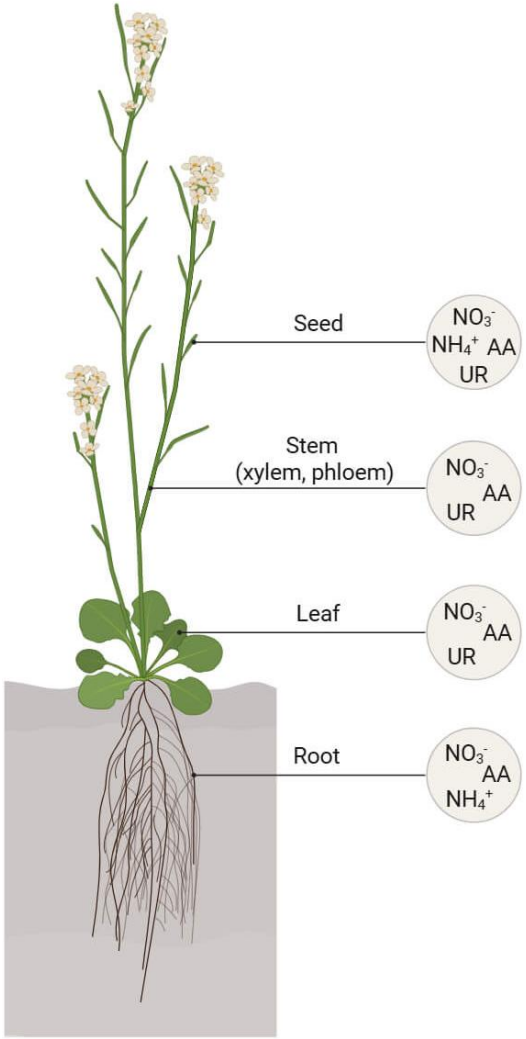
Biological N fixation at the root zone: **the N is fixed and released directly within this uptake zone**, with minimal transit distance and essentially no leaching loss.

| $NO_3$ | $NH_4$ |
|---|---|
| **75%** | **25%** |

# 01 | STRAWBERRY ROOT ARCHITECTURE

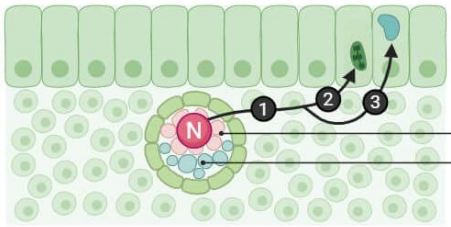



**Nitrogen Forms in *Arabidopsis* spp.**



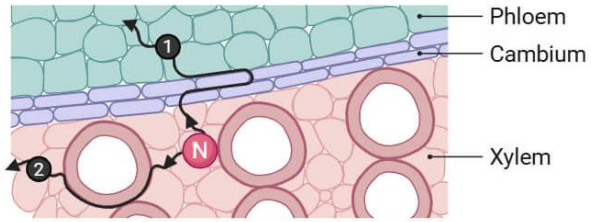

**Nitrogen leaf uptake and leaf-leaf allocation**

1. Xylem-leaf import (AMT, NPF, NRT)
2. Chloroplast uptake (DiT)
3. Vacuole uptake (CLC, AVT)



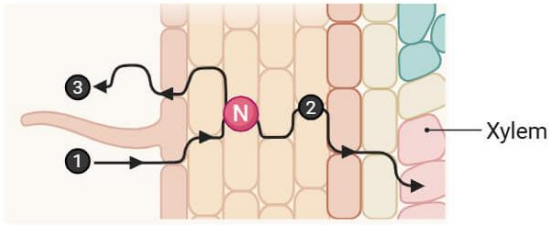

**Nitrogen xylem uptake and xylem-phloem allocation**

1. Xylem-phloem (NPF, NRT, AAP)
2. Deletion from xylem (NPF, NRT, AAP)




**Nitrogen root uptake and efflux**

1. Root uptake from soil (AMT, NRT, AAP)
2. Root-xylem transport (NPF, NRT, UPS)
3. Root efflux (NPF)




**Nitrogen (ammonium - $NH_4^+$, nitrate - $NO_3^-$, amino acids - AA, ureides - UR) transporter families in *Arabidopsis* spp.**: Nitrate Transporter1 (NRT1) family, Nitrate Excretion Transporter1(NAXT1) family, Nitrate Transporter1/Peptide Transporter Family (NPF), Ammonium Transporter (AMT), Amino Acid Vacuolar Transporter (AVT); Chloride Channel (CLC), Dicarboxylate Transporter (DiT), Ureide Permease.(UPS), Amino Acid Permease (AAP).

