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INCORPORATION OF NATIVE PLANTS FOR BIODIVERSITY CONSERVATION IN SOUTH TEXAS AGROECOSYSTEMS

A Thesis

by

KAITLYNN M. LAVALLEE

Submitted to the Graduate College of
The University of Texas Rio Grande Valley
In partial fulfillment of the requirements for the degree of
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INCORPORATION OF NATIVE PLANTS FOR BIODIVERSITY CONSERVATION IN SOUTH TEXAS AGROECOSYSTEMS

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December 2020

ABSTRACT

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I address the concerning disconnect between food production and regenerative ecological principles. First, understanding the foundational processes of seed-dormancy and germination are essential for successful restoration efforts using native species. We examine four common seed treatments (aerated hydroprime, acid scarification, cold stratification, sand scarification) on twelve commercially available species native to south Texas. *Pappophorum bicolor* Fourn. (pink pappusgrass) was sown in the field with the aerated hydroprime treatment, *D. virgatus* (Willd.) B.L. Turner (prostrate bundleflower) was planted after sand scarification treatment, and *Ratibida columnifera* (Nutt.) Woot. & Standl. (Mexican hat) was seeded without treatment. Small-scale field trials were conducted to investigate arthropod diversity and abundance, analyzed by functional guilds and role as pest or beneficial. Eggplant was incorporated in the plots to examine potential cash crop benefits in association with native plant hosts of arthropod-mediated ecosystem services but showed no significance between treatments. *D. virgatus* supported significantly higher pest populations, particularly Hemiptera: Aleyrodidae (whitefly), than control. *P. bicolor* had significantly higher diversity than *D. virgatus.* The uses for native plants in food production in the Lower Rio Grande Valley is only now being researched and deserve further exploration to foster more stable food systems and restore habitat in south Texas.

DEDICATION

This thesis is dedicated to the holistic entity of Earth and all of its inhabitants. I am humbled with the opportunity to delve into a microscopic portion of the many intricate connections that co-create life on Earth. The diverse array of plant and arthropod species that were sacrificed in the name of science have opened my eyes to the paradox of feeding humanity by starving the systems that sustain us. May we bring our awareness to an alternative approach that restores that which has done harm and nurture that which has the power to heal. With gratitude for the opportunity to expand my knowledge on the environment that provides for us, I strive to reciprocate this generosity. With hope, may we sow the seeds of the future to re-establish habitat for mutualistic life to come.

Also to my emotional support doghter, Maizie, whose cuddles helped reduce my stress immensely.

Special recognition to my family – to the most supportive parents, Lynn and Lindsay, the most inspiring sisters, Nikki and Alanna, and to my tia Cathy who adopted me as her own in Texas.

In memory of my dearly departed Grandpa Laurie, whose land stewardship greatly impacted me and led me to this work.

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Special recognition to Stephanie Kasper, who played a pivotal role in designing the field trials and provided appreciated reassurance with her advice and aid. Deepest gratitude to my agroecology lab mates who counted seeds, battled weeds, and collected bees!

Thank you Jorge Trujillo for reading and editing my writing (and for feeding me nutritious foods when I felt I had no time to care for myself!)

This research was made possible thanks to the generous donation of seeds from Douglass King Seeds, Native American Seeds, as well as the Kika de la Garza Plant Material Center.

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CHAPTER I

INTRODUCTION

Land Use History in the Rio Grande Valley

Since the 1900s, the southern tip of Texas has experienced quick fluctuations in land-use. The fertile subtropical climate that allows continuous crop production attracted investors and transitioned the region into an agricultural mecca (Brannstrom and Neuman, 2010). In the 1920's, as cattle ranching grew, invasive grasses from Africa were introduced for grazing (Wied et al., 2020; Schmidt et al., 2008). With these changes, exotic plant species invaded farm fields, urban lots, and natural ecosystems, further threatening the native environment (Rubio et al, 2014; Robertson and Hickman, 2012; Bennett and Strauss 2011; Sands et al., 2009; Fowler and Simmons 2008; Pimentel et al., 2005; Ramirez-Yañez 2005). Within a century, invasive grass communities would dominate the landscape and prevent natural, native community dynamics from re-establishing (Herron-Sweet et al. 2016). Increased interspecific competition alters the aboveground ecosystem composition, disserving native ecosystems (Tognetti and Chanteon 2012; Davies 2011; Tognetti et al. 2010; Clarke et al. 2005) Furthermore, some grasses contain allelopathy, changing the soil and affecting nutrient cycling (Weid et al. 2020; Lankau 2012). The simplified and introduced vegetative structure negatively impacts biodiversity and significantly reduces wildlife habitat (Barnes et al. 2013; Ellis-Felege et al. 2013).

As with most of the country, the Lower Rio Grande Valley (LRGV) was intensively developed with the invention of technologies of the Industrial and Green Revolution. Included in these innovations are practices of deep and repeated tillage with tractors, the application of pesticides and synthetic fertilizers, and more recently, genetically modified crops that resist both pest- and herbicides (Altieri 2011; Jain 2010; Foley et al. 2005; Rosset 2000). Although these technologies led to a production boom, there is now conclusive evidence that the increases are short-lived and eventually outweighed by the environmental impacts these damaging practices have had on hydrological systems (Govers et al. 2014; Elser and Bennett 2011), soil supply (Govers et al. 2017), soil health (Bünemann 2006), and biodiversity of plants and insects (Chaudhary and Kastner, 2016; McLaughlin and Mineau, 1995).

