

Yellowhorn

(Xanthoceras sorbifolium)

A New Drought Hardy Nut Crop for New Mexico



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- *Xanthoceras sorbifolium*, 'Yellowhorn' is a very **drought tolerant tree**. It can survive on 6" of water; but may need around 12" – 14" of water for good production. Important in the ongoing New Mexico drought.
- **Seeds/nuts** can be used to produce protein (26.2% - 35%) after oil extraction. **Leaves contain** 18% - 23% protein, plus polyphenols used as a natural tea drink.
- **Oil is rich in 'Mono' and 'Poly' unsaturated fats**, which makes them good for heart health... **'Heart Healthy'** ♥ ♥ ♥
- **The oil is rich in NERVONIC ACID (2.6%~5%)**, important in cognitive function and neurological disorders like Alzheimer's, Parkinsons, Demetia, etc. 'Brain Health'

White Flowered Yellowhorn Tree



- The fruit husk extract can inhibit the cells of ovarian cancer, cervical cancer, prostate cancer and Melanoma.
- The “press cake” after oil extraction is rich in protein (25~35%), and "can be used as high-protein food for human consumption, animal feed, or as an extracted hydrolyzed protein and amino acid.



Yellowhorn Flowers



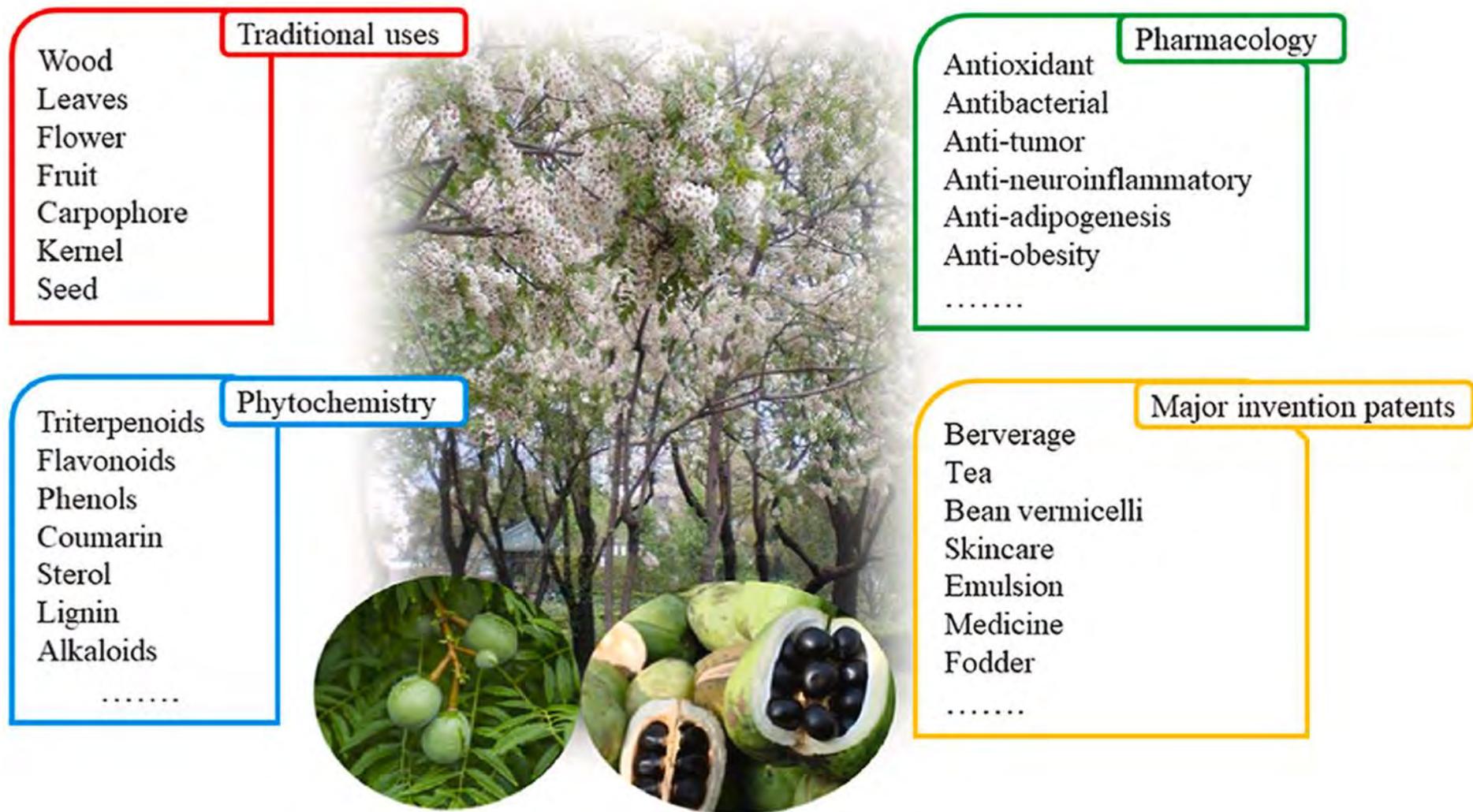
Yellowhorn Leaves



Yellowhorn Husk/Capsule with Seeds



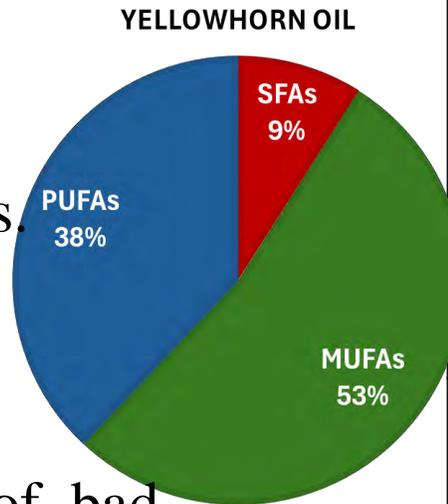
Yellowhorn Seeds/Nuts



Xanthoceras sorbifolium Bunge (*X. sorbifolia*)

