

Kelp Ag Product R&D: Liquid Kelp Biostimulant Product Refinement and Field & Market Testing Update:

Project Overview

This project aims to refine processing methods and evaluate the performance and market potential of an Alaska-made liquid kelp biostimulant derived from farmed sugar kelp. The work includes product formulation, pilot-scale production, laboratory analysis, on-farm field trials, and preliminary market testing.

Project updates rolling over from previous project report:

- **Field trials have been concluded, data is in the process of being synthesized, and whitepapers on field trial results are in process.**
- **Label has been created and marketing for product is underway with a variety of small and large-scale Alaska retailers being contacted for test marketing in state.**
- **The abstract submitted to the mariculture conference was accepted for a 15-minute presentation from project partners.**

Model Studies Results

Growth chamber bioassay studies to determine optimal rooting response of Mung Bean (*Vigna radiata*) to the project-produced biostimulant and two commercially available *Saccharina Latissima* products and dilutions were completed by Institute for Sustainable Horticulture Kwantlen Polytechnic University in Surrey BC, Canada. This experiment consisted of 25 treatments in total.

Four experiments were performed to evaluate different product doses, batches, and compare *Sea to Sprout* with known commercial products. Kelp extract produced in 2024 and 2025 was tested and both were shown to increase root growth in the assay. Product dosage at 1:100 was consistently found to improve both number and mass of roots. More concentrated applications (1:40, 1:10) were not effective.

Due to the timing of the project biostimulant production in May and June, the root bioassay study results were received in July, after the start of the field trials.

Field Trial Results (2025 Growing Season)

Preliminary statistical analyses have been completed for beet and potato field trials conducted at UAF Agriculture and Forestry Experiment Station and Twitter Creek Gardens, with full datasets, including soils data and final analyses expected by the end of January from project partners.

Response variables included plot-level yield metrics, fresh and dry biomass measurements, and subsampled leaf and root traits. Across all plots, qualitative observations were also recorded for plant vigor, pest resistance, disease incidence, and bolting sensitivity to support contextual interpretation of quantitative results.

Due to the timing of the project biostimulant production in May and June, the project team did not have 2025 batch root bioassay results on which to base dose for the field trials. Instead biostimulant dose was determined based on root bioassay results from 2024. The project biostimulant was mixed with water and applied as a root drench at a ratio of 25:1. As indicated by the 2025 root bioassay results, the optimal dosage was 100:1, likely having a significant impact on results:

Beets (AFES and Twitter Creek):

Across sites, beet responses to kelp application were generally positive at the vegetative level. At Twitter Creek, kelp-treated plots exhibited increased leaf area and leaf biomass relative to no-kelp controls, with effects approaching statistical significance (leaf area: $p = 0.0577$; leaf weight: $p = 0.0574$). These results suggest enhanced aboveground growth responses under kelp treatment.

At AFES, fertilizer rate significantly influenced beet root yield outcomes. Plots receiving 100% fertilizer exhibited significantly higher root-only plot yields than those receiving 70% fertilizer ($p = 0.00158$), and higher dry root biomass compared to 50% fertilizer treatments ($p = 0.0498$). These findings indicate a strong fertilizer rate effect and highlight the importance of evaluating kelp applications within appropriate nutrient management regimes.

Potatoes (AFES and Twitter Creek):

Potato response varied by site and treatment. At Twitter Creek, no-kelp treatments resulted in significantly higher average potato weight compared to kelp-treated plots ($p = 0.0148$). This negative response is consistent with concurrent dose-response observations from mung bean assays and is attributed to excessive kelp application concentration. Increased above-ground leaf size and vigor on the biostimulant -treated plots was observed at both test sites. These data reinforce the need for refined, crop-specific application protocols for belowground storage crops.

Preliminary field trial results reinforce the need for correct dosage and additional field trials. Preliminary soils data from pre-season testing indicate high degree of soil health at both test locations, indicating the benefit of future testing in more nutrient deficient conditions for better understanding the efficacy of the biostimulant.

Field trials for 2026 season:

While field trials for the 2026 growing season are not part of this project scope or budget, the project team is currently working with the State of Alaska Plant Materials Center in Palmer to design field trials on potatoes and grains.

White Papers and Technical Documentation

Spencer Spoit of Marine Biologics will produce two technical white papers, documenting the mung bean trials (attached to this report) and 2025 field trials (in progress), including methodologies, application rates, response variables, and preliminary interpretation. A third white paper focused on soil impacts (e.g., nutrient availability, organic matter dynamics, and biological indicators) will be prepared once soil data are received from Homer Soil and Water Conservation District (HSWC) and the University of Alaska Fairbanks (pending).

A fourth internally led paper is also attached, synthesizing peer-reviewed literature on biostimulant efficacy across crop types, soil textures, nutrient regimes, and climatic growing conditions. An FAQ page responding to basic customer questions such as the difference between a biostimulant and fertilizer is also attached. Collectively, these informational documents will be hosted on the Kachemak Kelp / Sea to Soil webpage to support transparency, reproducibility, and knowledge transfer.

Additional Trials and Greenhouse Testing

Coordination is underway with two additional Alaska-based biostimulant projects and Southeast Conference to assess the feasibility of late-winter greenhouse trials targeting additional crops. These trials are intended to expand crop response datasets under controlled conditions and inform prioritization of future field-scale testing. Trial design, crop selection, and timelines are currently under development.

Market Testing and Adoption Constraints

Early-stage marketing for product sales to Alaska gardeners is underway with a variety of small and large-scale Alaska retailers being contacted for test marketing.

Outreach to the Alaska agriculture sector conducted to date functions primarily as early-stage market testing and has highlighted structural barriers to adoption within the sector. Engagement with UAF Extension, NRCS, and the Division of Agriculture indicates that producers operate under low-margin conditions and exhibit high risk aversion to novel inputs that could negatively affect yield. Feedback consistently emphasizes the need for clear efficacy data, locally relevant field results, and peer validation prior to adoption. The team's current focus is on developing agreements with 2-3 Alaska farms to test the biostimulant at no cost in exchange for empirical data.

Complementary outreach with Kenai Local Food Connection is supporting dissemination and producer engagement through a newsletter interview and a planned presentation or tabling event at the Kenai Peninsula Farm Bureau meeting in February. While promising for awareness-building, these marketing activities are resource-intensive and underscore the need to strategically align outreach effort with research and production capacity.

Product-facing materials continue to advance, with the product label finalized. A supplemental information sheet is also being prepared to convey application guidance, use limitations, and research findings beyond what can be accommodated on the label. The attached additional FAQ page responds to basic questions about the product and its efficacy and uses.

Production and Processing Optimization

Processing improvements are underway, including procurement of a screw press and auger to enhance solids separation efficiency, throughput, and consistency. January work has focused on refining fermentation protocols, including residence time, vessel configuration, and handling practices.

Outcomes from this process optimization work will inform decisions regarding work flows and labor requirements. In parallel, a harvest and production calendar is being developed to better align biomass availability with processing, labor, fermentation capacity.



SEA TO SPROUT

All purpose liquid soil & plant microbial food source

Made From Kachemak Bay Kelp.

Stimulates and improves germination, growth, quality, yield, nutrient uptake and availability, and plant resilience to stress



VOLUME: 1 LITER



100% Sugar kelp (*Saccarina latissima*) regeneratively grown on kelp farms in the nutrient rich waters of Kachemak Bay, Alaska. Naturally fermented using pure water and beneficial *Lactobacillus* microbes.

Guaranteed analysis

CONSTITUENTS

Dissolved Solids:	5%
Organic Matter:	3%
Ash	2%
pH	4-5

MACRO/MICRONUTRIENTS

Potassium (as K ₂ O):	1%
Sodium:	<0.5%
Magnesium	450 ppm
Calcium	300 ppm

All batches meet AAPFCO limits on heavy metals in fertilizers.