Government subsidies have shaped LRGV commodity production into monocultures of cotton, sorghum, and sugar cane. Federal funding supports investment in expensive equipment specialized to select crops and limits the diversity of food grown. Although this form of agricultural production (with several other crops such as citrus, watermelon, onion, and cabbage) generates an estimated US$ 1.6 billion annually (Santa Ana, 2011), the monoculture crops face increasing disease and pest damage. Cotton production in America has been plagued by Mexican boll weevils (*Anthonomus grandis*) migrating from Mexico to feast on the ~19-million-acre Cotton Belt of America (Lawrence et al. 2019). A cooperative nation-wide Boll Weevil Eradication Program has been successful in reducing the pest presence in most states, but as the southernmost tip of the country, the LRGV is the entry point of these coleopteran pests and the eradication program remains active (Allen 2008; Smith 1998). Initial surveys using pheromone traps allow for early detection of boll weevils, where inputs of malathion ULV, a concentrated chemical insecticide, are aerially applied if found (Jones and Wolfenbarger, 1997). An attempt to solve one problem, another is created with secondary pest outbreaks. Due to non-target effects and chemical drift, pesticides wipe out parasitoids and disrupt predators that normally regulate the tobacco budworm populations, which in turn infest fields at economic injury levels (Butler et al. 2006; Elzen et al. 2000; Collins et al., 1979). This trend of cotton monocultures linked to increased pest pressure is not unusual (Andow, 1983) and is observed in other crops throughout the world (Paredes et al. 2020; Andres et al. 2016).

The summer grain crop sorghum experiences similar pestilence with the epidemic of the greenbug aphid (*Schizaphis graminum*) devastated the crops in 1963 (Harris, 2001). In response heavy insecticidal sprays were applied, but with their rapid reproduction, these sap-sucking pests developed insecticide resistance, entrenching growers in a pesticide treadmill cycle. Insecticides may also have contradicting effects to non-target pests by increasing fecundity, as seen in mites, and potentially catalyzing a pest outbreak through chemically stimulated reproduction (Risch 2012). More recently, genetic modification developed resistant strains and pesticide treated seeds reduced the damage, side effects, and costs by lessening insecticide applications.

The Mexican rice borer (*Daitraera saccharalis*) is the primary pest of sugarcane but rather than resolving the issue through genetic technology, biological control (BC) was first wielded to reduce crop economic injury. BC introduces natural enemies to control a pest population. In this case, parasitoids, organisms that lay their eggs in a living host where the larvae consume the host inside out, were released (Meagher, et al. 1998). Through an integrated pest management approach, BC combined with strategically timed sprays and plowing, and careful use of fertilizer were implemented (Showler et al. 2012). The pest problem continues for growers in light of varied management approaches due to the size and density of single species pests.

As demonstrated through this brief history of case studies of LRGV commodity crops and relative to the resource concentration hypothesis, modern monoculture systems are advantageous to herbivores and support insect outbreaks. Crop-damaging arthropods over-optimize the abundance of food and habitat. These conditions increase rates of immigration and rapid reproduction in a single season (Hunter 2002). Homogenous landscapes with degraded diversity minimize the ecological regulation necessary to maintain stability in these communities, as demonstrated in managed ecosystems that face susceptibility to pest outbreak (Salaheen and Biswas 2019; Horn 2002).

More recently, the Lower Rio Grande Valley (LRGV), which constitutes the collection of Hidalgo, Cameron, Willacy, and Starr counties, has urbanized at a rapid rate of nearly 50% in only a decade (Huang et. al 2011). These changes have contributed to the 95% native habitat loss and extreme habitat fragmentation of the Tamaulipan eco-region (Leslie 2016), urging ecological restoration efforts. With reduced agricultural land, food production paired with restorative agroecological practices show promise in mitigating the destructive changes experienced by the LRGV. The methods of sustainable food production are not exclusive to large farm operations. The stewardship practices we discuss can be applied in all levels from back-yard gardens, to neighborhood parks, to local fruit and vegetable producers. Considering growing urbanization, the need for civic engagement integrating biodiversity and food sovereignty, will be centers of vital preservation of both wildlife and food in south Texas.

Industrial Agriculture: The Cost to the Environment

The expansion of industrial agriculture can be directly linked to the major environmental changes that have occurred within the Anthropocene. Mechanized food production is reliant on consuming substantial quantities of non-renewable fossil fuels reserves

(Qiao et al., 2019; Almaraz et al., 2018; Horrigan et al., 2002). The extraction, combustion, and emission processes are leading causes to air pollution, which negative affect quality of life for largely minority populations (Lelieveld et al., 2019; Woo et al. 2019; Perera, 2017). It is widely accepted that anthropogenic activity, including the overuse of fossil fuels, are accelerating a changing climate.