Yellowhorn Oil Compared to Other Healthy Oils

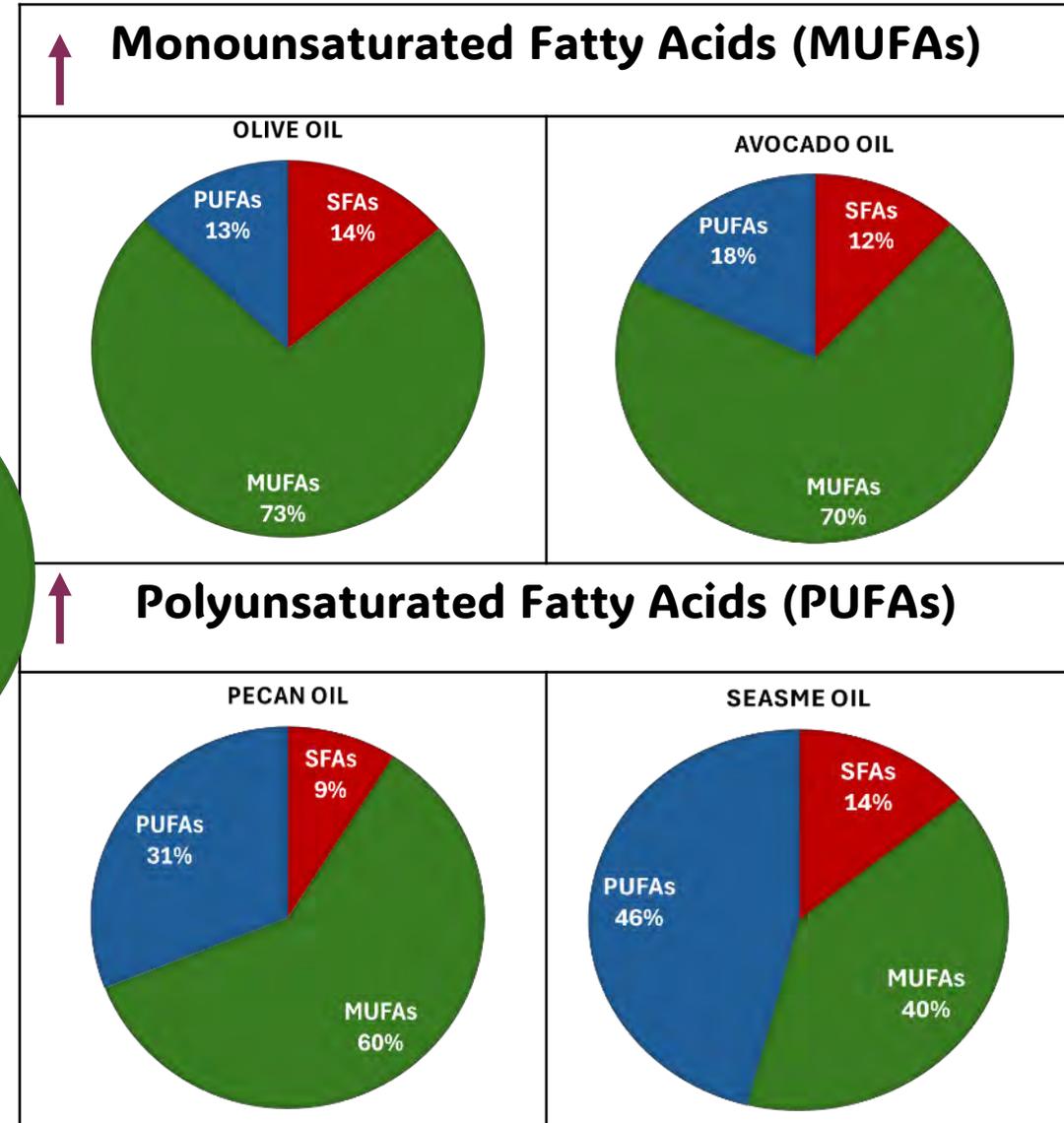
- High monounsaturated fats (MUFAs) similar to sesame oil.
- Higher polyunsaturated fat (PUFAs) composition than most other oils.
- Balanced mix of MUFAs and PUFAs.



Health Benefits

Cardiovascular Benefits: Reduction of bad cholesterol (similar to Avocado and Olive oils).

Anti-inflammatory Properties: Supporting immune function (similar to Pecan and Sesame oils).



- Both monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) are important,
- But polyunsaturated fatty acids are **generally considered more critical nutritionally** because some of them are **essential for your health...**
- Because your body cannot make them, (PUFAs).

Polyunsaturated Fatty Acids (PUFAs)

These are usually considered **more important to ensure they get into your diet.**

Examples include:

- **Omega-3 fatty acids**
- **Omega-6 fatty acids**

Key examples:

- **Alpha-linolenic acid (ALA)**
- **Linoleic acid**

Why they matter:

- Essential for **brain and nerve development**
- Important for **cell membranes**
- Produce **signaling molecules (eicosanoids)**
- Linked to **heart health and inflammation regulation**

Because the body **cannot synthesize ALA or linoleic acid**, they must come from food.

Monounsaturated Fatty Acids (MUFAs)

These are **very healthy but not essential**, because the body can produce them.

A major example is:

- **Oleic acid**

Benefits:

- Improve **cholesterol balance**
- Support **heart health**
- Often more **stable for cooking** than PUFAs

Common sources:

- olive oil
- avocado
- almonds
- pecans

Simple Takeaway:

<u>Type</u>	<u>Nutritional priority</u>	<u>Reason</u>
Polyunsaturated	Higher priority	Contains essential fatty acids
Monounsaturated	Important but secondary	Body can synthesize them

Yellowhorn oil is interesting because it contains a **balanced mixture of monounsaturated and polyunsaturated fatty acids**, plus one unusual fatty acid (Nervonic Acid) that is rarely found in most edible oils.

Typical Fatty Acid Profile of Yellowhorn Oil

<u>Fatty Acid</u>	<u>Type</u>	<u>Approximate %</u>
Oleic acid	Monounsaturated	~25–40%
Linoleic acid	Polyunsaturated	~35–45%
Alpha-linolenic acid	Polyunsaturated	~2–5%
Nervonic acid	Monounsaturated	~2–5%
Saturated fats (palmitic, stearic)	Saturated	~6–10%

Comparison to Other Oils

<u>Oil</u>	<u>MUFA</u>	<u>PUFA</u>	<u>Special Feature</u>
Yellowhorn	~30–40%	~40–50%	Contains nervonic acid
Olive oil	~70–75%	~10%	Very stable
Flaxseed oil	~20%	~70%	Extremely high omega-3
Pecan oil	~60–70%	~20–30%	High oleic