For more information visit kachemakkelp.com

Proudly produced in Homer, Alaska
by Kachemak Kelp, LLC.

Best by:

Application & Storage

Apply as a foliar spray, soil drench or directly to seeds and roots to stimulate germination and growth and improve resistance to stress.

Dilute 1:100 for all applications.

For home gardens: 2 teaspoons per gallon.

Soil drench and foliar spray: Apply 1/2 quart/acre

Seed and root: Dip or soak directly in diluted solution

Store in a cool and dry environment away from direct sunlight.

Sea to Sprout is a non-irritant, non-toxic substance intended for plant, soil and seed application only.

Users should follow safe practices: **Keep away from children, do not ingest, and wash hands after handling.**



Scan for product and
safety data information:



Sea to Sprout - Frequently Asked Questions

1. How is Sea to Sprout made?

- Sea to Sprout is made from Sugar kelp (*Saccarina latissima*) regeneratively farmed from local seed, without any inputs, in Kachemak Bay and Lower Cook Inlet, Alaska.
- We ferment the kelp using active lactobacillus culture. Fermentation helps break down cell walls and release phytoactive compounds (e.g., auxin-like substances, polysaccharides, and phenolics) that can enhance plant growth. Fermentation may further increase bioavailability of these compounds.
- When fermentation is complete we filter the liquid portion, reserving the solid portion for other uses.

2. What are the benefits of using a seaweed based plant biostimulant, and can it be used on different crops and types of plants?

- Seaweed-based plant biostimulants help plants grow better, handle stress, and use nutrients more efficiently, and they are highly versatile across many crop species and plant types. They are used on vegetables, fruits, row crops, turf, ornamentals, and tree crops. They are typically used in seed, soil, or foliar applications.

3. How does a biostimulant differ from a fertilizer?

- A biostimulant mainly works by stimulating the plant's own physiological and microbial processes, while a fertilizer's primary role is to supply nutrients like nitrogen, phosphorus, and potassium directly. They are complementary: fertilizers "feed" the plant, and biostimulants help the plant use that nutrition more efficiently and cope with stress.
- Fertilizers are defined by their nutrient content and are applied to correct or prevent nutrient deficiencies by adding essential elements (N, P, K, plus secondary and micronutrients) to soil or plants.
- Biostimulants are defined by their mode of action: they stimulate natural processes that improve nutrient uptake, use efficiency, and stress tolerance, typically without supplying significant amounts of nutrients themselves.
- Seaweed-derived biostimulants are known to contain phytoactive compounds (e.g., auxin-like substances, polysaccharides, and phenolics) that can enhance root growth. Fermentation may further increase bioavailability of these compounds.

4. How do biostimulants “work”?

- Fertilizers act mainly through direct chemistry and plant nutrition: increasing available ions in soil solution for root uptake and driving yield via mass nutrient supply.
- Biostimulants act through biochemical and biological modulation - by gently changing how plants and soil microbes function (e.g., plant metabolism, root architecture, microbial activity, signaling pathways), improving processes such as root growth, photosynthetic efficiency, and resilience to abiotic stress.

5. How much seaweed biostimulant is needed to see benefits? What happens to plant and root growth and vigor with a too-concentrated dose?

- Sea to Sprout and other seaweed biostimulants are super concentrated. A little goes a long way. It can be applied as a soil drench, foliar spray or directly to seeds and roots, diluted 1:100 for all applications.
- Excessive doses of seaweed biostimulants tend to inhibit growth by shifting from a positive, biostimulated state or “signal” to a “stress” that suppresses root and shoot growth. Physiologically, roots experience osmotic/ionic and hormonal imbalances, plus oxidative and sometimes metal toxicity, that collectively suppress meristem activity and elongation.

6. Can seaweed biostimulants be used in organic certified agriculture? Does the biostimulant need to be certified?

- Yes, seaweed biostimulants can be used in organic certified agriculture: Under USDA National Organic Program (NOP) rules, nonsynthetic seaweed products (liquids, soluble powders, meals) are permitted in organic crop production, as long as processing uses only water, heat, pressure, or other nonsynthetic materials.
- No, the biostimulant does not need to be certified: NOP does not require that every input used on an organic farm be “organic” or “certified” as a product; it requires that all inputs be allowed under the National List and comply with NOP handling/processing rules.
- Therefore, a seaweed biostimulant may be used on certified organic farms if the formulation and extraction method fit those NOP criteria, even if the product is not itself certified organic.

7. How are seaweed biostimulants classified and regulated in the US?

- There is currently no single, binding federal definition or dedicated category for “plant biostimulants”; instead, products are regulated either under state fertilizer/soil amendment laws or, if claims are made that the substance has pesticidal/plant regulator qualities, under FIFRA as pesticides/plant growth regulators by EPA.

For more information about Sea to Sprout and seaweed biostimulants see:

<https://www.kachemakkelp.com/sea-to-sprout>



Technical White Paper #1

Enhanced Root Growth with *Sea to Sprout*; Adventitious Root Growth Assay Using Fermented *Saccharina latissima* (Sugar Kelp) Extract

Executive Summary

This white paper summarizes a controlled bioassay evaluating the dose–response effects of a fermented seaweed extract derived from *Saccharina latissima* on adventitious root formation in Mung bean (*Vigna radiata*). The study demonstrates a concentration-dependent stimulation of root initiation and elongation. Results support the potential of fermented *S. latissima* extracts as plant biostimulants targeting early root development.

Background and Rationale

Adventitious root development is a critical determinant of early plant vigor, nutrient uptake, and stress resilience. Seaweed-derived biostimulants are known to contain phytoactive compounds (e.g., auxin-like substances, polysaccharides, and phenolics) that can enhance root growth. Fermentation may further increase bioavailability of these compounds.

This study was conducted by the Institute for Sustainable Horticulture, Kwantlen Polytechnic University in Surrey, British Columbia, Canada. It employed the Mung bean adventitious root assay, a sensitive and widely used model for screening root-promoting activity, to characterize the dose–response behavior of a fermented *S. latissima* extract. The key objectives of this study were:

- Quantify the effects of fermented *S. latissima* on adventitious root initiation and growth.
- Determine the dose–response relationship and identify an optimal concentration range.
- Assess potential inhibitory effects at high doses.

Seaweed Extract

- Source organism: *Saccharina latissima* (Sugar Kelp)
- Processing: Naturally fermented using pure water and beneficial *Lactobacillus* microbes
- Product dilution range (product to water, v:v) - 1:10 - 1:100

Experimental Design

- Assay type: Adventitious root growth assay in Mung bean (*Vigna radiata*)
- Treatments: Serial dilutions of fermented extract
- Control: Water and commercial kelp extract controls
- Replicates 10
- Exposure duration: 7 days
- Environmental conditions: 27 °C, 16-hour light / 8-hour dark, 80% relative humidity
- Datapoints: Number of roots, root dry-weight

Results and Discussion

Four experiments were performed to evaluate different product doses, batches, and compare *Sea to Sprout* with known commercial products. Kelp extract produced in 2024 and 2025 was tested and both were shown to increase root growth in the assay. Product dosage at 1:100 was consistently found to improve both number and mass of roots. More concentrated applications (1:40, 1:10) were not effective.

Experiment	Sample	Dose	No. of Roots	Mass Roots (mg)
1	2024 Product	1:100	103	13
	Commercial 1	1:75	98	11.4
	Control	1	7	0
2	2025 Product	1:100	95	11.8
	Control	1	13.4	2.1
3	2025 Product	1:100	87	9.4
	Control	1	1	0
4	2025 Product	1:100	67	7.9
	Commercial 2	1:100	56	8.9
	Control	1	15.3	3.3

Key Findings

- *Sea to Sprout* improves adventitious root initiation and growth.
- Optimal dilution: 1 part product to 100 parts water
- High doses inhibit root growth - a little goes a long way!