Deforestation is the second largest source of greenhouse gas emission. The release of sequestered carbon is often associated with land clearing for agriculture at rates of 5,800 $MtCO_2/yr$ (Pendrill et al. 2019; Waheed et al. 2018; Choi et al. 2011). This form of agriculture not only contributes to climate change but also is extremely vulnerable to the changes it influences (Schlenker and Lobell, 2010). Stable, established vegetative systems generously offer regulatory ecosystem services of carbon storage and temperature regulation are no longer available to counter the rising greenhouse gas emissions associated with human activity. The removal of forests is a negative cascading effect that results in the loss of the many generous ecosystems services they offer. Without perennial plant roots grounding soil particles, moisture retention in terrestrial ecosystems is diminished and exposed to erosion through wind and water (Kavian et al. 2014; An et al. 2008). Agricultural soils are disappearing at rates up to 40tons/ha/year. This amounts to a global estimate of 10 million ha, far exceeding the natural restoration of soil systems and that of native ecosystems (Pimentel and Burgess 2013; Montgomery 2007; Pimentel and Kounang 1998). The negative impact industrial agriculture has on the biosphere is also a burden on the economy indicated by a soil degraded associated global production loss of up to US $8 billion a year (Sartori et al. 2019). Exemplifying this call for intensified agriculture, hedgerows (tree lines bordered farmland) have been rapidly removed to increase production size. Without these functional shelterbelts flooding, erosion, wind damage, chemical drift, and pest outbreaks are more frequent and destructive (Baudry et al. 2000).

Eroded soils from cropland contain heavy amounts of synthetic fertilizer, greatly increasing the amount of phosphorus and nitrogen cycling through interconnected ecosystems (Bailey et al., 2020; Withers et al., 2019) These excess nutrients travel into aquatic ecosystems and result in widespread cultural eutrophication - the hypoxic growth of water surface organisms such as algae blooms, which are lethal to marine and aquatic life (Cooperrider et al., 2020). With this, biodiversity is severely reduced, fish and shellfish production decline, and the quality of drinking water worsens accounting for economic losses of US $2.4 billion in the U.S. alone (Wurtsbaugh, et al. 2019).

Perennial stands of plants, which have been historically removed for agriculture, are critical watershed components that regulate water flow where permanent vegetation aids in catching runoff before it reaches water systems (Cole, et al., 2020; Gene et al., 2019; Zak et al., 2018; Stehle et al. 2016). Furthermore, a diverse collection of woody, perennial species not only provide habitat for wildlife but also serve as buffers against the spread of pest and disease (Asbjorsen et al. 2012; Avelino et al. 2011). All of these services are valuable to food production but are not treated accordingly within the industrial system.

Impact on Insects

These conventional agricultural practices, coupled with rapid habitat loss, have often been associated with the steep declines in insect abundance (Leather 2018; Sánchez-Bayo and Wyckhuys 2019; Wagner 2020). Two-thirds of insects known to science have experienced a drastic decline in populations, with a reduced mean abundance of 45% (Dirzo et al. 2018). A recent study in Germany reported a 75% reduction in flying insects over the last quarter century

(Hallmann et al. 2017), and other research raises concerns about the global decline in pollinators (Potts et al. 2010). Insects provide considerable ecosystem services as allies to agriculture as (1) pollinators essential for crop production (Holzchuh et al. 2012), (2) biocontrol agents naturally controlling insect pests, and (3) are at the foundational level of most food networks. For example, the decline of aerial insectivore birds has been directly related to the reduction of their food source (Nebel et al. 2010), which can be detrimental for 60% of bird species that rely on insects for survival (Hallmann et al. 2017). As such, population stability of insects is of significant value to support life on earth, valued at more than $50 billion in the U.S. alone (Losey and Vaughan 2006).

Biodiversity Conservation

Growing concern over the consequences of biodiversity loss is emulated in the rising research on the topic. First developed in the 1970s, agroecology is the integrated study of the ecology of sustainable food systems. Throughout the 50 years of practice impressive transformation in agroecology has shifted beyond its roots of scientific participatory action to further embody a social movement (Gleissman 2015). Ecological intensification is a divergent approach that restores natural processes to supplement or replace external inputs while maintaining production through ecological enhancement (Kleijn et al. 2018). The most common way of implementing this practice is through the concept of ecosystem services, which puts an economic value on the natural, free benefits granted through fit, functioning bionetworks (Chen et al. 2006;). These are broken down into four parts:

1. Provisioning services offering food production, fiber, fuel, and water.
2. Cultural services providing outdoor education opportunities, recreation, spiritual sanctuary, and aesthetics.

3. Regulatory services amending climate, purifying water, mitigating storm damage
4. Supporting services that sustain the other services through healthy habitats, pollination, and natural pest management. In our research we focus on aboveground arthropod-mediated ecosystem services (AMES). Belowground services include soil formation, nutrient cycling, and waste assimilation, which play a vital role in sustainable food production, but will not be dissected in our work.

