National Science Fair 2025 ---Research Plan

OMEIAT NSF Submission

Project ID	
Project Title	**Keeping Root Vegetables Safer: Edible Bio-Shields to Reduce Tiny Plastics Sticking on Radish Roots**
Level	**Middle Level**
Category	**Environmental Science**
Participant Name	**MD.RUHEEN AFSAH**
School	**NARAYANA OLYMPIAD SCHOOL**
City	**CHENNAI**

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Project Title: Keeping Root Vegetables Safer: Edible Bio-Shields to Reduce Tiny Plastics Sticking on Radish Roots

A) Introduction

Root vegetables such as radish will grow underground and will remain in direct contact with soil. Today, soil will not only contain nutrients but also invisible pollutants called microplastics (MPs). These plastics will stick to the root surface and will not be fully removed even after washing or peeling.

This will create a food safety risk because radishes and other root vegetables are eaten with peel by many families. This project will test whether plant-based gel coatings can protect root vegetables. Two natural gels will be studied: Psyllium Husk Gel and Calcium Pectin Gel (Ca-Pectin).

B) PROBLEM and Background

Soil will not only provide nutrients to plants but will also collect invisible pollutants such as microplastics (MPs**)**. These MPs will come from broken-down plastics, mulch, compost, sewage, and dust. When root vegetables like radish will grow underground, MPs will attach to their outer surface. Washing and peeling will reduce some particles, but very fine MPs will remain trapped in cracks and root hairs. This will create a direct food safety risk**.**

Most edible films and coatings studied so far are applied on fruits to keep them fresh, but almost no work has been done on roots that remain inside soil during growth**.** This is a missing area in simple student-level research.

This project will try to fill that gap by testing safe, low-cost gels (Psyllium husk and Ca-Pectin) as bio-shields at the root–soil boundary. If it works, it will give a new and simple way to reduce plastic contamination in everyday food.

C) Objective

Research Question: Will Psyllium or Ca-Pectin gel coatings reduce the number of microplastic particles sticking to radish roots compared to uncoated radishes?

Variables & Groups

Type	Details
Independent Variable	Type of bio-shield (None, Psyllium, Ca-Pectin)
Dependent Variable	Microplastic residue on radish surface (mg/100 g peel or particles per mm^2)
Controls	Clean soil, MP soil without shield, placebo gel
Hypothesis	Shielded radishes will show fewer MPs than unshielded controls; Ca-Pectin will perform better than Psyllium

Experimental unit: Pot = n. I will thin to 1 plant per pot by Day 7–10. All analyses use number of pots per group (not number of plants).
Dependent Variables:

- Microplastic Adhesion Score = particles per mm² on the outside root surface (Nile-Red + UV + phone macro + grid counting).
- Plant growth metrics = root mass (g), max root diameter (cm), shoot height (cm), leaf count. Controlled Variables: pot size & soil volume, soil type, MP concentration = 1% w/w, MP size = 125–300 µm PET, 1 plant/pot, sowing depth, watering, light, temperature, growth duration, harvest and imaging method, randomized pot placement and daily tray rotation.
- Scope note (Methods/Limitations): In this project we count the particles on the outside surface (particles/mm²) using fluorescence images. Internal nano-plastics are not measured with our school tools.

D) HYPOTHESES

H1 – Food-Safety Effect (Primary)
H1a. Radish roots coated with Psyllium or Ca-Pectin bio-shields will show fewer plastic particles per mm² on the edible surface than unshielded roots in microplastic soil.
H1b. Ca-Pectin will reduce sticking more than Psyllium, because the Ca^{2+} (calcium ions) cross-linked network will be tougher and will last longer in wet soil.

H2 – Plant Performance & Shield Strength (Secondary)
H2a. Shielded plants will show better growth (larger roots, healthier shoots/leaves) than unshielded plants under plastic stress.
H2b. A medium-thickness layer will protect best in the wet-abrasion test (thin layers will wear off quickly, thick layers may crack).