# 02 | NITROGEN DEMAND BY CROP STAGE

## ESTABLISHMENT

### 30-40 lbs N/ac

LOW DEMAND

KULA APPLICATION GUIDANCE

› No Kula application first 2 weeks

› Begin week 3–4 at 10 lbs N eq/ac weekly

› Focus: root development & canopy establishment

## EARLY PRODUCTION

### 40-70 lbs N/ac

RISING DEMAND

KULA APPLICATION GUIDANCE

› 5 lbs N eq/ac weekly or 10 lbs biweekly

› Demand rises with plant growth

› Begin full Kula program from week 5

## PEAK PRODUCTION

### 50-80 lbs N/ac

PEAK DEMAND

KULA APPLICATION GUIDANCE

› 5 lbs N eq/ac weekly or 10 lbs biweekly

› Highest fruit set, N critical for berry size

› Monitor foliar N: target 2.5–3.5%

## LATE SEASON

### 30-60 lbs N/ac

TAPERING

KULA APPLICATION GUIDANCE

› 5 lbs N eq/ac biweekly

› Wind down program with crop

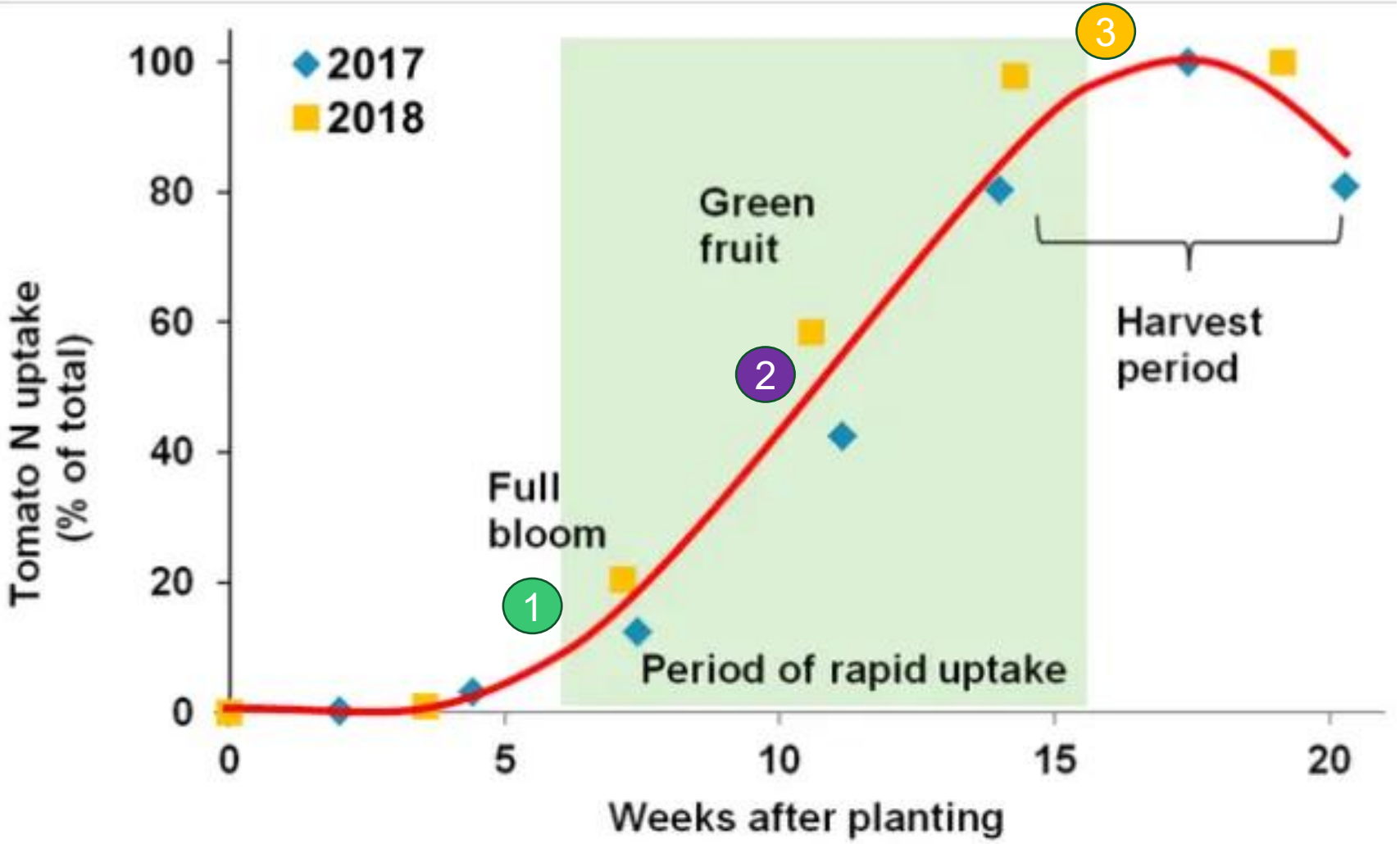
› Maintain quality through final harvests