In line with the diversity-stability hypothesis, biodiversity and ecosystem maintenance highlights the unanimity that the utility (biomass production, decomposing, nutrient cycling, etc.) of ecological communities is degraded when biodiversity is reduced. Higher densities of plant diversity have been linked to improved ecosystem services (Isbell et al. 2011), but when depleted, instability and cascading effects of rapid change occur (Craven et al. 2018; Cardinale 2012; Tilman et al. 2006), such as pest outbreaks discussed earlier. Furthermore, recent studies have suggested positive relationships between biodiversity and extreme climatic factors (De Boeck et al. 2017; Hautier et al. 2015). Community composition and ecological relationships offer paths to resistance and recovery in response to disruption (anthropocentric or natural). We will be applying this scientific perspective to semi-natural habitat management approaches of agroecological systems.

Ironically, agriculture depends on the services functioning ecosystems provide; yet large-scale conventional practices and related land conversion are largely contributing to the decline of necessary services (Lanz et al. 2018). The connection between diversity and stability relays into agriculture through the crop diversity-stability hypothesis where multi-cropping systems support stable annual harvests (Renard and Tilman 2019). Diversified farming systems combine both the ecological and agricultural approaches through the incorporation of functional biodiversity, mimicking natural environments that support sustainable food production (Kremen et al., 2012).

An estimated 13% of annual U.S. crops are consumed by herbivore pests. This amounts to US $18.77 billion in lost production every single year (Jones and Snyder 2018).

When reliance on chemicals continues to be the first response to this problem, costs continue to rise. Consequences from pesticide use results in up to $10 billion in damages to environments and human health every single year in the U.S. (Pimentel 2005). A current unmitigated aspect to these expenses is the decline of natural enemy populations.

Parasitoid-host relationships are specific and complex, co-evolving with micro-adaptions in volatile compounds (jasmonic acid response in plants to herbivore feeding) or morphological modification, over numerous generations (Bruinsma et al., 2008). This evolutionary arms race requires energy but with increasingly scarce and fragmented floral resources, parasitoids have faced a life-threatening trade-off between host and non-host food. Nectar availability directly increases fitness through extended lifespan (Berndt and Wratten 2001; Johanowitz and Mitchell 2000), fecundity (Zehnder et al., 2007; Wratten et al. 2001), maintenance, activity, and focus (Wäckers 2003). Predators and natural enemies are known to travel shorter distances to forage (Woodcock et al. 2010, van Emden 2003), heightening the need to implement natural resources and restore surrounding agricultural habitat.

Studies report reduced pest incidence due to increased predator presence in correlation to nearby natural habitat (Alignier et al. 2014; Chaplin-Kramer et al. 2010). For example, beetle banks, the purposeful planting of grassy strips along and within farm fields, provide habitat for predators. Although this practice may require an investment of 0.5% of the land, it has been documented to return an increased crop yield of 5% (Landis et al. 2000). Beetle banks have been implemented as an adaptable alternative to hedgerows, where farmers can incorporate pieces of perennial biodiversity allowing flexibility for production structure changes. Alternatively, if a beetle bank matures for more than a decade, the natural process of succession will take place and emergent woody plant species will begin to evolve the biodiversity edge as a comparable hedgerow (Thomas et al., 2006).

Insectary strips are another method used to build biodiversity through habitat management and support pest management services on farms, particularly targeting parasitoids (Landis, 2000; Zehnder et al., 2007). Studies on cropping systems of collards, lettuce, cereal grains, and eggplant demonstrate successful outcomes with the use of floral conservation (Aparicio et al. 2018; Riberio and Gontijo 2016; Roberts 2015; Hogg et al. 2011; Patt et al. 1997). *Lobularia maritima* (Sweet Alyssum) is a popular candidate of biocontrol for widespread pests such as aphids, thrips, and whitefly (Riberio and Gontijo 2016; Qureshi et al. 2010; Chaney 2004; Johanowicz et al. 2000). *L. maritima* is well studied, but with a native Mediterranean range it may not be the most suitable for effective application in global climates, like the subtropical semi-arid region of south Texas. Through a lab study investigating impact on parasitoids, *L. maritima* was documented to support lifespan of parasitoids to 4x longer and increasing parasitism 3.6x than without floral resources, with similar results to local "weeds" (Araj et al., 2018). Recently *L. martima* has become a "weed" itself where California reports its invasiveness. Although the floral resources are beneficial for agriculture, this species may outcompete native vegetation in more natural environments, reducing biodiversity, and thus potentially opposing their intentional use as Conservation Biological Control (CBC) (Cal-IPC).

In addition to beetle banks and insectary strips, combining top down with bottom up approaches, such as trap copping through the 'push-pull' method, is effective at diverting pests from the cash crop (Cook et al. 2007; Khan and Pickett 2004). This stimulo-deterrent strategy includes particular plants with feeding or oviposition repellant and/or attractant qualities to relocate herbivores away from the cash crop (Eigenbrode et al. 2016; Hassanali et al. 2007). This method is most effective when implemented simultaneously by incorporating deterrents alongside the cash crop and adding appealing plants as bait along field edges (Bhattacharyya 2017) but can also be implemented individually (ie. intercropping with companion plants or insectary strips). This technique is highly variable, as all sensory cues – visual, tactile, gustatory, or olfactory – must be taken into consideration before applying or whilst adapting growing practices (Roitberg 2007). Native plants can disrupt pest damage through their morphology via color, surface textures (trichomes, waxy surfaces, etc.), or chemically through their palatability, or scent that can impact oviposition or feeding (Khan et al. 2016). Non-host odors that native volunteer plants release can disrupt the olfactory cues and kairomones that host-crops emit, making it increasingly difficult to locate the crop and thus decreasing damage (Eigenbrode et al. 2016).