Technical White Paper #4 Scientific Literature on the Efficacy of Seaweed Biostimulants

Introduction

Seaweeds have been widely used as a source of nutrients in agriculture for centuries, and solid scientific evidence of seaweed biostimulants' function of mitigating abiotic stress and enhancing plant productivity is well documented. Here we provide the abstracts and links to four recent reviews of the scientific literature examining the efficacy of seaweed biostimulants. Some papers reviewed also address the current state of knowledge of the mechanisms of action of biostimulants on soils and plants. We have included useful figures from several of the publications. This Technical White Paper is intended to provide broad context on the current state of seaweed biostimulant efficacy research, and is not a full representation of the current body of literature. For results of field trials and laboratory analyses of *Sea to Sprout* see Technical White Papers 1, 2, and 3.

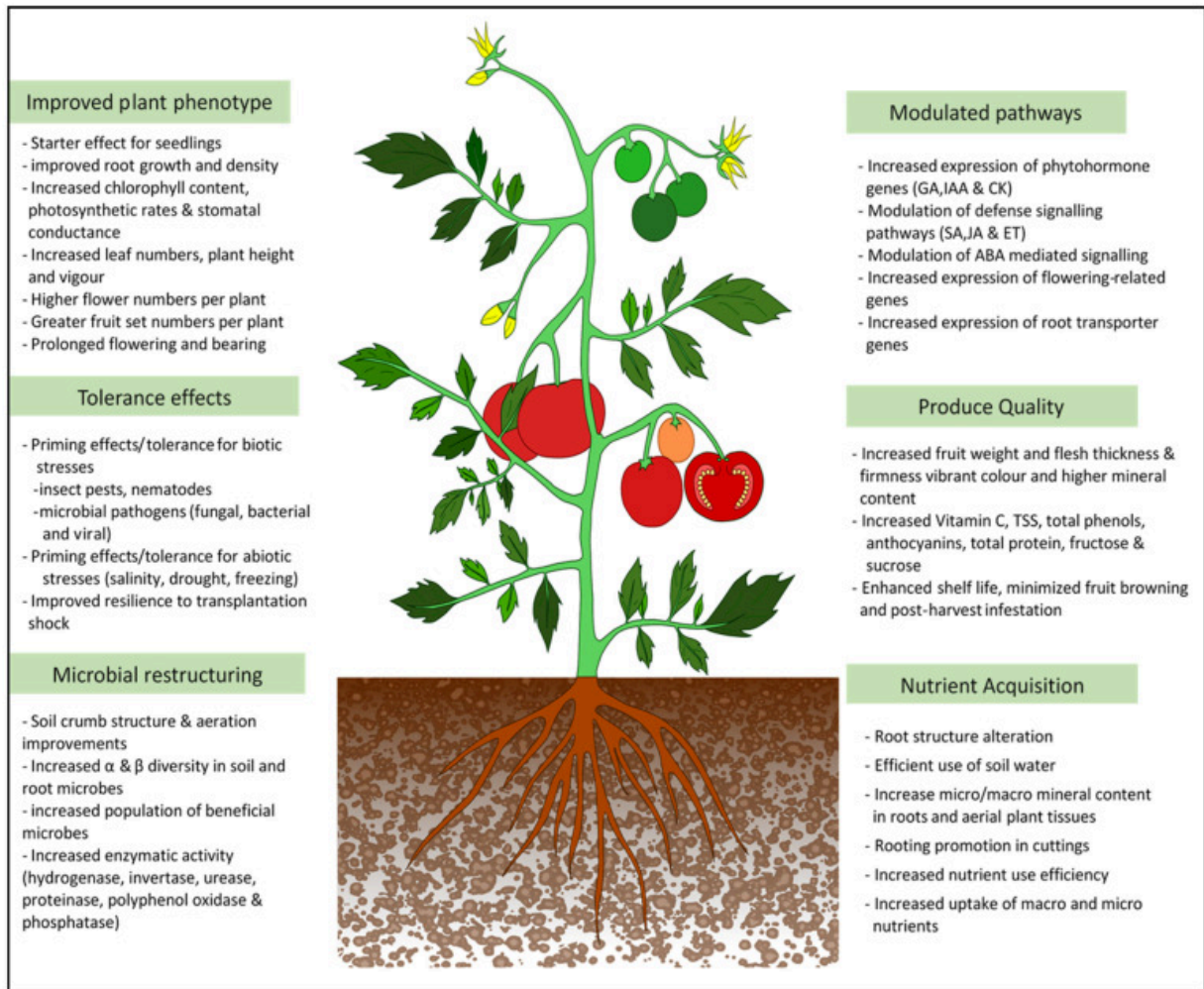
1. Biostimulant Properties of Seaweed Extracts in Plants: Implications towards Sustainable Crop Production ([Ali et al 2021](#)):

Abstract

The use of seaweed-based bioproducts has been gaining momentum in crop production systems owing to their unique bioactive components and effects. They have phytostimulatory properties that result in increased plant growth and yield parameters in several important crop plants. They have phytoelicitor activity as their components evoke defense responses in plants that contribute to resistance to several pests, diseases, and abiotic stresses including drought, salinity, and cold. This is often linked to the upregulation of important defense-related genes and pathways in the plant system, priming the plant defenses against future attacks. They also evoke phytohormonal responses due to their specific components and interaction with plant growth regulation. Treatment by seaweed extracts and products also causes significant changes in the microbiome components of soil and plant in support of sustainable plant growth. Seaweed extracts contain a plethora of substances which are mostly organic, but trace levels of inorganic nutrient elements are also present. Fractionation of seaweed extracts into their components and their respective bioassays, however, has not yielded favorable growth effects. Only the whole seaweed extracts have been consistently proven to be very effective, which highlights the role of multiple components and their complex interactive effects on plant growth processes. Since seaweed extracts are highly organic, they are ideally suited for organic farming and environmentally sensitive crop production. They are also very compatible with other crop inputs, paving the way for an integrated management approach geared towards sustainability. The current review discusses the growth and functional effects evoked by seaweed extracts and their modes and mechanisms of action in crop plants which are responsible for elicitor and phytostimulatory activities. The review further analyses the

potential value of seaweed extracts in integrated crop management systems towards sustainable crop production.

Figure 3- Overview of the positive effects of seaweed extracts on the plant and soil systems (Ali et al 2021).



2. Farming of Seagrasses and Seaweeds: Responsible Restoration & Revenue Generation (USDA 2024):

Summary

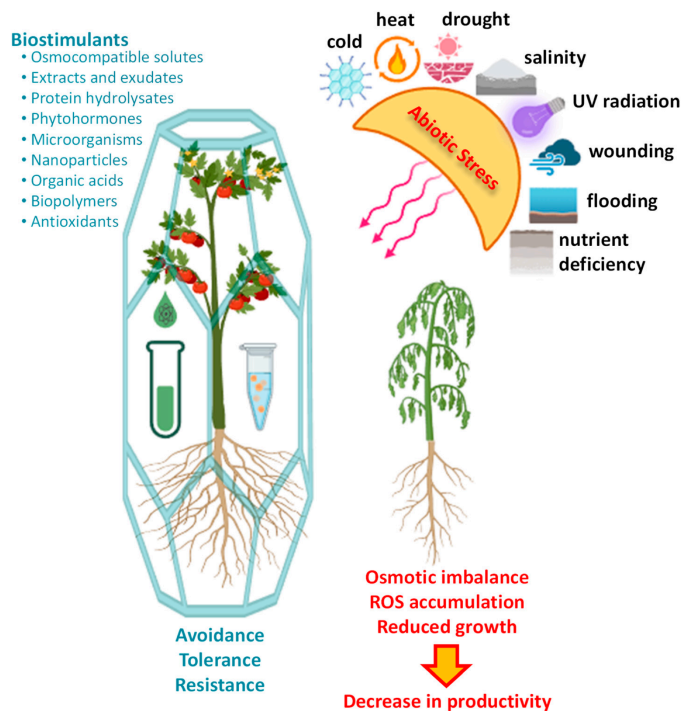
- [Appendix 8](#) - Seaweeds as Biostimulants Review
- Evidence of categorial benefits of seaweed-based biostimulant application by crop type for 55 crop types.
- A review of seaweed-based biostimulant product application on agricultural crops and their learned benefits as presented in peer-reviewed literature. Articles were retrieved from 2014-2024, a time frame that reflects a period of increased published research on the topic.

