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CHEADLE CENTER FOR BIODIVERSITY & ECOLOGICAL RESTORATION

CCBER Undergraduate Student Research Report

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The effect of common soil amendments on the germination and growth of native plants frequently used in restoration in coastal southern California

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ABSTRACT

A common practice in ecological restoration is to amend soil to help promote the growth and establishment of native plants. However, there is often little research done to determine the germinate rate of native species in field soil and how those germination rates are affected by soil amendments. This is particularly important to understand when direct seeding is being planned for a restoration site and to understand how plants will establish in an area after restoration has concluded. In 2017, restoration began on the site of an old golf course near the University of California Santa Barbara (UCSB). Surveys of the former golf course have shown that the soil quality is generally poor, with low levels of nutrients and high salinity. Consequently, the restoration plan will incorporate the addition of amendments to the soil to help with the establishment of native plants. To better understand how the soil amendments will impact the germination rate of native plants that are being targeted for restoration, a greenhouse experiment was undertaken on seven locally sourced plants that are native to the coastal Santa Barbara region. Species were grown in soil collected from the former Ocean Meadows Golf Course at the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) native plant greenhouse and nursery. Seeds were planted in four different potential soil amendments (biochar, gypsum, mulch, and untreated), and their germination and growth measured in early 2017. Six of the seven species germinated in all soil treatments, except for one shrub, which did not germinate in any soil treatment. Growth rates were similar across species, with greater growth rates observed in the greenhouse potting soil for all species. Soil pH and salinity did not have a significant effect on the germination or growth rate of any species. Future studies should look at soil structure, the concentration of nitrogen and other nutrients, and other soil characteristics to determine why some soil amendments promoted plant growth and establishment more than others for native plants. This experiment was undertaken by UCSB undergraduate research interns Anne-Marie Parkinson and Danielle Gantar, who were sponsored by the UCSB Associated Students Coastal Fund.

INTRODUCTION

In 2013, The Trust for Public Land purchased the 64-acre Ocean Meadows Golf Course to restore and preserve the wetlands of the upper Devereux Slough, which, in the mid-1960s, were filled with topsoil for the development of a golf course. The Trust for Public Land gifted the area to the University of California, Santa Barbara (UCSB), who will serve as the long-term steward of the open space. In collaboration with Environmental Science Associates (ESA), UCSB's Cheadle Center for Biodiversity and Ecological Restoration (CCBER) has developed a restoration plan for the area, now called the North Campus Open Space (NCOS). Implementation of the restoration plan began in February 2017.

A key aspect of the restoration plan is to excavate much of the soil that was added to the area to create the golf course, and place the soil onto the upland area along the southwest side of NCOS. Surveys of the former golf course have shown that the soil quality is generally poor, with low levels of nutrients and high salinity. Consequently, the restoration plan will incorporate the addition of amendments to the soil to help with the establishment of native plants. In 2015-2016, UCSB PhD student, Madeline Nolan, conducted an *in-situ* experiment that tested the effect of different soil amendments on the growth and survival of six local native plants. Her experiment assessed the effect of gypsum, biochar, and mulch treatments.

This project extended Madeline Nolan's study by examining the rate of germination and subsequent growth of seven locally sourced native species in the same soil, but off-site at the CCBER Greenhouse. The aim was to advance the understanding of how some native species respond to the different soil amendments. These seven-native species are often used by CCBER in restoration plantings, so this study can inform direct seeding efforts at NCOS. Germination and growth rates were examined for the seven species in each of the amended soils from the field site and in potting soil used for native plant propagation at the CCBER greenhouse and nursery. We predict that the germination and growth rates of all the species will be greatest in the greenhouse potting soil because it has a lower pH and salinity, and more nutrients available then field soils. Between the different amendments, we predict that germination and growth rates will be greater in the amended soil, regardless of amendment type, compared to the control due to the ameliorating effects of the amendments on soil quality.

METHODS

Soil and Seeds

In total there are five different soil treatments (Table 1). The field soil was collected from the experimental plot established at NCOS by PhD student Madeline Nolan in 2015. In November of 2015, three different amendments, biochar, gypsum, and mulch, were applied to the soil in separate sections within the plot. Soil was collected from each section and transported to the CCBER greenhouse. Potting soil used for plant propagation at the CCBER greenhouse and nursery (hereafter termed "greenhouse soil") was add as a fifth soil treatment.