The biocontrol strategies reviewed all reduce pesticide use, which limits the development of pest resistance, thus saving farmers expenses on chemical sprays, which are often inaccessible for small-scale farmers (Khan et al. 2011). Reducing the use of chemical deterrents ultimately protects wildlife and human health as well (Pimentel 2005). However, the inclusion of native plants to meet these goals has not been widely adopted, likely due in part to limited research addressing native plants as contenders as well as the negative connotation they have been assigned by conglomerate corporations.

Natural Solution in Native Plants

Plant species that have evolved in south Texas are better adapted to the local climate conditions. The LRGV is characterized as semi-arid subtropical climate, where native plants have developed high resistance to the seasonal irregularities of droughts with lower water requirements. Native plants are also adapted to local soil and ecosystem conditions with increased resiliency to complex dynamics through lower nutrient and pest-control requirements (Gibson et al. 2016; Lankau 2013; Garrido et al 2011; Simmons et al. 2011) The perennial nature of many native plants allows for habitat permanency for a year-round provision of resources, especially for arthropods, supporting stable environments. Economically, the initial costs involved with investing in the restoration of native habitat are minimized through a natural reseeding cycle. When naturally occurring plants, which weave the fabric of life in ecosystems, are removed cascading effects follow (Kinzig et al. 2006). Modern agricultural practices continue to contribute to the removal of native plants, the habitats they provide to the natural world, and the free ecosystem services associated (Pendrill et al., 2019).

In light of the mounting ecological disturbances affiliated with conventional practices, the US government is responding through agricultural conservation easements such as the Conservation Reserve Program (CRP), State Acres for Wildlife Enhancement (SAFE) Initiative, the Grassland Reserve Program, and the Farmable Wetlands Program. Rarely do these programs center native flora as critical players in ecosystem restoration or acknowledge their capacity to not only meet the needs of individual programs (reducing run-off, soil erosion, etc.) they also restore wildlife habitat. Encouraging or even mandating the implementation of native plants can significantly stabilize declining native plant communities.

To effectively re-establish populations of natural vegetation and the habitat for valuable arthropod allies, viability and germination are foundational physiological processes to analyze (Menges, E.S, 2000). Viability as a measurement of a seed's living tissue and its potential to break dormancy, builds a base of comparison for effective germination strategies. Germination is much more variable as the developmental process of mature, viable seeds depend on a contingent of factors such as ideal temperature, water, and physiochemical signals to break dormancy (Baskin & Baskin, 1998).

Plants are taxonomically classified based on genetic and evolutionary relationships. To accentuate the research presented, the species studied have been classified into families Poaceae, Fabaceae, and Asteraceae. These groupings provide information on variable functions that can be applied to diverse fields.

Monocot species of grasses in the Poaceae family are highly adaptable. These R-strategists depend on abiotic factors for their reproduction, developing self-fertilization through wind or water, or asexually spreading through rhizome or stolon roots systems. With reduced, inconspicuous florets on a spikelet, grass species have specialized in self-pollination (Richards, 1990). Considering these generative dynamics, the germination methods for our study species are hypothesized to be most successful in aerated hydropriming and cold stratification treatments, which are not reliant on animal interaction.

Legumes are plant species in the family Fabaceae, which are characterized by their ability to fix nitrogen. This is a favorable trait to source the macronutrient into soil systems and enrich crop plants with lesser synthetic inputs that tax ecological stability through consequences such as eutrophication (Conley et al. 2009). Most of these species produce hard-shelled seeds, which are impermeable to water, exhibiting physical dormancy that requires environmental factors to invoke germination (Hu et al. 2009; Baskin et al. 2006; Alderete-Chaves, et al. 2011). Endozoochory is a natural process that stimulates germination of legume species with exposure to digestive enzymes and microbial fermentation that helps break physical dormancy (Venier et al 2012). Based off of the seed structure and previous research, the legume study species are predicted to have highest germination when the physical dormancy is broken through scarification treatments.

Flowering herbaceous plants such as forbs often have showy reproductive structures, which have evolved to attract animals to acquire their pollination services. We studied four species in Asteraceae, a highly diverse family containing 10% of all angiosperms (Broholm et al. 2014). Seasonal perennial behaviors led us to believe that the cold stratification would break-dormancy as observed in wild populations and has been supported in scientific literature (Eddleman and Meinhardt, 1981). The seeds also sustain granivore animal diets where animal sometimes act as dispersal mechanisms, leading us to believe that the acid scarification will have an effect on their germination as well (Heleno, et al. 2011).