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Hochmuth, G. & Albregts, E. (1994). Fertilization of strawberries in Florida. *University of Florida IFAS Extension Circular* 1141. — N rate recommendations by stage, FL context
Koike, S.T., Bolda, M., & Daugovish, O. (2013). *Strawberry Production in California*. UC ANR Publication 3473. — N demand by growth stage, CA-specific recommendations

# 02 | NITROGEN DEMAND BY CROP STAGE




**1** Demand rises with plant growth

**2** Highest fruit set, N critical for berry size

**3** Wind down program with crop

# 03 | THE KULA BIO DIFFERENCE

## The Carbon Advantage

Xanthobacter autotrophicus stores an internal carbon reserve (polyhydroxybutyrate, PHB) that fuels nitrogen fixation independently of plant-supplied sugars. Unlike competitors that rely on photosynthate from the crop, our organism fixes N from day one, even in low-sugar environments, stressed plants, or post-application windows when carbon supply is limited.

### Carbon Independence

Nitrogen fixation does not require rhizosphere carbon from host roots. Works across soil types and conditions, from sandy loam to clay.

### Instant Activity

N fixation begins from day of soil application. No colonization lag period. Starts fixing N immediately.

### Reduced N Losses

N is fixed in situ and delivered where root demand exists, minimizing volatilization (no surface $NH_3$) and leaching (no excess $NO_3$ pool).