Practical Interpretation

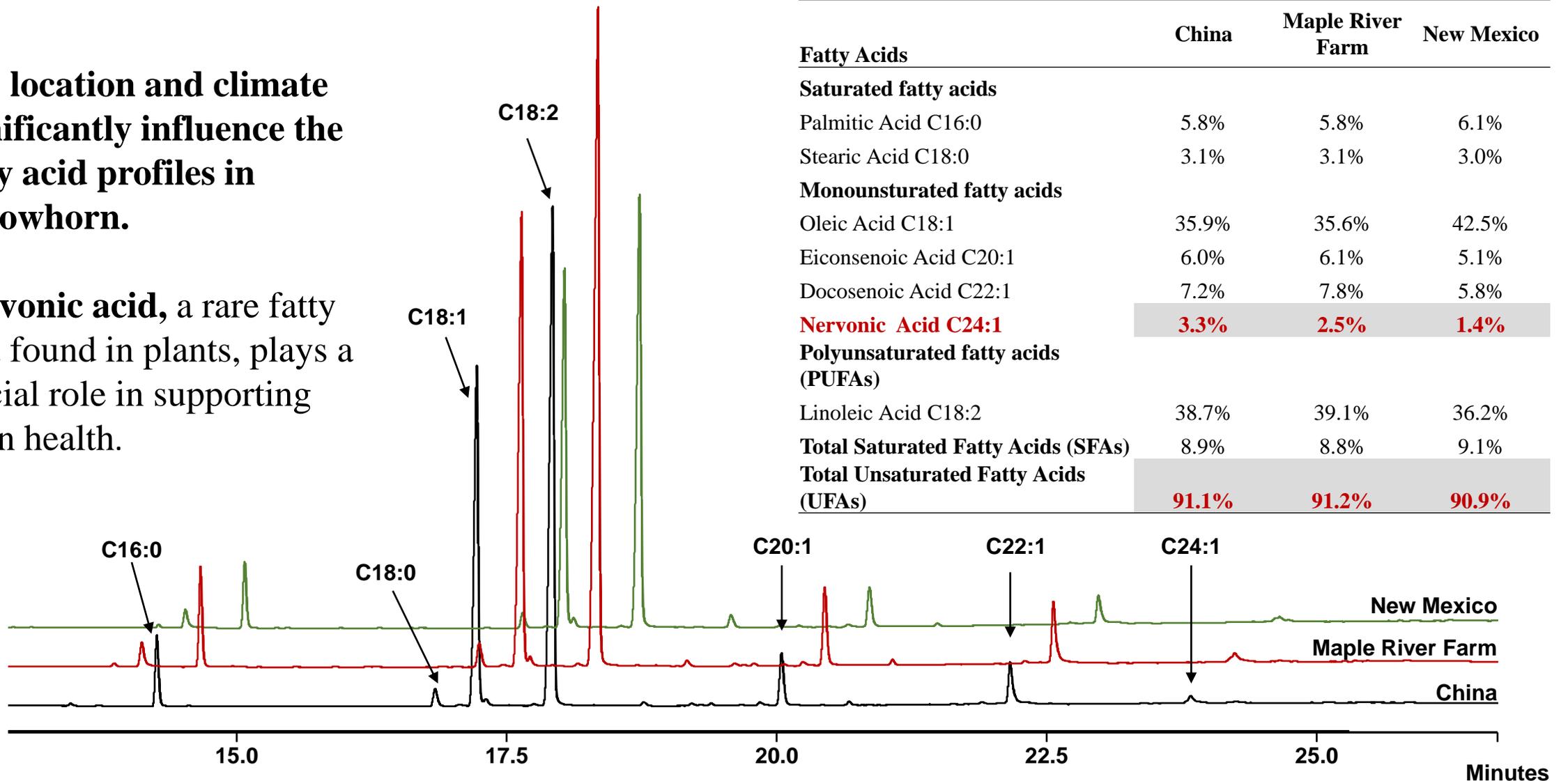
From a **nutrition and specialty oil perspective**, Yellowhorn oil is valuable because it combines:

- **Essential fatty acids (linoleic and some omega-3)**
- **Heart-healthy oleic acid**
- **Rare nervonic acid for neurological interest**

This combination is why it's being studied as a **high-value specialty oil** rather than a **bulk commodity oil**.

Yellowhorn Major Fatty Acid Profile

- The location and climate significantly influence the fatty acid profiles in Yellowhorn.
- Nervonic acid, a rare fatty acid found in plants, plays a crucial role in supporting brain health.



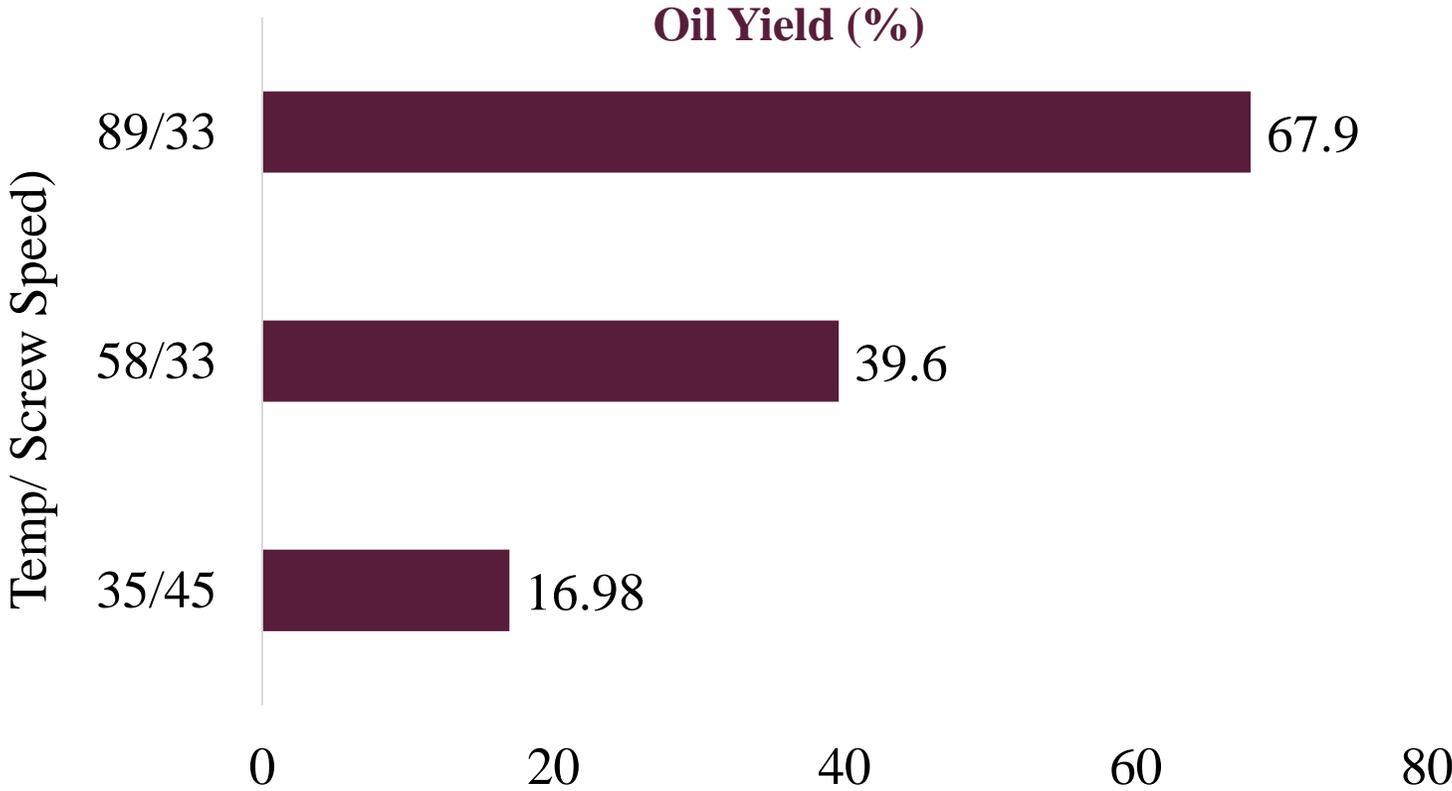
Relative Abundance of Yellowhorn Oil Predominant Fatty Acids