E) Procedure (Variables & Materials included)

E2) Materials

- Seeds & Soil: radish seeds, garden soil.
- Microplastics (MPs): PET from clean bottles: cut → grind inside a large zip bag (to catch dust)
- sieve to 125–300 µm --→ rinse with water --→ dry --→ weigh and mix into soil at 1% w/w. Keep a photo with ruler of the particle size.
- **Gels**: ERBG-PSY (Psyllium husk + warm water), ERBG-PEC-Ca (Pectin + calcium source: 0.3% $CaCl_2$ drops or very dilute lime water).
- Containers & Tools: 2-L bottles or small pots (same size), labels, digital scale, measuring spoons, small brush, ruler, phone + clip-on macro lens, graph paper.
- Jar Abrasion Test: lidded jar, 20 g sand, 20 mL water, glass marbles (same size).
- Imaging box: small black box (shoebox) with fixed phone holder, fixed UV torch angle, fixed camera-to-sample distance, same exposure for all photos.
- Imaging reagents: tiny amount of Nile-Red dye, UV torch.

Safety: mask (for grinding plastics), gloves, safety glasses, separate blender (non-food), spill kit (damp wipes, tray).

E3) Gel Preparation (short recipes)

- ERBG-PSY (Psyllium): Mix 1 tsp psyllium husk with 50–60 mL warm water. Stir 2–3 min, let
- it cool to a thick gel. Brush a thin–medium layer.
- ERBG-PEC-Ca (Ca-Pectin): Dissolve 1 g pectin in 100 mL warm water, add a few drops lemon, cool. While stirring, add 0.3% $CaCl_2$ drop by drop (about 1 mL $CaCl_2$ per 10 mL pectin to start) until it becomes a smooth, spreadable gel. Quickly rinse the coated seed once in clean water to keep surface pH ~6–7 (check with pH strip). Brush a thin–medium layer.
- Seed safety mini-test (before sowing): Germinate 10 seeds on moist tissue for each: No shield / Psyllium / Ca-Pectin. Record % germination in 48–72 h to confirm gels are safe.

E4) Phase 1 ---Preliminary Experiment: Coating Integrity (Wet-Abrasion) Test

Goal: pick the best thickness so the main test is fair.

1) For each gel, make Light / Medium / Heavy thickness and coat 3 groups of 5 marbles per thickness.
2) Weigh groups to get Avg. gel mass per marble (mg/marble).
3) Stress test: Jar + 20 g sand + 20 mL water, shake 60 seconds to mimic wet soil rubbing.
4) Re-weigh after rinsing/drying, compute % coating mass lost.
5) Decision rule: Choose the lowest % loss (usually Medium) as the optimized thickness for the main experiment.

E4a) Low-Cost Wet-Abrasion & Mechanical Stress Simulation (Student Protocol Box

Purpose: A simple, repeatable way for students to test how well a bio-gel coating survives rubbing in wet soil. Results feed into Table 1 and the Decision Rule (choose the thickness with the lowest % mass loss).

Materials (low cost):

- ✓ Small glass marbles or uniform plastic beads (seed models)
- ✓ Clean sand (~20 g per test)
- ✓ Water (~20 mL per test)
- ✓ Clean jars or plastic containers with tight lids
- ✓ Stopwatch or timer (60 seconds)
- ✓ Digital kitchen scale (milligram accuracy if possible)
- ✓ Rinse water and a clean drying surface (cloth/paper towels)

Procedure:

1) Coat marbles/beads with your bio-gel at Light / Medium / Heavy thickness.
2) Weigh each coated group and record the starting mass (gel + marble).
3) Put one coated group into a jar, add ~20 g sand and ~20 mL water.
4) Close the lid and shake vigorously for 60 seconds to simulate wet soil abrasion.
5) Remove the marbles, rinse gently, dry carefully.
6) Weigh again to get the final mass.
7) Calculate % mass loss for each thickness.
8) Choose the most durable thickness (lowest % loss) for the main experiment.

Why this works: The jar, sand, water, and shaking mimic the rubbing and erosion a seed/young root experiences underground in wet soil, without any special machines.