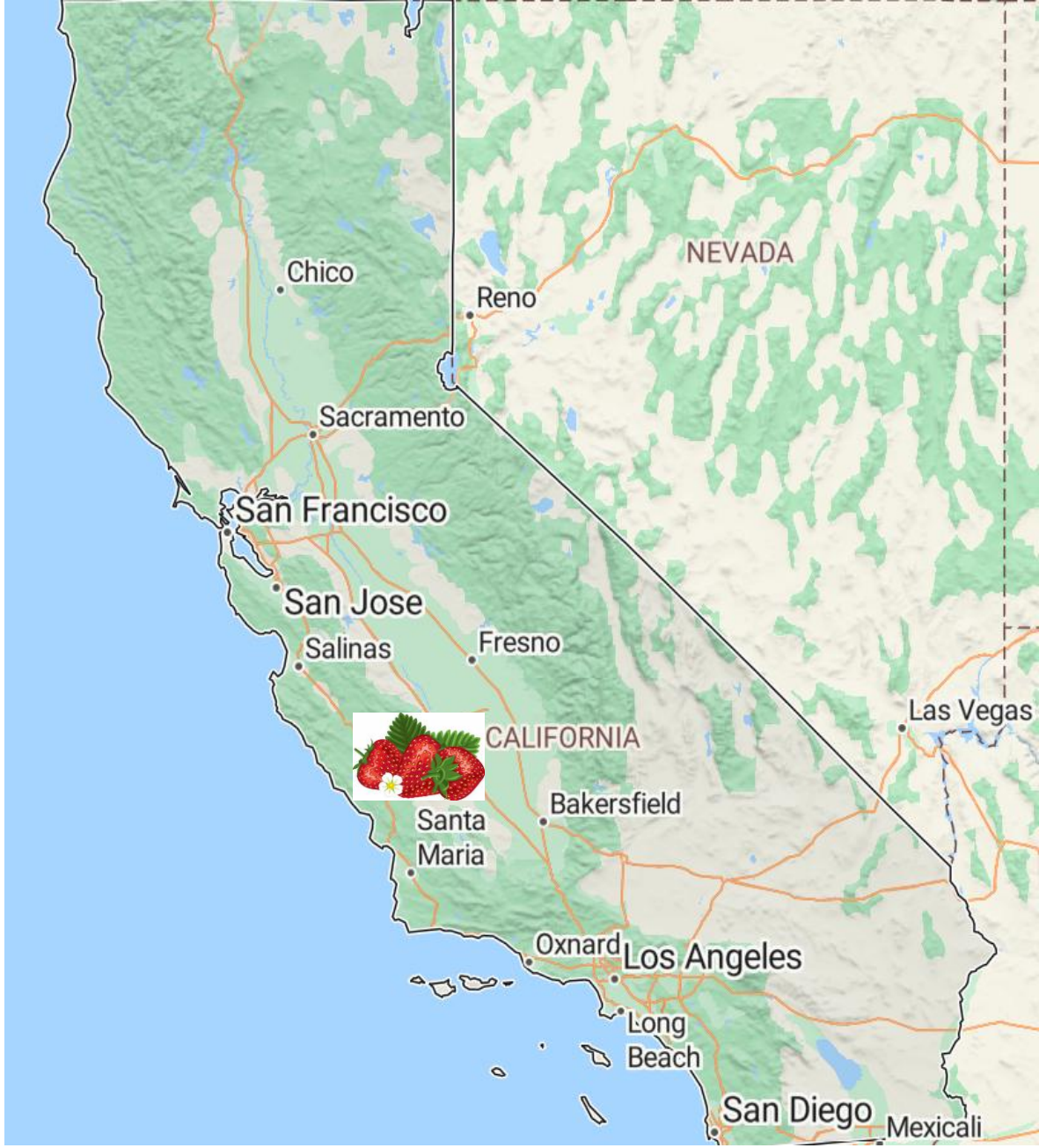


*Severin et al. (2010) FEMS Microbiol. Lett. 306:79–84.* | [2] *Dixon & Kahn (2004) Nature Rev. Microbiol. 2:621–631.*