3. Plant Biostimulants to Enhance Abiotic Stress Resilience in Crops (Di Sario et al 2025):

Abstract

The escalating impact of abiotic stress on crop productivity requires innovative strategies to ensure sustainable agriculture. This review examines the promising role of biostimulants in mitigating the adverse effects of abiotic stress on crops. Biostimulants, ranging from simple organic compounds to complex living microorganisms, have demonstrated significant potential in enhancing plant resilience, stress tolerance, and overall performance. The mechanisms underlying biostimulant action—such as enhancing antioxidant defenses, regulating hormonal pathways, and inducing metabolic adjustments—are reviewed. Furthermore, we incorporate the latest research findings, methodologies, and advancements in biostimulant applications for addressing abiotic stressors, including drought, salinity, high temperatures, and nutrient deficiencies. This review also highlights current challenges and future opportunities for optimizing biostimulant use in sustainable crop production. This revision aims to guide researchers and agronomists in applying biostimulants to improve crop resilience in the context of climate change.

Figure 1. The role of biostimulants in mitigating the negative effects of abiotic stress on crop productivity. Abiotic stress conditions, such as drought, salinity, extreme temperatures, and nutrient deficiencies, induce detrimental changes at morphological, physiological, biochemical, and molecular levels, severely limiting plant growth and productivity. Biostimulants help crops counteract these stress-induced damages, restoring plant performance and enhancing resilience against environmental stressors. Illustration created using BioRender. (Di Sario et al 2025)



4. Trends in Seaweed Extract Based Biostimulants: Manufacturing Process and Beneficial Effect on Soil-Plant Systems (Boukhari et al 2020):

Abstract

The time when plant biostimulants were considered as “snake oil” is erstwhile and the skepticism regarding their agricultural benefits has significantly faded, as solid scientific evidences of their positive effects are continuously provided. Currently plant biostimulants are considered as a full-fledged class of agri-inputs and highly attractive business opportunity for major actors of the agroindustry. As the dominant category of the biostimulant segment, seaweed extracts were key in this growing renown. They are widely known as substances with the function of mitigating abiotic stress and enhancing plant productivity. Seaweed extracts are derived from the extraction of several macroalgae species, which depending on the extraction methodology lead to the production of complex mixtures of biologically active compounds. Consequently, plant responses are often inconsistent, and precisely deciphering the involved mechanism of action remains highly intricate. Recently, scientists all over the world have been interested to exploring hidden mechanism of action of these resources through the employment of multidisciplinary and high-throughput approaches, combining plant physiology, molecular biology, agronomy, and multi-omics techniques. The aim of this review is to provide fresh insights into the concept of seaweed extract (SE), through addressing the subject in newfangled standpoints based on current scientific knowledge, and taking into consideration both academic and industrial claims in concomitance with market’s requirements. The crucial extraction process as well as the effect of such products on nutrient uptake and their role in abiotic and biotic stress tolerance are scrutinized with emphasizing the involved mechanisms at the metabolic and genetic level. Additionally, some often overlooked and indirect effects of seaweed extracts, such as their influence on plant microbiome are discussed. Finally, the plausible impact of the recently approved plant biostimulant regulation on seaweed extract industry is addressed.

Figure 2. Conceptual illustration highlighting the positive impact of seaweed extracts on the whole soil–plant system. Such effects encompass improving fruit quality, and plant phytohormone content, increasing soil enzymatic activity, improving the rooting system and the overall physiological features of plants. (Boukhari et al 2020)

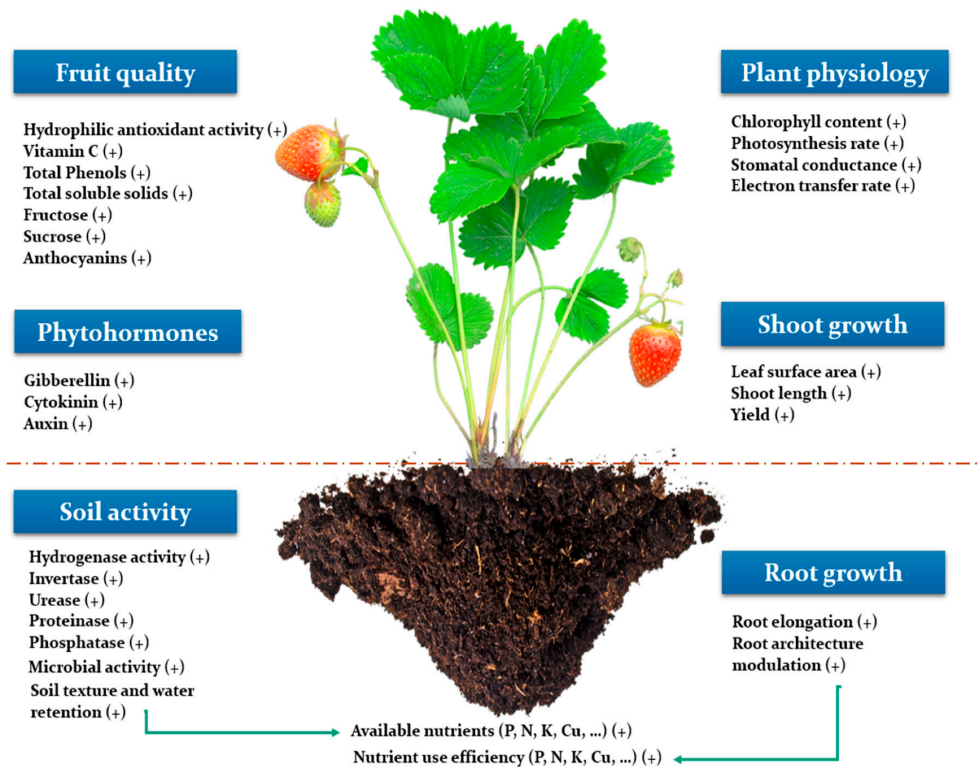
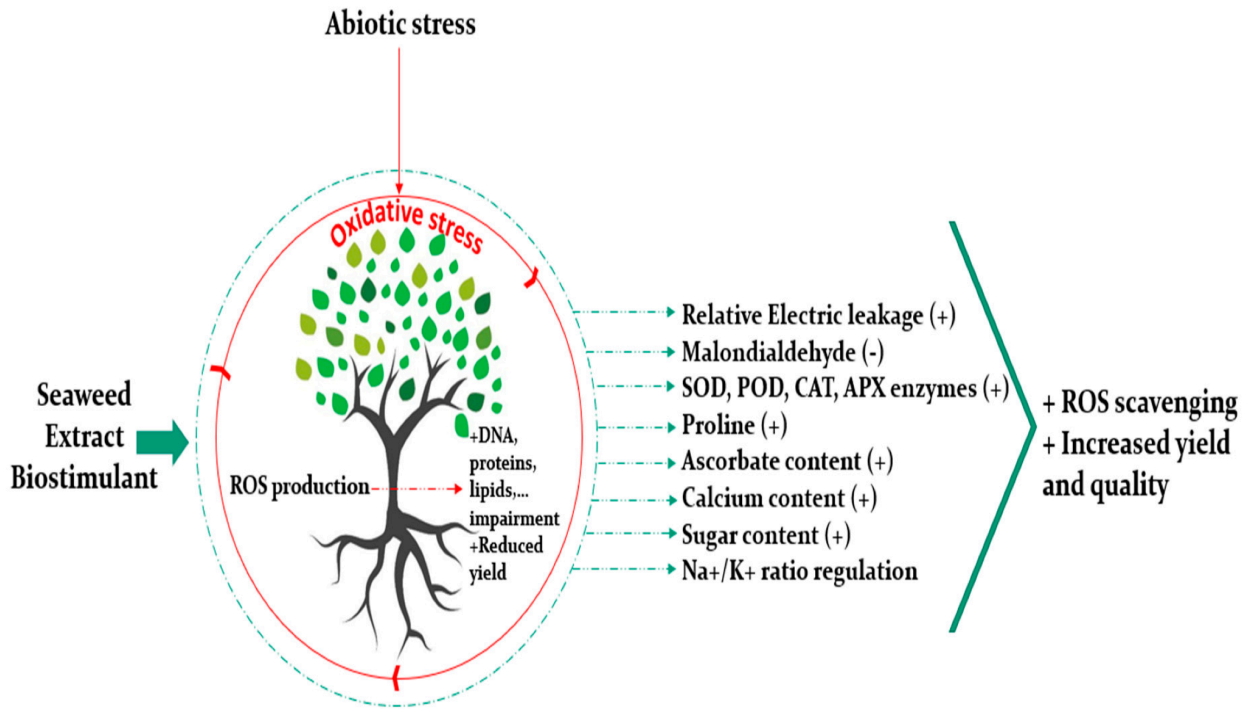