Fatty Acids	China	Maple River Farm	New Mexico
Saturated fatty acids			
Palmitic Acid C16:0	5.8%	5.8%	6.1%
Stearic Acid C18:0	3.1%	3.1%	3.0%
Monounsaturated fatty acids			
Oleic Acid C18:1	35.9%	35.6%	42.5%
Eicosenoic Acid C20:1	6.0%	6.1%	5.1%
Docosenoic Acid C22:1	7.2%	7.8%	5.8%
Nervonic Acid C24:1	3.3%	2.5%	1.4%
Polyunsaturated fatty acids (PUFAs)			
Linoleic Acid C18:2	38.7%	39.1%	36.2%
Total Saturated Fatty Acids (SFAs)	8.9%	8.8%	9.1%
Total Unsaturated Fatty Acids (UFAs)	91.1%	91.2%	90.9%

Standardization of Yellowhorn Oil Extraction



- Oil Pressing Temperature: 35-89 °C (35-192.2 °F)
- Screw Speed: 20-50 RPM



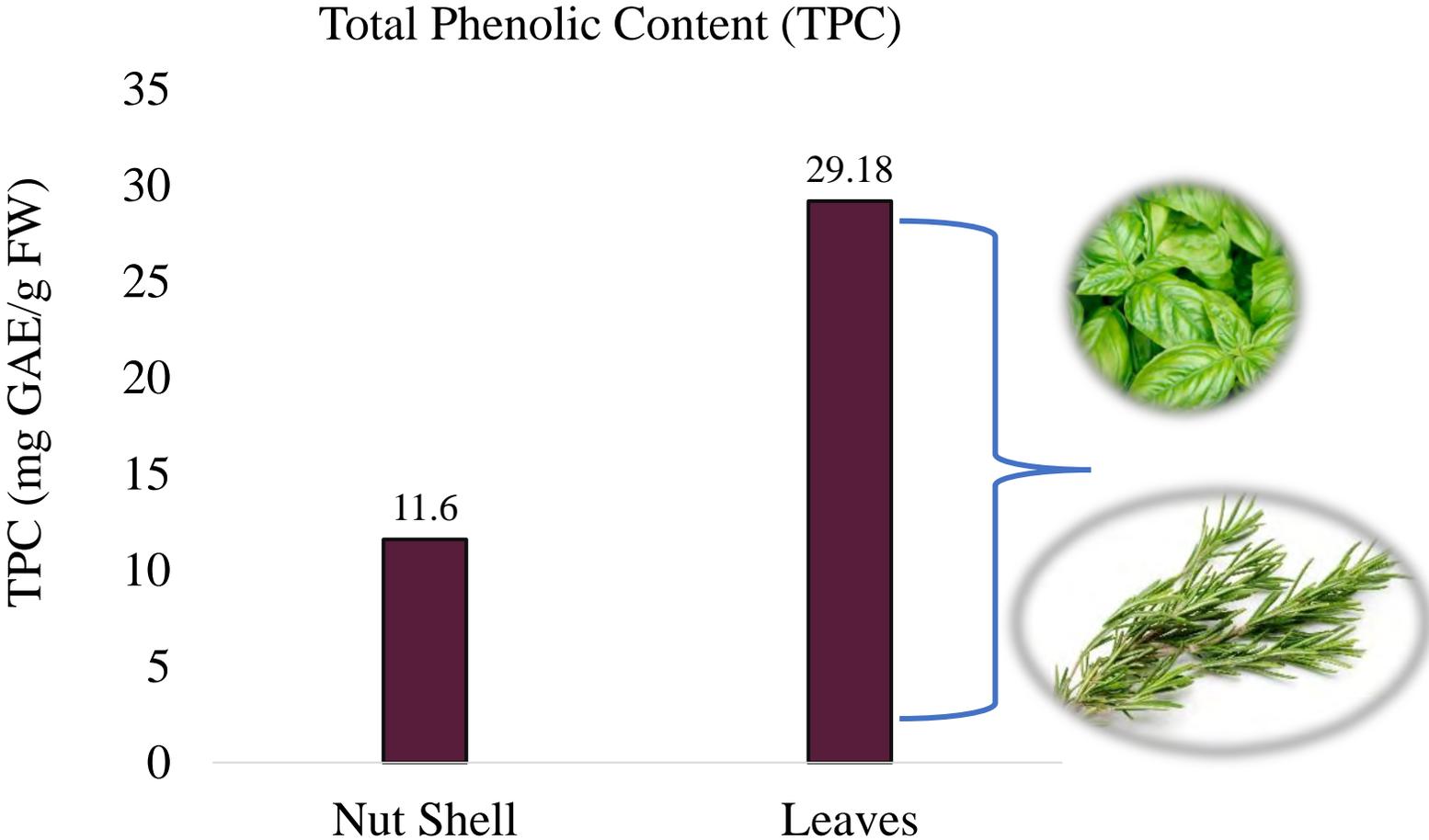
Research in Progress...