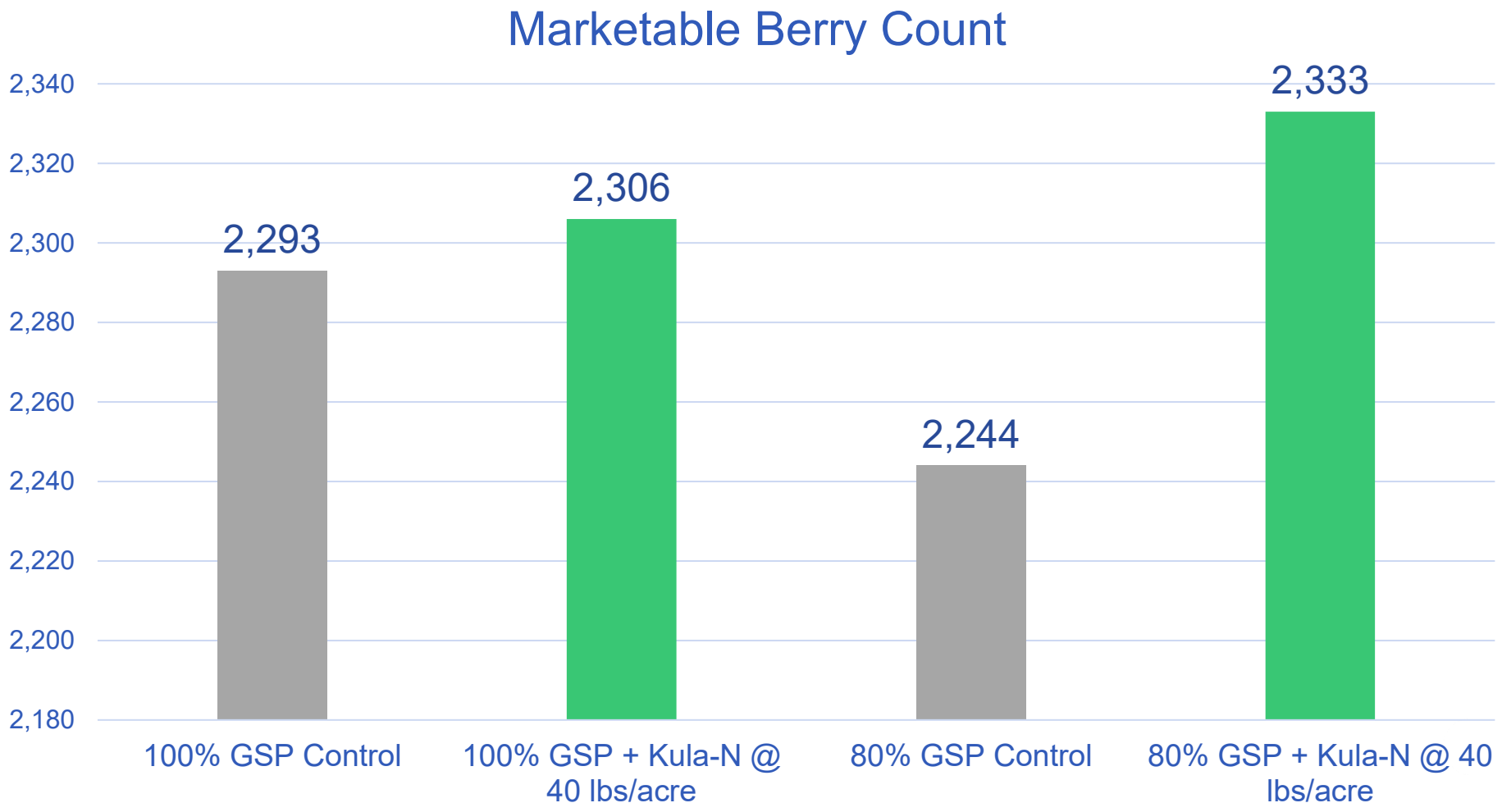
# 04 TRIAL RESULTS

Santa Maria, CA · Product: Kula-N (organic) · Design: Boost (100% GSP) & Replacement (80% GSP) · Year: 2023–2024