Figure 3. Beneficial effect of seaweed extracts under abiotic stress: Seaweed extracts play an important role in reactive oxygen species scavenging (ROS) through triggering several mechanisms involving stimulation of antioxidants and inhibition of lipid peroxidation. Superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), ascorbate peroxidase (APX). ([Boukhari et al 2020](#))





Project Title:

Determining optimal rooting response of Mung Bean (*Vigna radiata*) to various *Saccharina Latissima* products and dilutions in a growth chamber bioassay

Report to:

Spoitz Enterprises Inc.
215-1610 Pandora Street,
Vancouver, BC, V5L 1L6

From:

Institute for Sustainable Horticulture
Kwantlen Polytechnic University
12666 – 72th Ave
Surrey BC, V3W 2M8

Trial site:

Kwantlen Polytechnic University, Langley campus
20901 Langley Bypass, Langley BC, V3A 8G9V

Director:

Deborah Henderson, PhD

Research Trial Team:

Aria Tamanaei

July, 2025

Background:

Saccharina latissima, commonly known as sugar kelp, is a brown macroalga of the family *Laminariaceae* with a wide distribution across the North Atlantic, Arctic, and North Pacific regions. In recent years, it has garnered significant attention for its sustainable cultivation and versatile applications, ranging from food and feed to biostimulants and biomaterials (Diehl et al.)

Large-scale cultivation of *S. latissima* has been optimized using longline and net systems, achieving yields up to 91 t FW·ha⁻¹ over 1.5 years. This species contributes to nutrient removal and carbon sequestration, enhancing ecosystem services while supporting sustainable agricultural systems (Boderskov et al.).

S. latissima contains a rich composition of bioactive molecules, polysaccharides (alginate, fucoidans), polyphenols, amino acids, minerals (e.g., Fe, Zn, Mn), and plant hormones (auxins, cytokinins), that collectively stimulate plant growth and stress resilience (Pacheco, D et al.). Extracts from brown algae, including *S. latissima*, have demonstrated enhanced root architecture, biomass accumulation, chlorophyll content, and tolerance to drought or salinity stress in a range of crops (Bilan et al.).

Cotas et al (2022), conducted trials using *S. latissima* extract and found significantly increased lettuce leaf mass and micronutrient levels—zinc and manganese—relative to controls, confirming the efficacy of crude seaweed extracts as natural biofertilizers. Another trial using tomato and petunia seedlings found that sugar kelp extracts improved biomass and root index ratings, particularly under low fertilization conditions (NEIWPC 2020).

The stimulatory effect of algal extracts is hypothesized to arise from synergistic interactions among phytohormones, nutrients, and secondary metabolites that activate plant physiological pathways. However, formulation stability, extraction methods, and product consistency play a vital role.

Building upon existing research, this study evaluates a series of *Saccharina latissima*-derived products (Products 1, 2, 3, F4, and F1B) for their potential to enhance root development and biomass accumulation under controlled bioassay conditions. A range of high and low concentration dilutions was employed to reflect the practical need for dosage optimization, aiming to minimize phytotoxic effects while maximizing biostimulant efficacy.

Materials and methods:

Experiment:

In this experiment, two were provided by the Kachemak Kelp Hub, and were selectively fermented prior to packaging. The design of Experiment followed the layout illustrated in Table 1 below.

Treatment #	F4	F1B	Remo	Kelpman	Potassium (10,000 PPM)	Water
Exp 2						
1	10:1					
2	15:1					
3	20:1					
4	25:1					
5	30:1					
6	50:1					
7	100:1					
8		10:1				
9		15:1				
10		20:1				
11		25:1				
12		30:1				
13		50:1				
14		100:1				
15			750:1			
16			200:1			
17			75:1			
18				200:1		
19				75:1		
20				20:1		
21					10:1	
22					20:1	
23					40:1	
24					80:1	
25						1

Table 1: The arrangement of the second experiment.

This experiment consisted of 25 treatments in total. Two test products were evaluated, each at seven different dilution levels (7 treatments per product). Positive controls included two commercially available products, Remo and Kelpman, each tested at three dilution levels (3 treatments each), as well as a potassium solution (10,000 ppm) tested at four dilution levels. A water-only treatment served as the final control. Each treatment was replicated nine times to ensure statistical reliability.

Approximately 500 mung bean seeds were sown in seedling trays (26 × 52 cm) filled with Sunshine Mix #4 as the growing medium. The trays were placed in a controlled-environment growth chamber maintained at 27 °C, under a 16-hour light / 8-hour dark photoperiod and 80% relative humidity for a duration of seven days to promote uniform seedling development (Figure 3).



Figure 1: Mung bean seedlings in seedling trays

To organize the treatments and replicates systematically, twenty mL glass vials were arranged in a plastic box. Each box contained 12 rows, with 9 vials per row, resulting in a total of 108 vials per box (the number of replicates in each box). In this configuration, each row represented a distinct treatment, and each vial within a row corresponded to an individual replicate of that treatment. The complete vial arrangement is shown in Figure 2. Two of these boxes were used in this experiment, plus 10 extra vials for the water control.

The 20 mL glass vials were filled with the appropriate dilutions of the test products and control solutions in preparation for treatment application. Following the initial growth period in seedling trays, uniform and healthy mung bean seedlings exhibiting fully expanded primary leaves were selected. Each seedling was then cut 4 cm below the cotyledonary node to produce standardized cuttings. These cuttings were immediately placed into the prepared vials containing the designated test solutions.