Summary

My passion for native botany in alignment with the need for preserving biodiversity while concurrently producing healthy foods to feed a growing population inspired this work. Our research endeavor aims to expand our knowledge on native flora and their associated arthropod-mediated ecosystem services (AMES) to develop locally adapted agroecological practices in the LRGV. In this thesis, we first break down the processes of germination in 12-commercially available native plants through laboratory experimentation on five dormancy-breaking treatments. Based off the results disclosed in chapter two, we proceed to select successful species to incorporate in field trials detailed in chapter three. We investigate arthropod relationships between a diversity of native and non-native species in a small-scale food production system. We hypothesize pollinator and parasitoid presence to be highest in the native aster, *Ratibida columnifera* (Mexican hat) and anticipated volunteer *Helianthus annuus* (common sunflower) in the control, as well as highest fruit set in the cash crop. We predict the native grass *Pappophorum bicolor* (pink pappusgrass) will host a significant amount of predators, which we predict would correspond with lowest damage in the cash crop.

Finally, I synthesize this work in the final chapter on the broader impact of research in the LRGV. Included are recommendations for local growers, researchers, and active civic scientists. I conclude by addressing philosophy on indigenizing food systems and reclaiming community power

CHAPTER II

IMPACT OF SEED PRE-TREATMENT ON THE GERMINABILITY OF SOUTH TEXAS NATIVE PLANTS

Abstract

The incorporation of native plant species is central to restoration efforts, but often is limited by both the availability of seeds and the relatively low germination rates of seeds that are commercially available. Certain treatments are known to help improve germination rates, but efficacy of these treatments are species specific. In this study we simulated four common seed treatments (physical scarification, acid scarification, cold stratification, and aerated hydropriming) to examine the effect of these treatments on seed germination of 12 commercially available species native to south Texas. We found that the impact of the different seed treatments was species specific, where the hydroprime treatment resulted in 100% germination in *Pappophorum* bicolor (pink pappusgrass) while it resulted in lowest germination in *W. acapulcensis* var. *hispida* (zexmenia) with 0% germination. Similarly, acid treatment had 55.6% germination in *R. columnifera*, and only 1.7% in *Dalea purpurea* (prairie clover). Our results offer recommendations on species specific seed treatments to achieve maximum germination rates for native plants in south Texas.

Introduction

Native plant species are well adapted to local environments – they often have fewer resource requirements, lower maintenance needs, and thus less dependency on inputs (Bratcher et al. 1993). They also contribute to biodiversity to stabilize ecosystems (Meyer 2006). As a result, these plants can provide tremendous ecosystem services when incorporated into landscaping, restoration efforts, and even in farms. For example, native plants implemented in horticultural systems host lower densities of thrip pests (Schell et al. 2010) and compared to exotic plants, native plants attract higher numbers of natural enemies (Fielder and Landis 2007), showing promise for native plants integrated in pest management. Furthermore, native plants offer soil stabilization, erosion reduction, and mitigate chemical runoff from entering waterways (Helmers et al. 2012; Geertsema et al. 2016), at a relative low cost.

Improving germination rate of native seeds are essential for successful restoration efforts using native species (Donohue et al. 2010; Jiménez-Alfaro et al. 2016). Many plant species have low seed viability as a strategy against seed herbivory, and long-term ecological survivorship (Elias et al. 2006; Baskin and Baskin 2014). Though efforts in selective breeding have helped to improve seed germination in some commercially available seeds, germination rates are still relatively low, for example, we recorded germination rates can as low as 0-1.7%. Pre-sow treatments can improve germination rates of some species, ultimately improves efficiency of restoration efforts by reducing seed loss and maximizing investments in transportation, planting, etc. (Adkins et al. 2002).

Common techniques for improving seed germination often mimic environmental events that break seed dormancy of viable seeds. For example, sand scarification treatments represent seed damage from ungulate trampling and digging mammals (Olff and Ritchie 1998). Acid scarification imitates endozoochory simulating the process of seeds traveling through digestive tracts of granivorous birds and mammals (Cosyns et al. 2005; Ramos et al. 2006). On the other hand, certain seeds will stay dormant until exposed to a certain amount of time in cold temperature or warm, damp conditions. In this case, cold stratification, or the purposeful regulation of temperature changes, may help native seed banks that are then often activated in the spring as the weather warms (Rehman and Park 2000; Baskin et al. 2004). Another seed treatment includes aerated hydropriming, which re-creates the natural occurrence of heavy seasonal rains. Common germination-inducing practices listed in Table 2.1 are often used to improve seed germination and are commonly employed in a variety of application and situations. These natural events occur within south Texas, but the erratic frequency of such is not supportive to intentional restoration, which requires well-coordinated conditions. This is only a small selection of literature within a growing field of study that merely suggests potential correlations but does not determine the highly variable.

In this work, we investigate the impact of four seed treatments on the germinability of 12 different commercially available plants native to southern Texas (Table 2.2). Most of these species are commonly used in restoration efforts across the region. We compare how these treatments – including acid scarification, aerated hydroprime, cold stratification, and sandpaper scarification – may improve the germination of viable seeds relative to a control treatment.

Methods

For this study, we examine 12 different species that were commercially available at the time of this project. All species are native to south Texas and are relevant in the restoration of agricultural land across the region. Seeds included in this study are listed in Table 2.2. Seed source ID: i) Douglass King Seeds (San Antonio, TX), ii) Native American Seed (Junction, TX), and iii) Kika de la Garza Plant Material Center (Kingsville, TX).