Graduate Student Working on Mechanical Screw Press

Characterization of Yellowhorn By-Products

Phenolic Content



Research in Progress...



Characterization of Yellowhorn By-Products

Valorization Pathway

Key Values

Shell



Biochar

Pellet Fuel

Bio-oil

C: 53.6%, Lignin: 42.9%, C:N: 116.4

Fiber: 28.6%, ADF: 68.5%, Ash: 1.93%

Fat: 1.50%, NFC: 19.2%, Sol. Protein: 17%
of CP

Valorization means the act of giving value to something or increasing its value.

Research in Progress...

Photos provided by: Jeff Ju, China

photos taken in China of Yellowhorn cultivation

yellowhorn.providence@gmail.com



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and taken in China of Yellowhorn cultivation

yellowhorn.providence@gmail.com



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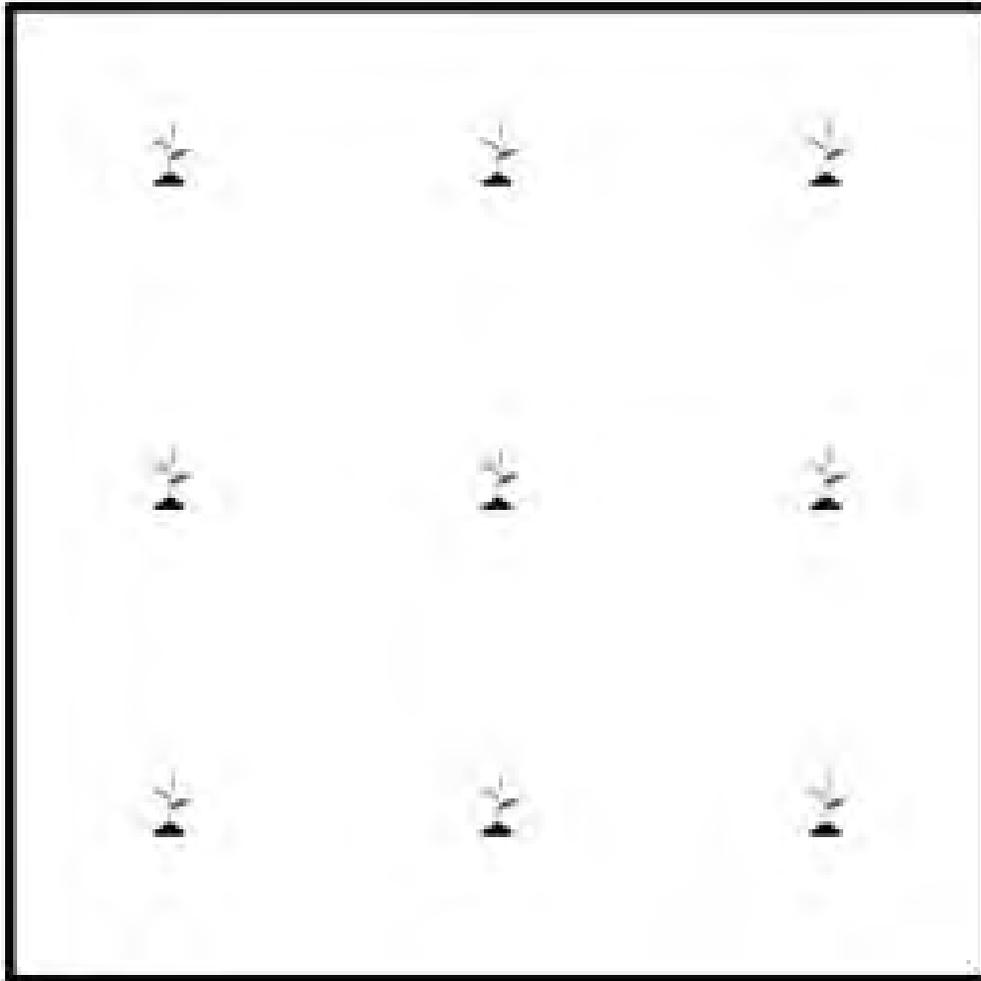
Photos provided by: Greg Schoen, Silver City, NM of Yellowhorn seedling production in PVC pipes



Photos provided by: Jeff Anderson, NMSU, floral scape, and 8-month-old germinated seed in field 2025



Maple River Farms, Owosso, MI
Don Honcoop at:
don@mapleriverfarms.com



208.71'

Yellowhorn Tree Spacing

- $208.71' \times 208.71' \sim 43,560'$
- 12' x 15' Tree Spacing
- 180 sq. ft.
- $43,560\text{sqft}/180\text{sqft} = \text{Trees/Row}$
- **242 Trees/acre**

208.71'

Yellowhorn Layout for New Mexico



**~242 Trees
per Acre**



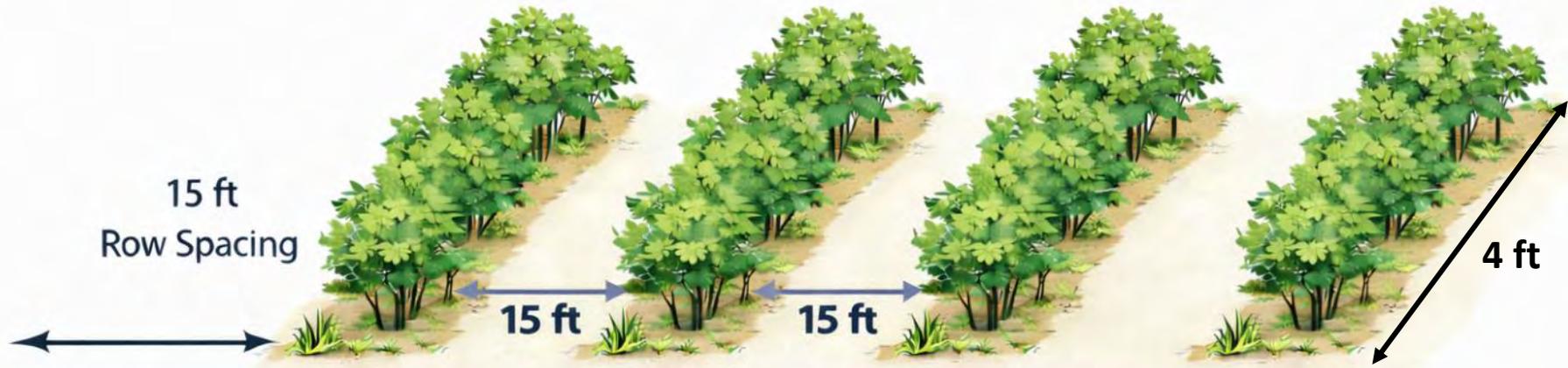
**~665 lbs of Oil
per Acre
(early yield)**