The vials containing the cuttings were placed in a growth chamber maintained at 27 °C, with a 16-hour light / 8-hour dark photoperiod and 80% relative humidity. The cuttings were exposed to the test solutions for a duration of seven days. During this period, vials were routinely monitored and refilled with reverse osmosis (RO) water as needed to maintain consistent solution volumes and prevent dehydration. At the end of the seven-day treatment period, the cuttings were removed from the growth chamber. The number of roots produced on each cutting was counted and recorded. Subsequently, the roots were cut, placed on labeled aluminum foil sheets corresponding to their treatment group, and securely wrapped. The wrapped samples were transferred to a drying oven, where they were maintained at a constant temperature of 30c until fully desiccated. Upon drying, the dry weight (biomass) of each

replicate's root system was measured using a precision analytical balance, and the values were recorded for statistical analysis.

Upon completion of data collection and compilation, a one-way ANOVA was conducted to assess differences among treatments. The analysis indicated statistically significant variation between treatment groups. To identify which specific treatments differed significantly, a Tukey's HSD test was subsequently performed as a post-hoc analysis.

Results:

In this experiment a high rate of plant mortality was observed among several replicates of the F4 and F1B products, particularly at higher concentrations. As illustrated in Figure 7, these treatments resulted in little to no root development and were accompanied by visible symptoms of stress, such as leaf abscission. These findings suggest phytotoxic effects associated with the higher concentrations of F4 and F1B formulations.



Figure 2: Comparison of treatments highlighting phytotoxicity and root development.

Higher concentrations of Product F4 and F1B, specifically Treatments 1 and 2 (F4 at 10:1 and 15:1 dilution) and Treatments 8 and 9 (F1B at 10:1 and 15:1 dilutions), exhibited plant mortality, characterized by stem tissue damage below the cotyledonary node and complete leaf abscission. In contrast, lower concentrations of these products demonstrated a stimulatory effect on rooting. For example, Treatment 7 (F4 at 100:1 dilution) showed enhanced root development with no visible signs of phytotoxicity.

Table 4 shows the statistical differences among the 25 treatments with respect to mean root number and biomass. Treatments that share the same letter are not significantly different from one another. In contrast, treatments that do not share any letters are significantly different. This table provides a clear comparison of treatment performance, helping to identify which products and dilutions had the most consistent and statistically supported effects on root number and biomass.

treatments	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Mean Root #	7.22 ef	3.22 ef	10.11 ef	17.11 def	41.67 cd	48.33 bc	103 a	1.33 f	8.33 ef	7 ef	20.67 cdef	19.44 cdef	33.78 cde	83.67 a	46.44 bcd	87.89 a	97.78 a	80 a	73.56 ab	41.67 cd	0 f	0 f	0.56 f	24.44 cdef	6.56 ef
Mean Biomass (mg)	0.71 e	0.17 e	0.76 e	2.2 e	3.06 de	3.78 de	13.03 a	0.03 e	0.92 e	0.51 e	1.7 e	2.92 de	3.31 de	8.73 abc	4.16 cde	9.98 ab	11.39 ab	11.56 ab	7.63 bcd	2.22 e	0 e	0 e	0 e	3.88 cde	0.02 e

Table 2: Mean mung bean root number and biomass (in mg) of all treatments in Experiment 2. The same letter below means indicates no significant difference between the means.

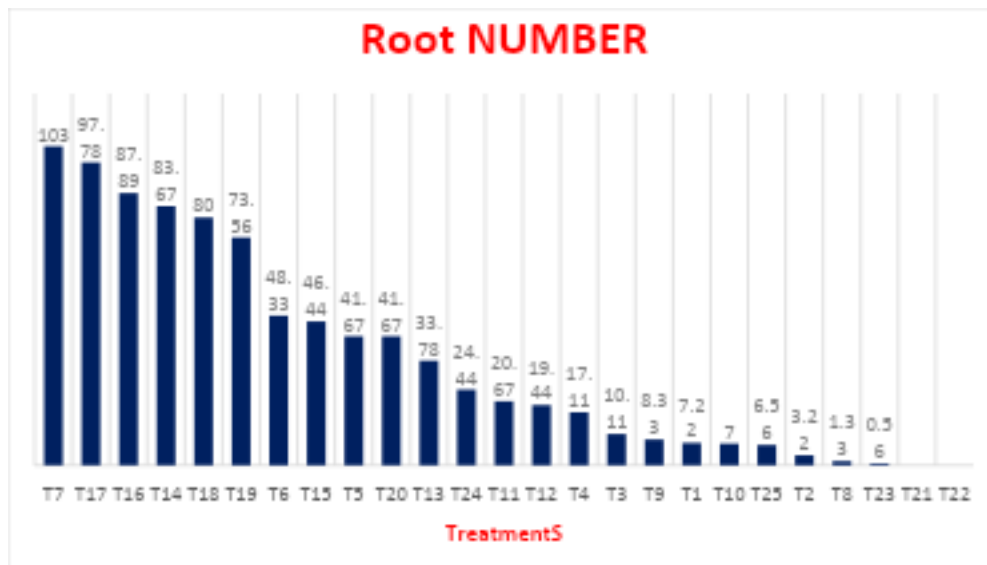


Figure 3: illustrates the average number of roots produced across 25 different treatments, presented in descending order. Each bar represents the mean root count per treatment, highlighting substantial variability in root development under the tested conditions.

Treatment 7 (Product F4 at a 100:1 dilution) and Treatment 17 (Product Remo at a 75:1 dilution) produced the highest root numbers, averaging 103 and 97.8 roots, respectively. These results indicate that this concentration range provided the most positive effect on root initiation. In contrast, Treatments 22 and 21 (Potassium at 20:1 and 10:1 dilution, respectively) yielded no root formation (0 roots).

These findings underscore the variation in treatment efficacy, with only a select few concentrations demonstrating statistically significant root development.

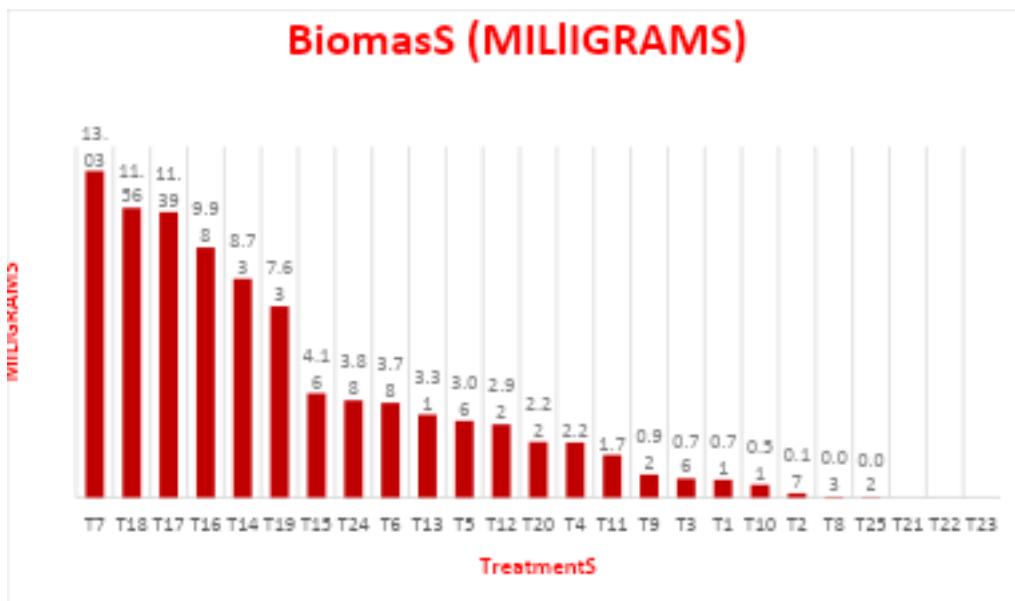


Figure 4: Presents the average dry root weight (biomass) across 25 different treatments, arranged in descending order. Each bar represents the mean biomass per treatment, revealing variability in root development under the tested conditions.