Pre-Treatment

We treated seeds (n = 10; per 12 spp.) with a pre-experiment sterilization protocol using a 1:1 de-ionized (di-) water and bleach (6% sodium hypochlorite) (Great Value, Bentonville, AK) solution for 10 minutes in rotational equipment, where we implemented the incu-shaker and a centrifuge for different seed sizes. For smaller grass seeds we separated by replication in 50-mL centrifuge tubes (Fisher Scientific International Inc., Pittsburgh, PA) but for the larger forb and legume seeds we combined all replications in a flask and sterilized with an incu-shaker (Benchmark Scientific, Sayreville, NJ). We rinsed seeds with di-water through the equipment and repeated three times (modified Lindsey et al. 2017).

First, we conducted an initial seed germinability test for all 12 species by sorting seeds form each species into groups of 100, recording the weight of 10 replications, then averaging the results, and using this weight as reference for the remainder of the experiment. We placed each group within an assay of 100x15-mm petri dishes (Fisher Scientific International Inc. Pittsburg, PA), lined with Whatman no. 1 filter paper (GE Health Life Sciences, Chicago, IL). To each dish we added 4-mL of di-water before sealing with Parafilm (Bemis Company, Inc. Beenah, WI). Assays were placed in a controlled environmental chamber (Percival Scientific, Perry IO) with 14:10 light/dark cycle, 27°C, and 65-70% RH.

Seed Viability

To examine seed viability, we exposed subsets of each species bioassay (n=10) to 4-mL of a 1% 2,3,5 triphenyl tetrazolium chloride (TTC) solution before sealing the petri dish. TTC is commonly used to indicate viability as it stains mitochondrial respiring tissues (França-Neta and Krzyzanowski 2019; Verma and Majee 2013). Two hard-coated legume species (*L. texensis* and *A. angustissima*) were imbibed in di-water for 24-hours in preparation for TTC exposure. All viability assays were stored in room temperature with no light. We recorded viability by dissecting seeds and recording stained seeds after 3-4 days.

Post-Treatment

We applied four commonly used germination techniques – sandpaper scarification, acid scarification, cold stratification, and aerated hydroprime - and tested their potential for improved germination to our study species (Table 2.2). A subset of assays was then treated using the methodologies below before imbibing them with water and incubating the seeds in the environmental chamber, where they were left for 10 days (Chambers et al., 2018; Wang et al., 2016; Sondheimer and Galson, 1966). Every other day the replications were temporarily removed from the environmental chamber to count and record radicle and cotelydon growth. The following methods were applied by replication (n = 10) where each replication contains ~100 seeds.

Sand Scarification

The smaller seeds of the Poaceae family (*P. bicolor, C. cucullata, C. subdolistachya, and B. repens*) were separated by replication (n=10, 100/n) and scrubbed between two pieces of 60-coarse sandpaper (#3, St. Paul, MN). Larger seeds of Asteraceae (*R. columnifera, S. calva, G. pulchella, W.*), and Fabaceae (*D. virgatus, L. texensis, A.angustissima, D. purpurea*), also separated by replication (n=10, 100/n) were shaken in a glass jar lined with 60-coarse sandpaper. Both methods were conducted for approximately 60-seconds before plating with 4-mL di-water.

Acid Scarification

We soaked our 12 study species (n = 10, 100/n) in 10% H_2SO_4(Burgoon Company, Texas City, TX, USA) for 50-minutes. Using coffee filters (Great Value, Bentonville, AK, USA), we strained the seeds and rinsed with di-water three times before placing seeds into the petri dish with 4mL di-water.

Cold Stratification

We wrapped seeds by replication (n = 10, 100/n) in a paper towel dampened by tap water, removing excess water by wringing it out. We organized the replications by species in labeled cups and placed them in a freezer (-18°C) for 60-days. Seeds thawed for ~ 60 minutes before plating with 4mL of di-water.

Aerated Hydroprime

Seeds of all study species were separated by replication (n=10, 100/n) in drawstring bags (Dollar Tree, Chesapeake, VA, USA), tied to a 5lb weight plate, placed in a 20-gallon tank (AquaPhoenixScientific, Hanover, PA, USA), and filled with 10-gallons of tap water. An aquarium aerator (AquaCulture, Bentonville, AR, USA) exposed the seeds to micro-bubbles for 24-hours before plating with 4mL di-water.

Control

We conducted no treatments to all replications (n=10, 100/n) for all 12 species. The addition of 4-mL di-water, consistent amongst all assays (except viability), remained true for the control as well.

Statistical Analysis

Data was subjected to normality test and due to the non-normal nature of the data, median and the interquartile range were used to summarize the data, and non-parametric tests, including Kruskal-Wallis, and Align Rank ANOVA were used to analyze the data in the study.

Comparison of the germination rates and the viability among the species were conducted using Kruskal-Wallis test. Significant differences in the final germination within each species were evaluated using Holm's sequential Bonferroni adjusted multiple comparisons with Mann Whitney U Test (Holm 1979). The Mann Whitney U pairwise comparisons were used within individual species with a total germination >10%, across all five treatments. Interaction between treatments and individual species on the total germination was analyzed using an Aligned Rank ANOVA. All tests were tow-tailed and performed at a significance level of 0.05 using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, AT).