0.33 gallons per tree



**1~2 Acre-Feet
Water Use**

Yellowhorn Hedgerow Layout for New Mexico



**~726 Trees
per Acre**



**~2,000 lbs of Oil
per Acre
(early yield)**



**1~2 Acre-Feet
Water Use**

Perfect! Let's make a **realistic oil yield projection for a newly planted Yellowhorn hedgerow (726 trees/acre, 4 ft in-row × 15 ft between rows)**, reflecting conservative yields for young trees:

Year	Oil per Tree (lb)	Total Oil per Acre (lb)	Oil per Acre (oz)	Revenue per Acre (\$8.50/oz)	Notes
1	0.0	0	0	\$0	Newly planted seedlings
2	0.2	145	2,320	~\$19,700	Very young trees, tiny harvest
3	0.5	363	5,808	~\$49,400	Early flowering begins
4–5	1.5	1,089	17,424	~\$148,000	Early production, hedgerows begin yielding significantly
6–7	3–4	2,178–2,904	34,848–46,464	~\$296,000–\$395,000	Trees maturing, increasing yield
8+	6–8	4,356–5,808	69,696–92,928	~\$592,400–\$789,900	Full maturity, peak harvest

Key Points

1. Early years (1–3) **produce very little oil**, so growers should plan cash flow accordingly.
2. Yield accelerates from **Year 4–5 onward**, reaching moderate oil volumes.
3. Full potential (~5,000 lb oil per acre) occurs by **Year 8+** with proper management.
4. This table is **more conservative and realistic** than assuming 2.75 lb/tree from the start.

The market for **Yellowhorn oil** is best understood as a **specialty oil market**, not a bulk commodity oil like soybean or canola.

Its value comes from **nutraceutical, cosmetic, and specialty chemical uses**, especially because of compounds like **Nervonic acid**.

Nutraceutical / Brain Health Market (Highest Value)

This is probably the **most important future market.**

Why: Yellowhorn oil contains nervonic acid, which is being studied for **brain and nerve health.**

Typical uses:

- Brain health supplements
- Memory / cognitive products
- Infant brain development formulas
- Aging / neurodegenerative support products

The **global nervonic acid market alone** is projected around **\$150–\$200 million by 2025** with continued growth as brain-health supplements expand.

Some reports estimate the broader nervonic-acid industry reaching **tens of billions by 2032** due to demand for neurological and cognitive products.

2. Functional Food / Premium Edible Oil Market

Yellowhorn oil is rich in unsaturated fats and omega fatty acids.

Uses:

- premium cooking oils
- specialty healthy oils
- omega-rich functional foods

The global **Yellowhorn oil market itself** is estimated around **\$1.34 billion in 2024** and projected to reach **over \$3 billion by 2033** with strong growth.

Drivers include:

- plant-based diets
- interest in specialty oils
- demand for natural ingredients.

3. Cosmetic & Personal Care Industry

This is a **major market for specialty plant oils.**

Yellowhorn oil works well for:

- anti-aging creams
- moisturizers
- skin barrier repair
- hair products

Plant-derived oils are increasingly used in cosmetics because companies want **natural and sustainable ingredients.**

4. Pharmaceutical Ingredients

A smaller but **high-value niche**.

Potential uses:

- nerve repair compounds
- neurodegenerative disease research
- drug delivery lipids

Pharmaceutical-grade nervonic acid is expected to grow steadily because it supports **myelin and nerve cell membrane health**.

5. Industrial / Biofuel Markets

This is a **lower-value but large-volume market.**

Uses:

- biodiesel
- lubricants
- Biochemicals

However, if Yellowhorn oil becomes valuable nutraceutically, it will likely **not be used much for fuel** because the price would be too high.

Most Likely Commercial Path (if grown in the U.S.)

If someone develops a Yellowhorn industry in North America, the **most realistic buyers would be:**

- 1. Nutraceutical ingredient companies**
2. Cosmetic ingredient manufacturers
3. Specialty oil processors
4. Functional food brands

This is similar to how **argan oil, macadamia oil, and camelina oil markets developed.**

What Makes Yellowhorn Economically Interesting

The oil potentially has **three stacked markets:**

- ✓ Edible oil
- ✓ Cosmetic oil
- ✓ **High-value nervonic acid extraction**

That **third market is the real opportunity.**

❖ The economic potential of **Yellowhorn** largely depends on how the oil is marketed—

either as a **bulk edible oil** or as a

high-value nutraceutical oil rich in compounds like Nervonic acid.

Below is a realistic illustration of how the economics could look for growers.

Example of Yellowhorn Acre Economics

1. Tree Density

Typical orchards are planted at about:

- 200–250 trees per acre**

(You previously used **242 trees/acre**, which is a reasonable spacing.)

2. Mature Seed Yield

Reported yields vary widely, but a **moderate mature yield** might be:

- 20–40 lbs of seed per tree**

Using a middle estimate:

- 30 lbs per tree**

Per acre

$$242 \text{ trees} \times 30 \text{ lbs} = \mathbf{7,260 \text{ lbs of seed}}$$

3. Oil Content

Yellowhorn seeds contain roughly:

- 55–65% oil**

Using **60% oil**

$$7,260 \text{ lbs seed} \times 0.60 = \mathbf{4,356 \text{ lbs oil}}$$

That equals roughly:

- 520–530 gallons of oil per acre**

Scenario 1: Bulk Specialty Oil

If the oil is sold as a premium edible oil:

Typical specialty oil price:

- \$15–\$25 per liter**

Converted to gallons:

- about **\$57–\$95 per gallon**

Using **\$70 per gallon**

520 gallons × \$70 = \$36,400 gross per acre

After processing, harvesting, and marketing costs, a grower might net roughly:

\$10,000–\$18,000 per acre

Scenario 2: Nutraceutical Ingredient Market

If the oil is processed for **Nervonic acid**, the economics change dramatically.