Table 1. Descriptions of the five soil treatments in the experiment.

Soil Treatment	Description
Control	Untreated field soil from the former Ocean Meadows Golf Course. This soil has a high clay content.
Biochar	Field soil with a charcoal amendment that reduces soil acidity (pH), attracts and holds nutrients but does not add nutrients, and increases or decreases salinity depending on the base salinity of soil (Thomas et al. 2013).
Gypsum	Field soil with a gypsum amendment that supplies calcium to the soil without raising the pH and helps break-up and loosen the structure of clay soils (Walworth 2012).
Mulch	Field soil with a mulch amendment that slows down water runoff and allows clay soil to absorb more water, enhances soil moisture and cools soil temperature.
Greenhouse	Commercially available organic potting soil (Sunshine #4) that contains some added nutrient fertilizer and allows for ample aeration and filtration or drainage.

Seeds of seven native species (Table 2) were acquired from locally sourced collections. Species were selected from three different functional groups, shrubs, grasses, and forbs, to represent the three main groups of plants that are used by CCBER in restoration. For each species, 1,350 seeds were counted for sowing.

Table 2. The seven-native species and their lifeforms.

Species	**Lifeform**
Encelia californica (ENCA)	Shrub
Isocoma menziesii (ISME)	Shrub
Salvia leucophylla (SALE)	Shrub
Lupinus succulentus (LUSU)	Forb
Eschscholzia californica (ESCA)	Forb
Stipa pulchra (STPU)	Grass
Elymus glaucus (ELGL)	Grass

Sowing and Study Design

Three germination trays were potted for each of the five soil types, resulting in a total of 15 trays. Each tray was divided into a 7x3 grid with plastic dividers separating the sections (Figure 1). Thirty seeds were sown in each section for a total of 90 seeds of each species in each tray. The species were randomly assigned to one of the seven columns.

Sowing methods for the species varied slightly. ESCA seeds were scatted on top but were not pressed into the soil due to the small seed size. For the other six species, forceps were used to submerge the seed just below surface level, and the soil was then smoothed over to cover the seed. Following sowing, the trays were watered every other day. The trays were kept inside a greenhouse for 4 weeks until the plants germinated. On March 8, after initial germination had occurred for most species, all trays were relocated outside and covered with a chicken wire cage to prevent animals from eating the seedlings (Figure 2).

Figure 1. The grid layout for each of the soil trays.

Figure 2. The caging set up following the first month inside the greenhouse.

Germination Monitoring

Trays were observed every day for seedling emergence, which was when the first leaf primordia or stem emerged from the soil. The date of the first seedling emergence in each section of 30 seeds was recorded as the initial germination date. All weeds were removed from the trays.

Harvesting, Growth and Soil Measurements

Harvesting consisted of manually removing the above ground biomass of the seedlings. Three harvests were conducted, at 4, 6 and 8 weeks. For each harvest, we randomly harvested one-third of the total number of seedlings in all three trays of each soil type. All seedlings were then dried in a 65°C oven for 24 hours. The average seedling weight for each species at each time point was used to estimate growth rate. After the completion of the third harvest, soil was harvested for analysis of pH and salinity. The soil was dried in an oven, at 65°C for 48 hours. The pH and salinity were measured using standard methods.

RESULTS

Germination

Plants germinated in all soil treatments for six of the species (Figure 3). No germination was observed for the shrub Salvia leucophylla (SALE). Across all soil treatments, species germinated on average ten days after being sowed, but the percent of sown seeds that germinated was variable across species and soil types. The grass species, Elymus glaucus (ELGL), had the highest germination rates in all soil types, ranging from 74% in the greenhouse soil, down to 33% in the gypsum treated soil. Conversely, excluding SALE, the lowest percent germination was observed for the shrub species, Isocoma menziesii (ISME), with 1-3 percent of seeds germinating in each soil type.