# 04 TRIAL RESULTS

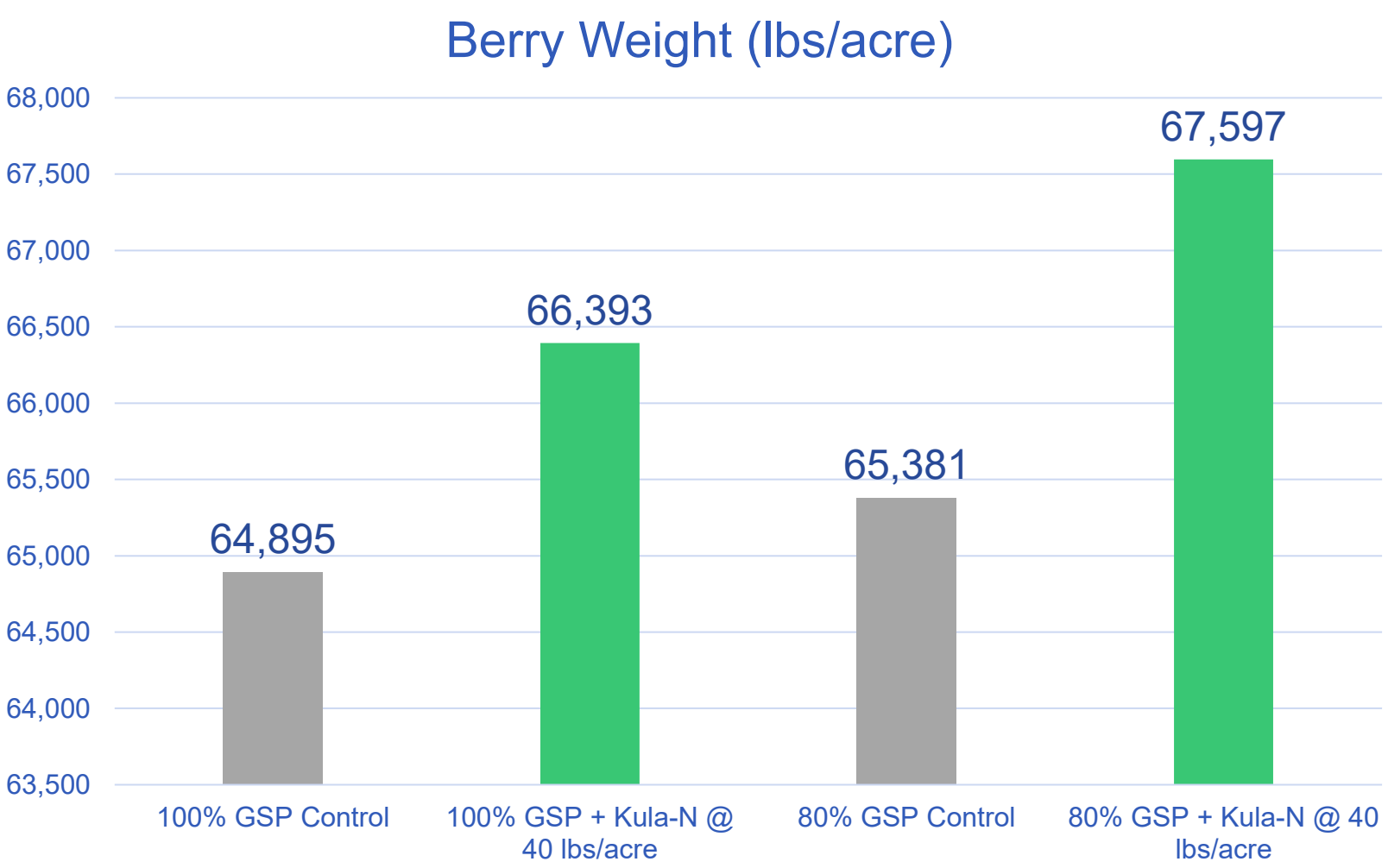



**24 applications per season**

**First application at a rate of 3 lbs N eq/ac**

**Rest of application at a rate of 1.5 lbs N eq/ac**

# 04 TRIAL RESULTS




**+ 1,498 lbs/acre as boost program**

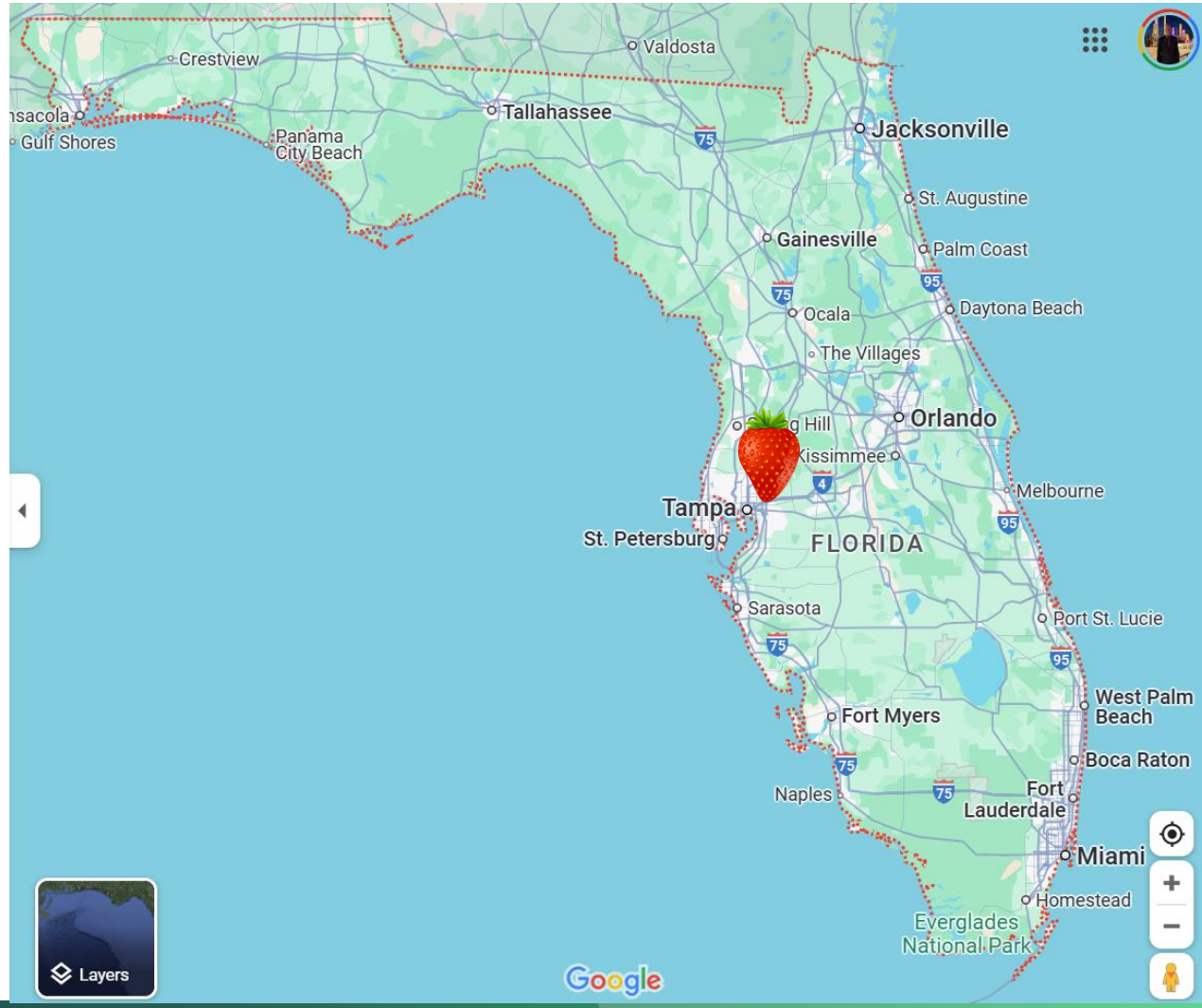