Typical Yellowhorn oil contains:

- 2–5% nervonic acid**

Using **3%**

$4,356 \text{ lbs oil} \times 0.03 = \mathbf{131 \text{ lbs nervonic acid per acre}}$

Purified nervonic acid can sell for:

- \$500–\$2,000 per kilogram** depending on purity. $131 \text{ lbs} = \mathbf{59 \text{ kg}}$

Example price: $\$800/\text{kg} \times 59 \text{ kg} = \$47,200$ value from nervonic acid alone

The remaining oil can still be sold for food or cosmetics.

Scenario 3: Cosmetic Oil Market

Cosmetic oils sell even higher in some cases.

- ❖ Premium botanical oils retail:
 - **\$80–\$300 per liter, or**
 - **\$303-\$1,136 per gallon**

- ❖ Even wholesale cosmetic oil might sell for:
 - **\$40–\$70 per liter, or**
 - **\$70 - \$265 per gallon**

This can push acre value above **\$40,000 gross** if the market exists.

Most Likely Early Market

Realistically, the **first markets would probably be:**

- 1. Cosmetic ingredient suppliers**
- 2. Nutraceutical companies**
- 3. Specialty oil brands**

This is exactly how markets developed for oils like:

- **Argan oil**
- **Camelina oil**
- **Macadamia oil**

Key Limitation Right Now

- ✓ The biggest issue is **Scale/#Farms in Production**

Yellowhorn oil currently comes from **China**, and global production is still relatively small.

For a North American industry to develop, it would need:

- orchards
- processing infrastructure
- nutraceutical buyers
- regulatory approvals

Market Price

❖ Pecan

Typical grower price:

- \$2.50–\$4.50 per lb in-shell

Example revenue:

1,500 lbs × \$3.50 = ~\$5,250 per acre

Top orchards can reach **\$7,000–\$10,000 per acre.**

❖ Yellowhorn Oil

If sold as a specialty oil:

- \$50–\$90 per gallon wholesale

Possible gross revenue:

\$20,000–\$35,000 per acre (depending on yields and markets).

If sold for Nervonic acid extraction, value could be higher.

Bottom Line Comparison

<u>Factors</u>	<u>Winner</u>
<ul style="list-style-type: none">• Water efficiency	<ul style="list-style-type: none">• Yellowhorn
<ul style="list-style-type: none">• Early production	<ul style="list-style-type: none">• Yellowhorn
<ul style="list-style-type: none">• Yield per acre	<ul style="list-style-type: none">• Yellowhorn (potential)
<ul style="list-style-type: none">• Market maturity (current)	<ul style="list-style-type: none">• Pecan
<ul style="list-style-type: none">• Infrastructure (current)	<ul style="list-style-type: none">• Pecan

✓ Right now pecans win because the market already exists. But if a nutraceutical market for nervonic acid develops, Yellowhorn could become one of the most valuable drought-tolerant oil crops for the Southwest.

Comparison of Sources

<u>Plant</u>	<u>Nervonic Acid</u>	<u>Commercial Potential</u>
Malania oleifera	30–60%	Very limited supply (tropical)
Lunaria annua	10–20%	Not practical
Cardamine spp.	10–15%	Mostly wild
Acer truncatum	5–7%	Some development (limited)
Yellowhorn	2–5%	Most scalable tree crop



Maple River Farms, Owosso, MI



This 9-year-old tree produced 20 gallons of capsules containing nuts.

Don Honcoop at:

don@mapleriverfarms.com

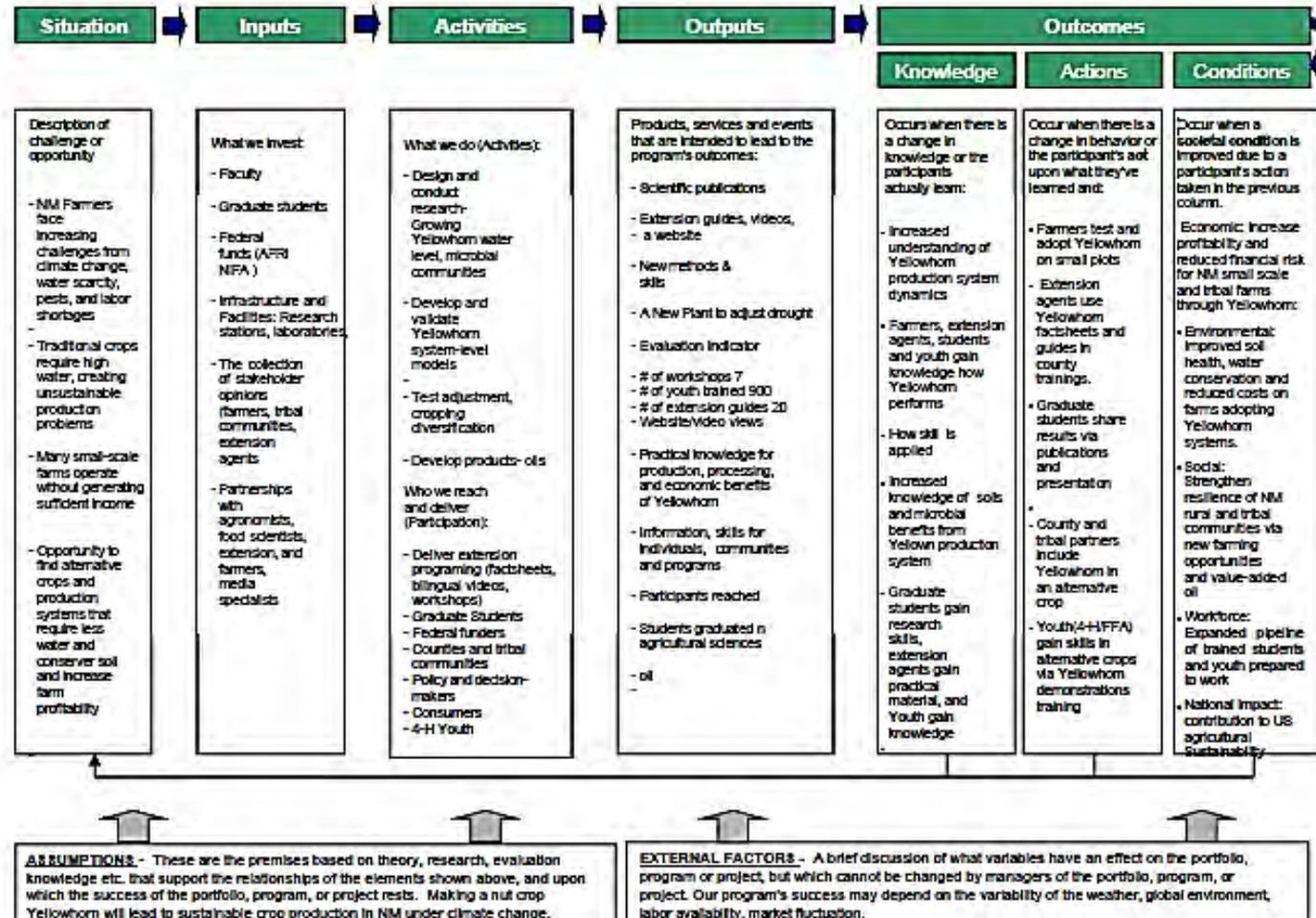




Yellowhorn tree, 8275 South 1300 West, West Jordan, UT 84088

Generic Logic Model for an Alternative Crop Yellowhorn

(This model is intended to be illustrative guide for reporting on NIFA-funded research and extension activities.)



Generic Logic Model for an Alternative Crop Yellowhorn

❖ SITUATION: Description of challenge or opportunity

- NM Farmers face increasing challenges from climate change, water scarcity, pests, and labor shortages
-
- Traditional crops require high water, creating unsustainable production problems
- Many small-scale farms operate without generating sufficient income
- Opportunity to find alternative crops and production systems that require less water and conserve soil and increase farm profitability

❖ Inputs: What we invest:

- Faculty
- Graduate students
- Federal funds (AFRI NIFA)
- Infrastructure and Facilities: Research stations, laboratories,
- The collection of stakeholder opinions (farmers, tribal communities, extension agents
- Partnerships with agronomists, food scientists, extension, and farmers, media specialists

❖ ACTIVITIES: What we do (Activities):

- Design and conduct research-Growing Yellowhorn water level, microbial communities
- Develop and validate Yellowhorn system-level models
- Test adjustment, cropping diversification
- Develop products- oils

Who we reach and deliver (Participation):

- Deliver extension programming (factsheets, bilingual videos, workshops)
- Graduate Students
- Federal funders
- Counties and tribal communities
- Policy and decision-makers
- Consumers
- 4-H Youth

❖ OUTPUTS: Products, services and events that are intended to lead to the program's outcomes:

- Scientific publications
- Extension guides, videos,
- a website
- New methods & skills
- A New Plant to adjust drought
- Evaluation Indicator
- # of workshops 7
- # of youth trained 900
- # of extension guides 20
- Website/video views
- Practical knowledge for production, processing, and economic benefits of Yellowhorn
- Information, skills for individuals, communities and programs
- Participants reached
- Students graduated in agricultural sciences
- oil

❖ Knowledge Occurs when there is a change in knowledge or the participants actually learn:

- Increased understanding of Yellowhorn production system dynamics
- Farmers, extension agents, students and youth gain knowledge how Yellowhorn performs
- How skill is applied
- Increased knowledge of soils and microbial benefits from Yellowhorn production system
- Graduate students gain research skills, extension agents gain practical material, and Youth gain knowledge

❖ Actions Occur when there is a change in behavior or the participant's act upon what they've learned and:

- Farmers test and adopt Yellowhorn on small plots
- Extension agents use Yellowhorn factsheets and guides in county trainings.
- Graduate students share results via publications and presentation
- County and tribal partners include Yellowhorn in an alternative crop
- Youth(4-H/FFA) gain skills in alternative crops via Yellowhorn demonstrations training

❖ Conditions Occur when a societal condition is improved due to a participant's action taken in the previous column.

- Economic: Increase profitability and reduced financial risk for NM small scale and tribal farms through Yellowhorn:
- Environmental: Improved soil health, water conservation and reduced costs on farms adopting Yellowhorn systems.
- Social: Strengthen resilience of NM rural and tribal communities via new farming opportunities and value-added oil
- Workforce: Expanded pipeline of trained students and youth prepared to work
- National impact: contribution to US agricultural Sustainability



‘Yellowhorn’ Healthy, Sustainable and Economically Profitable

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<iframe width="740" height="436" src="https://www.youtube.com/embed/Pe8KQptDLT4" title="Yellowhorn - A Viable Crop for New Mexico" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture; web-share" referrerpolicy="strict-origin-when-cross-origin" allowfullscreen></iframe>

https://pubs.nmsu.edu/_a/A103/index.html

If **Yellowhorn oil** were produced in the United States (for example in the Southwest), the **first buyers would likely come from a few specific industries** that already purchase specialty plant oils. These markets are smaller than commodity oils but **pay much higher prices per pound**.

1. Nutraceutical Ingredient Companies (Most Likely Early Buyers)

This is probably the **single most important market**.

Yellowhorn oil contains **Nervonic acid**, which is used in products targeting:

- brain health
- nerve repair
- cognitive support
- infant neurological development

Typical buyers:

- supplement manufacturers
- medical nutrition companies
- ingredient suppliers to supplement brands

Examples of companies that buy specialty fatty acids include:

- DSM-Firmenich
- BASF
- Lonza

These firms often purchase **plant oils rich in rare fatty acids**.

2. Cosmetic Ingredient Manufacturers

The cosmetic industry buys **large volumes of plant oils**, especially those with unique fatty acid profiles.

Yellowhorn oil could be used for:

- anti-aging creams
- moisturizers
- skin barrier repair
- hair oils

3. Functional Food Companies

Another likely buyer group is **functional food companies** that sell oils with health benefits.

Potential buyers include health-food brands that sell:

- omega oils
- brain-health foods
- premium cooking oils

4. Pharmaceutical Research Suppliers

A smaller but high-value market involves **research chemicals and pharmaceutical ingredients**.

Because **Nervonic acid** plays a role in **myelin formation**, pharmaceutical companies and research labs buy it for:

- neurological research
- drug development
- medical nutrition

This market typically purchases **purified compounds extracted from the oil**.

5. Specialty Oil Processors

Some companies specialize in **processing unusual oils** and selling them into multiple industries.

These firms buy raw oil and then produce:

- refined cosmetic oils
- nutraceutical capsules
- fatty acid isolates

Examples include:

- AA Oil Mills
- Jedwards International