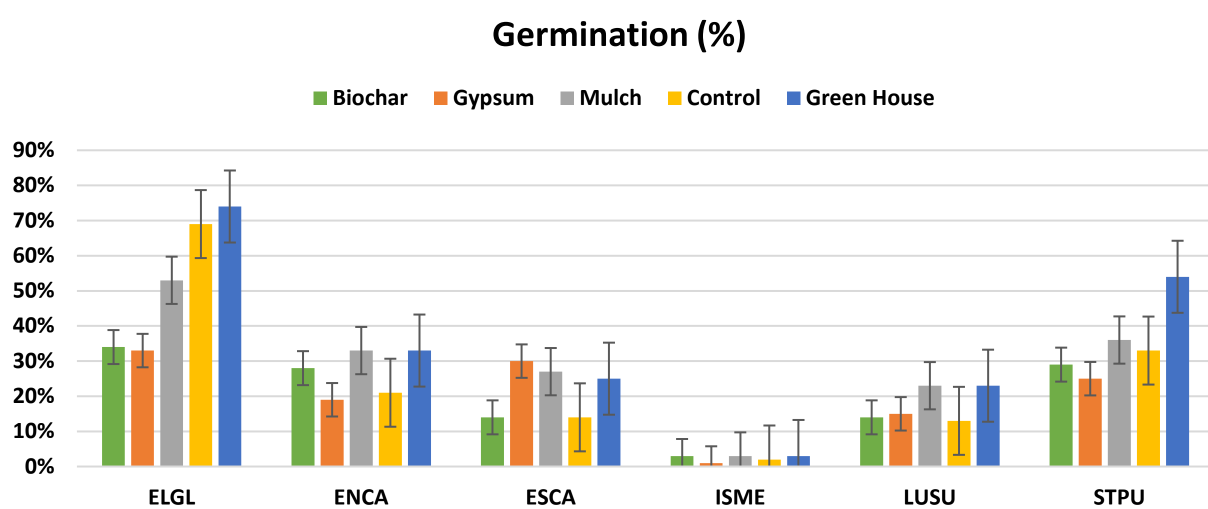

Figure 1. Percent germination by soil type of all seeds sown for six of the species assessed in the experiment. Error bars represent ± 1 standard deviation. SALE is excluded from the graph because it had zero germination in all soil types.

Growth Rate

Excluding SALE, growth rates were similar for most species that germinated, with the greatest growth rate occurring in the greenhouse soil (Figure 4). The exception was the forb species, *Lupinus succulentus* (LUSU), which exhibited greater growth rates than any other species in all soil types, and had the greatest growth rate in the mulch treated soil.

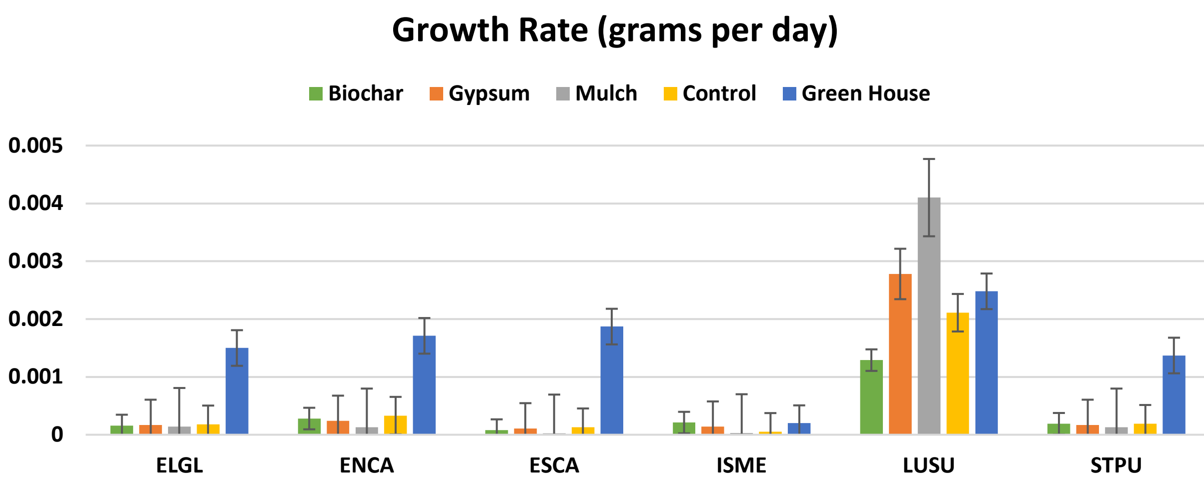

Figure 2. Mean growth rate (grams per day) by soil type of six of the species assessed in the experiment. No germination was observed for the shrub species, Salvia leucophylla. Error bars represent ± 1 standard deviation.