**+ 2,216 lbs/acre as a replacement**

**20% Reduction in organic N**

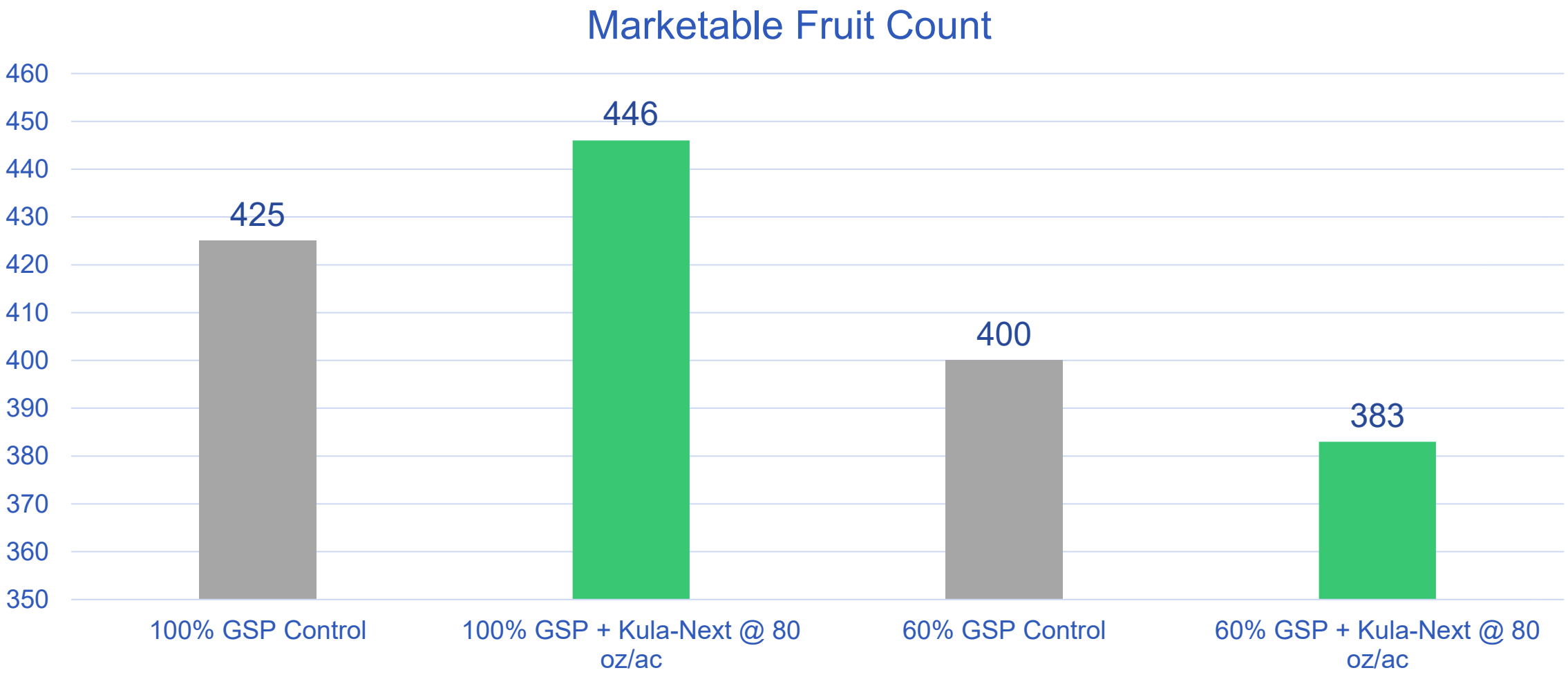
# 04 TRIAL RESULTS

Thonotosassa, FL · Product: Kula-Next ~5 lbs/week (conventional) · Design: Boost (100% GSP) & Replacement (60% GSP) · Year: 2024–2025