Treatment 7 (Product F4 at a 100:1 dilution) and Treatment 18 (Product Kelpman at a 200:1 dilution) recorded the highest biomass values, with averages of 13.03 mg and 11.56 mg, respectively, indicating a strong positive effect on root growth. In contrast, Treatments 23 and 22 (Potassium at 40:1 and 20:1 dilution, respectively) resulted in no measurable root biomass (0 mg).

Other notable treatments included Treatment 17 and Treatment 16 (Product Remo at 75:1 and 200:1 dilutions), which produced biomass values of 11.39 mg and 9.98 mg, respectively, demonstrating their effectiveness in enhancing root development.

As shown in Table 4, treatments sharing the same letter grouping are not significantly different from one another, while treatments with different letters are statistically distinct in terms of root biomass.

These results emphasize the variation in treatment efficacy, with only a subset of dilutions producing a statistically significant increase in root biomass.

Conclusion:

In terms of root number, Product F4 at a 100:1 dilution demonstrated the highest performance, followed closely by Product Remo at a 75:1 dilution, a commercially available kelp-based biostimulant. Product F1B at a 100:1 dilution ranked fourth overall in root number generation.

Regarding dry root biomass, Product F4 at 100:1 again yielded the highest value, followed by Product Kelpman at 200:1, another commercially available kelp-based product. Product F1B at 100:1 ranked fifth in biomass production.

Overall, between Products F4 and F1B, Product F4 at a 100:1 dilution was the most effective treatment, outperforming others in both root number and biomass, and demonstrating strong potential as a biostimulant in Experiment 2.

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Preliminary Results Jan 2, 2026

Methods summary:

AFES Beets

During harvest, we weighed the total yield from each plot of all harvested, marketable beets after washing (including leaves). Then we cut off the leaves of all the beets and weighed all the beets from the plot. We randomly selected 3 beets from each plot. For those beets, we measured the area (cm²) and weight of one randomly selected leaf per plant. Then we cut off all leaves from each of the selected beets and weighed them (roots only). We cut up the selected leaf and the selected 3 beets and dried them in a drying oven and weighed them again after drying.

- Response Variables:
 - Leaf Area (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)
 - Fresh Weight (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)
 - Dry Weight (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)
 - Fresh Root Weight (of each of 3 randomly sampled beets)
 - Dry Root Weight (of each of 3 randomly sampled beets)
 - Plot Yield - Whole Plant
 - Plot Yield - Root Only

Twitter Creek Beets

The only difference between Twitter Creek and AFES is that at Twitter Creek we not only weighed and measured the weight and area of one randomly selected leaf. But we also weighed all the leaves together from each selected beet plant replicate. We dried all the leaves from each selected plant, together, so that we have the fresh and dry weight of all the leaves for each plant.

- Response Variables:
 - Plot Yield - Whole Plant
 - Plot Yield - Root Only
 - Leaf Area (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)
 - Fresh Leaf Weight (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)

- Dry Leaf Weight (of 1 randomly sampled leaf from each of the 3 randomly sampled beets)
- Fresh Leaves Weight (of all leaves from each of the 3 randomly sampled beets)
- Dry Leaves Weight (of all leaves from each of the 3 randomly sampled beets)
- Fresh Root Weight (of each of 3 randomly sampled beets)
- Dry Root Weight (of each of 3 randomly sampled beets)

AFES Potatoes

Total belowground biomass yield (potatoes only, no leaves) was measured for each plot. From each plot, 5 potatoes were selected and weighed all together (unfortunately, we did not have each of the 5 potatoes weighed individually). Then the group of 5 potatoes from each plot were cut up and dried together.

- Response Variables:
 - Plot Yield - Root Only
 - Fresh Weight (of a group of 5 randomly selected potatoes)
 - Dry Weight (of a group of 5 randomly selected potatoes)

Twitter Creek Potatoes

Every potato from every plot was weighed individually. Then 3 potatoes from each plot were randomly selected, weighed, and then cut up and dried individually. Pest damage and cracking were documented.

- Response Variables:
 - Fresh Weight Potato (of every potato from every plot)
 - Number of Potatoes per plot
 - Average Potato Weight (of all potatoes in a plot)
 - Plot Yield - Total Weight of All Potatoes
 - Number of Cracked Potatoes
 - Number of Pest Damaged Potatoes
 - Fresh Weight (of 3 randomly selected potatoes)
 - Dry Weight (of 3 randomly selected potatoes)

All Plots

For all plots, we qualitatively observed plant characteristics including plant vigor, pest resistance, disease resistance, and bolting sensitivity.

Results

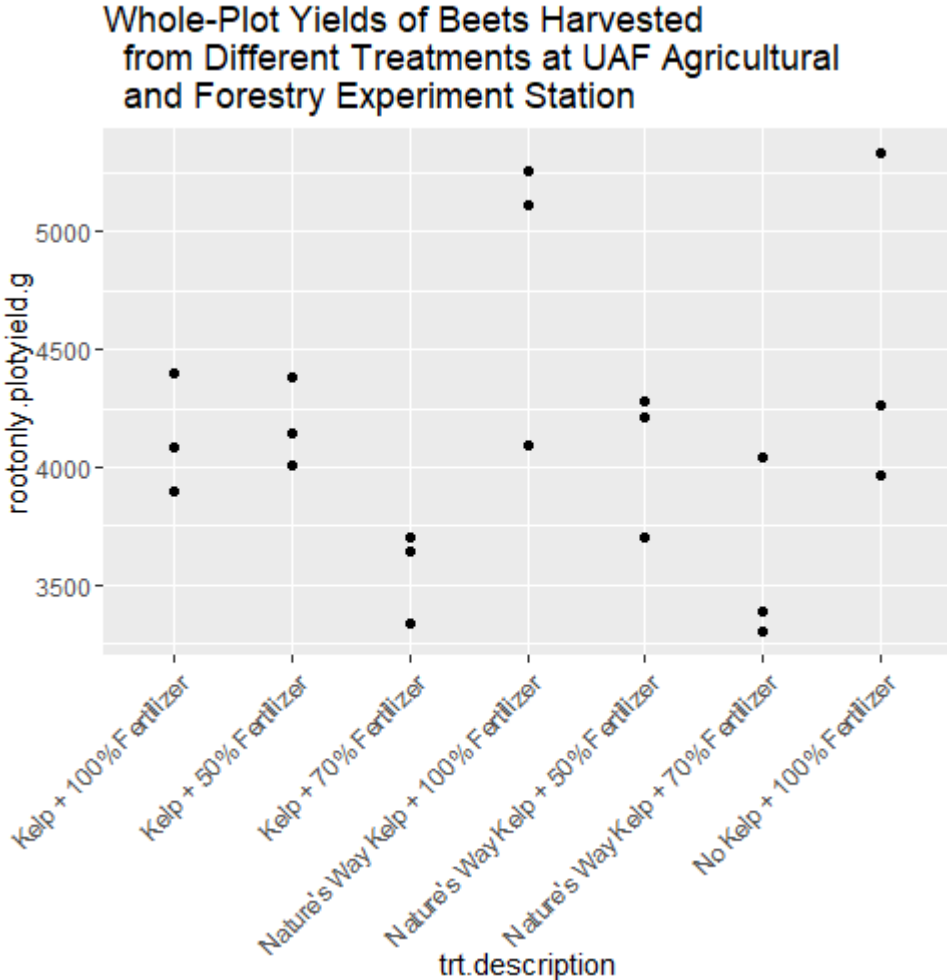
I analyzed the effect of kelp and fertilizer additions on every response variable. These were the results that were significant ($p < 0.05$) or close to significant.