Soil Analysis

The four types of field soil had a greater average pH (9.03) compared with the more neutral pH (6.7) of the greenhouse soil. In contrast, the field soils had a lower average salinity (0.32 dS/m) than the greenhouse soil (0.41 dS/m) (Figures 5).

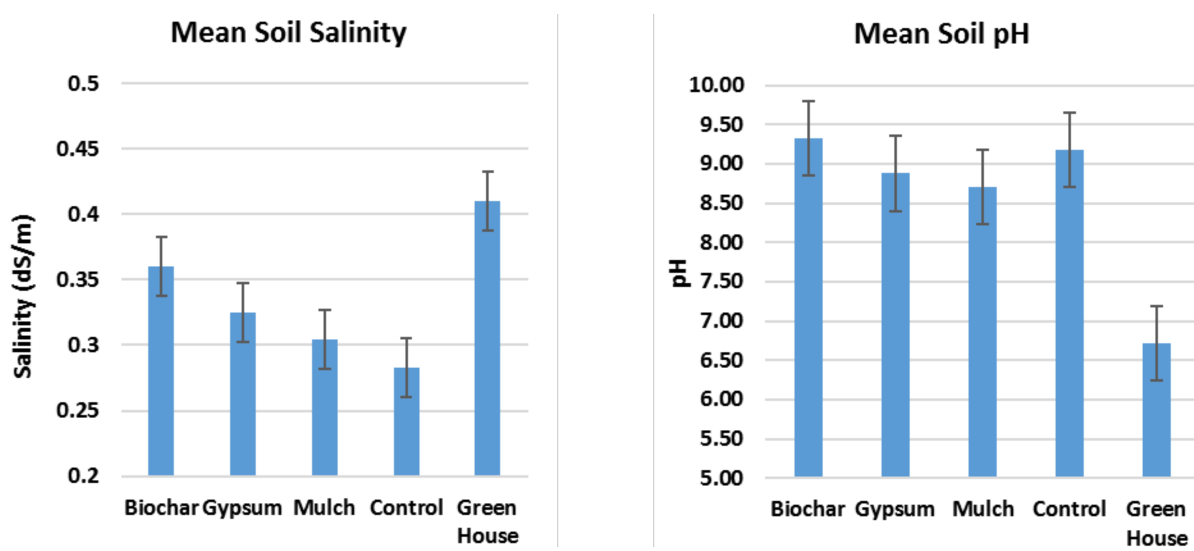

Figure 3. The mean salinity (in decisiemens per meter, dS/m) and pH of the five types of soil assessed in the experiment.

DISCUSSION

We found that most of the native species tested, were able to germinate and successfully grow in all the amended soils. This suggests that the soil, even unamended soil, should not prevent individuals that are direct seeded from germinating and growing. However, depending on the species, more seed might need to be sown in unamended soil to achieve germination rates that could establish a population. Despite high salinity rates being a concern at NCOS, we found that salinity was highest in the greenhouse soils which in turn had the highest growth rates. This result suggests that salinity might not be as big of a concern in the restoration site as previously thought. In addition, the greater growth rates observed for most species in the greenhouse soil could actually be due to a more amenable pH as opposed to being less saline. There could also be other properties of the greenhouse soil that may have contributed to the higher germination rates and growth rates. For example, the greenhouse soil could have higher levels of available nutrients or a soil structure that better promotes aeration and filtration/drainage. In addition, it appeared that the field soils contained a high amount of clay, which would have allowed less aeration and filtration/drainage than the greenhouse soil, but further testing to determine the exact silt, sand, clay proportions are needed. Future studies should expand the number of species that were considered and examine additional soil properties such as soil texture, structure and the availability of nitrogen and other nutrients as these factors may have a greater effect on seed germination and plant growth rates than salinity and pH.

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