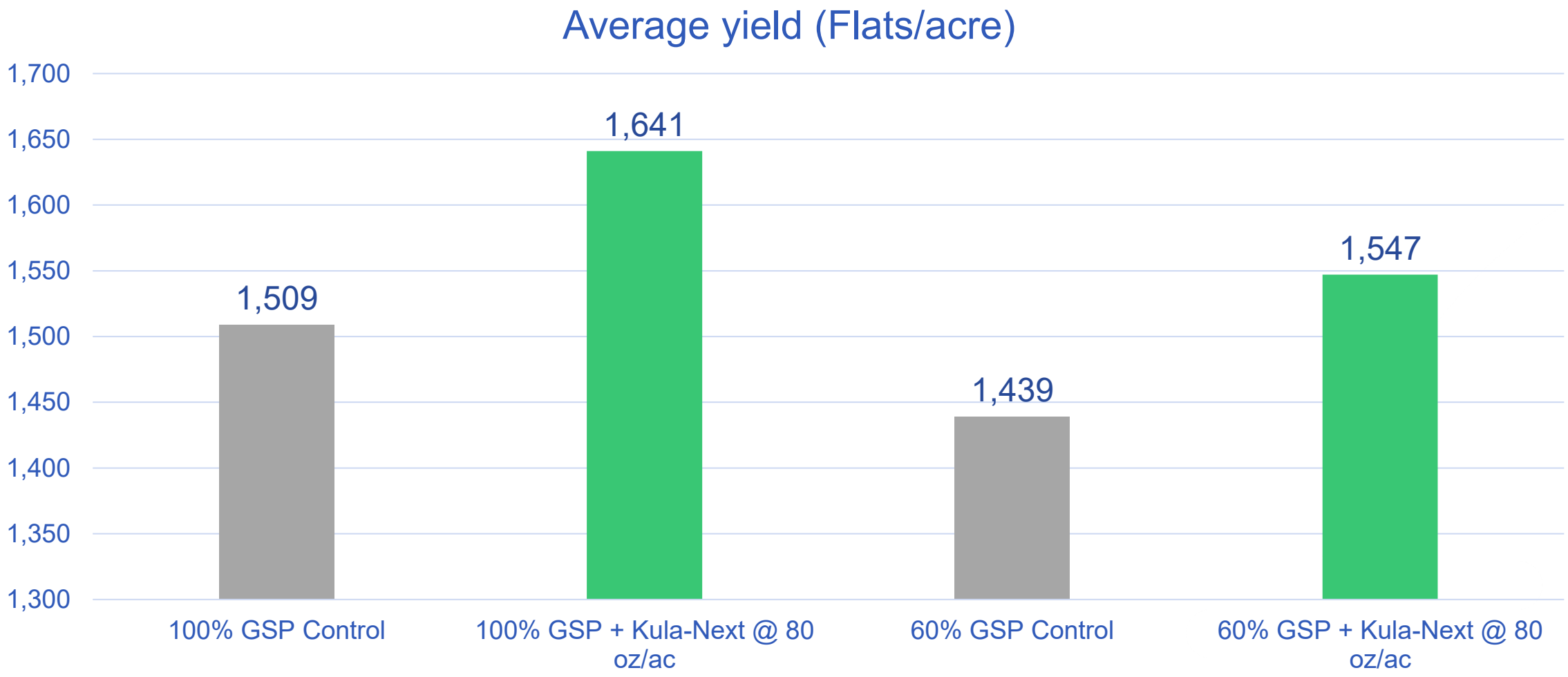




# 04 TRIAL RESULTS



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# 04 TRIAL RESULTS



Pictures from left to right show 60% GSP Control, 60% GSP + Kula-Next at 320 ounces per acre, and 100% grower standard practice nitrogen control.

# 04 TRIAL RESULTS

## MARKETABLE FRUIT WEIGHT

**BOOST (100% GSP)**

**+8.6%**

28.9 lbs vs 26.6 lbs

**REPLACE (60% GSP)**

**+2.6%**

at 80 oz/ ac

## MARKETABLE FRUIT COUNT

**BOOST (100% GSP)**

**+4.9%**

446 vs 425

**REPLACE (60% GSP)**

**+0.5%***

at 80 oz/ac

## FLATS PER ACRE

**BOOST (100% GSP)**

**+8.7%**

1,641 vs 1,509

**REPLACE (60% GSP)**

**+2.6%**

at 80 oz/ac

## RETURN ON INVESTMENT

**BOOST (100% GSP)**

**+$2,770/ac**

$34,431 vs $31,662

**REPLACE (60% GSP)**

**+$809/ac**

at 80 oz/ac

# 05 | ROI & COMMERCIAL SUMMARY

**$2,770/ac**
ROI increase Kula-Next boost
(FL 2025)

**+8.7%**
Flats/acre increase
(FL boost, 100% GSP)

**40%**
N reduction possible
with maintained yield

**+4.0%**
Berry count uplift
(CA 80% GSP + 40 lbs)

## CALIFORNIA PROGRAM SUMMARY

› Product: Kula-N (organic, OMRI listed)

› Timing: Begin weeks 3–4 | Drip irrigation

› Rate: 40 lbs of N eq/acre

› Key Data: +4.0% berry count / +3.4% berry weight at 80% GSP

› Pitch: Supplement organic N with reliable biological fixation

› No external sugars needed · works in organic programs

## FLORIDA PROGRAM SUMMARY

› Product: Kula-Next (conventional soluble powder)

› Timing: Begin weeks 3–4 | Drip irrigation

› Boost Rate: 80 oz/acre (100% GSP)

› Replace Rate: 80 oz/ac at 60% GSP fertility

› Key Data: +$2,770/ac ROI | +8.7% flats/acre (boost)

› Replace 40% N and still outyield 100% GSP control