E5) Phase 2 ---Main Experiment: Setup & Sowing

- Prepare Clean soil and MP soil (1% w/w, 125–300 µm PET).
- Set up G1–G7, 5 pots per group (pot = n).
- Apply the optimized thickness by brushing/dipping seeds (or the very young root). Let set 5–10 minutes.
- Sow 3–5 seeds per pot → thin to 1 plant per pot by Day 7–10 (keep the healthiest).
- Randomize pot positions, rotate trays daily to avoid edge effects.

E6) Phase 3 ---Growth & Weekly Observation

- Daily care: same for all groups (water, light, temperature).
- Weekly photos: macro photos of sample plants. Use one clear "root-window" pot per shield (qualitative).
- Tracer check: Before main study, shine UV on cocoa alone to confirm no glow. Use tracer only in window pots for visibility, not in counted groups.
- On-root persistence: Take Week 1, 2, 3 photos of the shield in the window pot. Do a tape-lift (press clear tape to root surface, mount on white card, photo under UV) to show shield/particles on the tape.

E7) Phase 4 ---Harvest & Measurements (Week 4–5)

- After 4–5 weeks, radishes will be harvested.
- Roots will be washed, dried, and measured for weight and diameter.
- Each root will be rinsed, and rinse water will be filtered using pre-weighed filters.
- Filters will be dried and re-weighed to calculate residue.
- Some roots will be checked under UV light for glowing MP dots.
- Purpose: To measure MP contamination and compare groups.

F)Data Collection & Analysis Plan

Table 2 – Sample Log / Pot Ledger

Date	Pot ID	Group	Soil Type (Clean/MP)	Seed Sown (Y/N)	Thinned (Y/N)	Notes

Table 3 – Coating Durability (Phase-1)

Thickness	N	Start Mass (mg)	End Mass (mg)	Mass Lost (mg)	% Loss	Notes

Table 4 – Randomization & Care Log

Date	Rotation Done (Y/N)	Water Given (mL)	Room Temp (°C)	Notes
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Table 5 – Per-Plant Raw Outcomes (Phase-4)

Sample ID	Root Mass (g)	Diameter (cm)	Leaf Count	Rinse Volume (mL)	Filter Start Wt (mg)	Filter End Wt (mg)	Residue (mg/100 g peel)	UV Dots (per mm^2)	Notes

Table 6 – Controls & Blanks QC

Filter ID	Blank Rinse? (Y/N)	Start Wt (mg)	End Wt (mg)	Δ mg	Pass/Fail (≤ threshold)

Table 7 – Group Summary (Statistics)

Group	n	Mean Residue (mg/100 g)	SD	Range	% Reduction vs Control

h) TIMELINE (4–5 Weeks)

- ✓ Week 1: Prepare gels, run coating durability test
- ✓ Week 2: Prepare soil, sow seeds, set up pots
- ✓ Week 3–4: Observe growth weekly, record data, take photos
- ✓ Week 5: Harvest radishes, collect data, filter rinses, weigh MPs, prepare charts

G) Risk & Safety

- ➢ Grind plastics inside a large zip bag or covered jar to catch dust, wear mask + glasses, use a separate blender (not for food).
- ➢ Label all MP containers, keep a spill kit (tray + damp wipes).
- ➢ Use tiny amounts of Nile-Red, wear gloves, never point UV at eyes.
- ➢ Collect all MP soil and plant waste in a sealed heavy bag labeled “Do Not Compost”, dispose as non-compostable per local rules.
- ➢ Adult supervision during grinding, UV imaging, and electrical use.

H) Expected Outcome & Limitations

Expected: Shielded roots show lower particles/mm² than unshielded, Ca-Pectin likely beats Psyllium, Medium thickness protects best, shielded plants keep equal or better growth. Limitations (honest): School tools can’t directly measure nano-plastics inside tissues. I focus on surface sticking that I can image and count. That still matters for food safety, because any reduction on the outside surface is helpful. The optional washing mini-test will show how shields make normal rinsing more effective.

I) Significance

This research is practical for families, school gardens, and small farmers. If edible bio-shields work, we get a simple, low-cost method to keep root vegetables cleaner at the surface—the part we eat—without harming plant growth. It turns measuring a problem into preventing it, which is more useful in real life.

J) References (starter list—expand after full reading)

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