For AFES Beets, 100% fertilizer resulted in higher root-only plot yields than 70% fertilizer. $p = 0.00158$

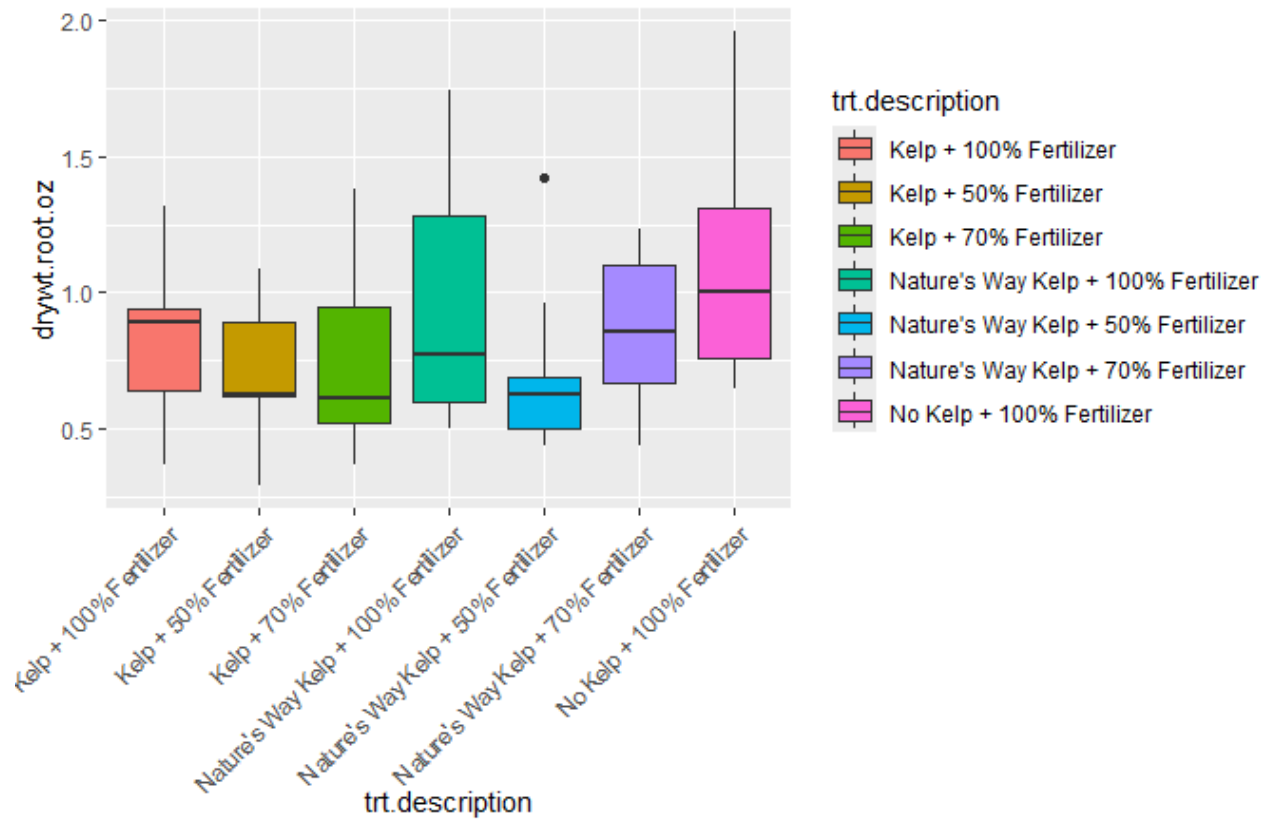
For AFES Beets, 100% fert resulted in higher dry weight of roots than 50% fert $p = 0.0498$

For TCG Potatoes, No Kelp resulted in higher average potato weight than Kelp. $p = 0.0148$

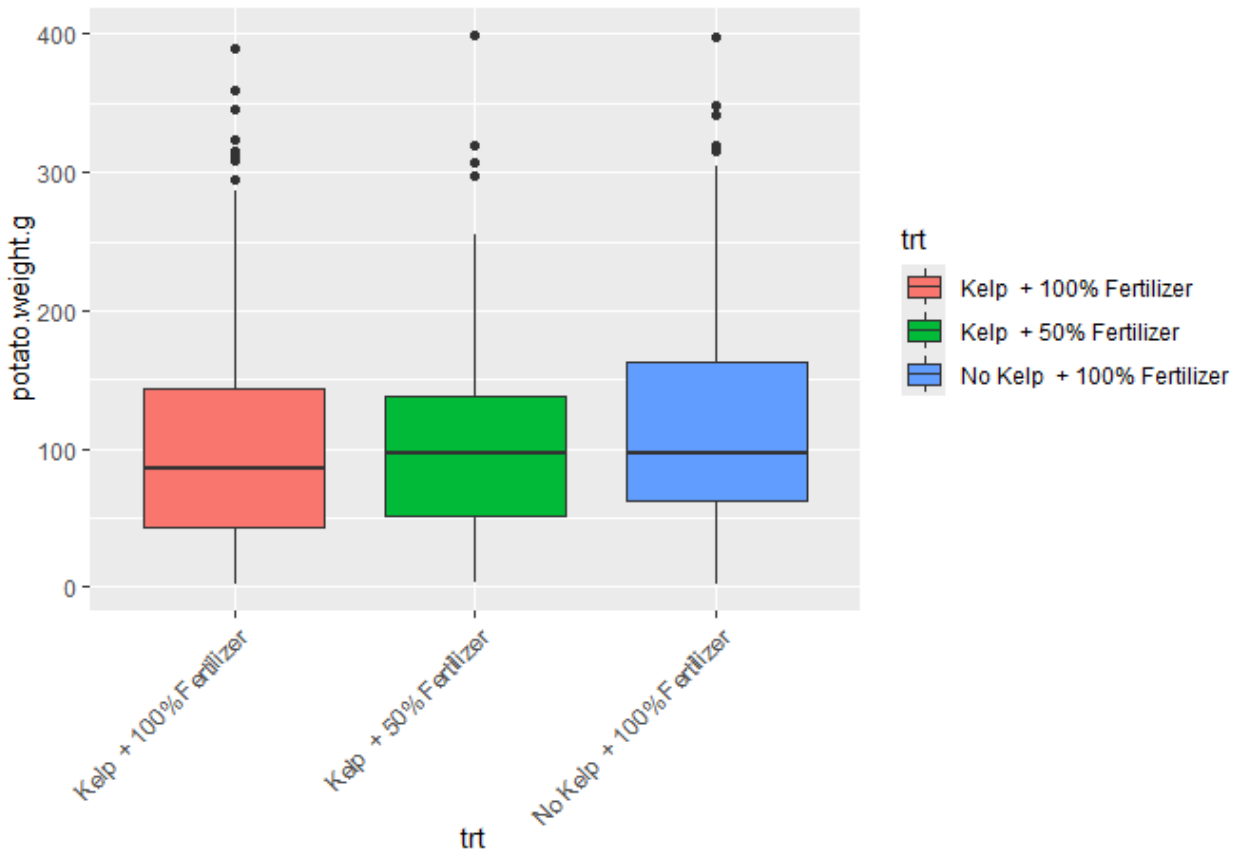
For TCG Beets, Kelp led to bigger leaf area (of 3 leaves subsampled) and higher leaf weights (of 3 weights subsampled) than No Kelp $p = 0.0577$ for leaf area and $p = 0.0574$ for leaf weight



Dry Weights of Beets Harvested from Different Treatments at UAF Agricultural and Forestry Experiment Station



Average Weights of Potatoes Harvested from Different Treatments at Twitter Creek Gardens



Average Leaf Area (cm²) of Beets Harvested from Different Treatments at Twitter Creek Gardens