Results

Preliminary Analysis – Summary Statistics

Table 2.3 summarizes total median germination and viability of the 12 study species. Species are sorted by the median germination, a total of all five treatments (n=50), presented in descending order. *R. columnifera* had the highest viability (78.7%) as well as germination rate (62%) in contrast to *A. angustissima* with lowest viability (12.3%) and *G. pulchella* and *W. acapulcensis* with 0% germination. Similarly, *D. virgatus, B. repens, C. subdolistachya, D. purpurea,* and *W. acapulcensis* had <10% median germination. *R. columnifera, C. cucllata, P. bicolor,* and *S. calva* exhibited strong prospects for germination with >70% viability.

Germination

Figure 2.2 displays final germination on day ten within select species that produced germination >10%. Species meeting this standard and included in this analysis are *C. cucullata, D. virgatus, L. texensis, P. bicolor, R. columnifera,* and *S. calva.*

The best germination results throughout the entire experiment (within all treatments and between all species) were found in *P. bicolor.* The aerated hydroprime on *P. bicolor* germinated at 100%, significantly higher than acid (Mann Whitney U; $t = 13.1$, $df = 10$, $p = <0.000$), cold (Mann Whitney U; $t = -13.6$ $df = 10$, $p = <0.000$), control (Mann Whitney U; $t = -7$, $df = 10$, $p = <0.000$), and sand (Mann Whitney U; $t = 10.8$, $df = 10$, $p = <0.000$).

There are no statistical differences among the top germination output in control, acid scarification, and the aerated hydroprime treatments in the *C. cucullata* of final germination. Sand scarification performed significantly lower than acid scarification (Mann Whitney U; $t = 6.2$, $df = 10$, $p = <0.000$), aerated hyrdroprime (Mann Whitney U; $t = 7.8$, $df = 10$, $p = <0.000$), and control (Mann Whitney U; $t = 6.34$, $df = 10$, $p = <0.000$). Cold stratification reported significantly lower germination than acid scarification (Mann Whitney U; $t = 7.6$, $df = 10$, $p = <0.000$), aerated hydroprime (Mann Whitney U; $t = 3.9$, $df = 10$, $p = <0.000$), and control (Mann Whitney U; $t = 7.7$, $df = 10$, $p = <0.000$).

In all the bioassays *R. columnifera* had the highest accumulative germination rate of all species (Table 2.1). All treatments, except sand scarification produced comparable germination results >50% by the end of our tend day trial. Acid scarification (Mann Whitney U; $t = 8$, $df = 10$, $p = <0.000$), aerated hydroprime (Mann Whitney U; $t = 8$, $df = 10$, $p = <0.000$), cold stratification (Mann Whitney U; $t = 12.3$, $df = 10$, $p = <0.000$), and control (Mann Whitney U; $t = 11.5$, $df = 10$, $p = <0.000$) produced significantly higher germination than sand scarification.

When analyzing the *S. calva*, there is no significant difference between cold stratification and acid scarification or between acid scarification and aerated hydroprime treatments. However, the highest germination results found in cold stratification were significantly higher than aerated hydroprime (Mann Whitney U; $t = 4.55$, $df = 10$, $p = <0.000$). The control showed significantly lower results than cold stratification (Mann Whitney U; $t = -8.8$, $df = 10$, $p = <0.000$) and acid scarification (Mann Whitney U; $t = -4.9$, $df = 10$, $p = <0.000$).

To understand the process of time-to-germination, we apply the same statistical analysis to the second day germination results comparing all treatments. We notice species germination sooner with treatment than without. In all species, except *P. bicolor* and *L. texensis*, (not included in Figure 2.3) a seed treatment accelerated germination early based on second day results. Of the top candidates we explore, 50% of the study species had the highest germination output with the aerated hydroprime treatment. In particular, the aerated hydroprime treatment for *R. columnifera* demonstrates early germination that is significantly higher than all other treatments. For example, it produced 4x the germination compared to the control (Mann Whitney U; $t = -2.7$, $df = 10$, $p = <0.000$) and double the germination of cold stratification (Mann Whitney U; $t = -0.9$, $df = 10$, $p = <0.000$). By the second day, the aerated hydroprime treatment of *C. cucullata* stimulated germination to ~40% compared to the control with no germination (Mann Whitney U; $t = -15.3$, $df = 10$, $p = <0.000$). *S. calva* also displayed significantly improved germination with the treatment resulting in nearly 50% of its total germinal output by the second day. Acid stratification (Mann Whitney U; $t = -6.2$, $df = 10$, $p = <0.000$), cold stratification (Mann Whitney U; $t = -1$, $df = 10$, $p = <0.000$) and control (Mann Whitney U; $t = -5.6$, $df = 10$, $p = <0.000$) germinated early, but significantly lower than the aerated hydroprime. All treatments had germination output by the second day, but the sand scarification treatment outperformed acid (Mann Whitney U; $t = -4.9$, $df = 10$, $p = <0.000$), hydroprime (Mann Whitney U; $t = -3.4$, $df = 10$, $p = <0.000$), cold (Mann Whitney U; $t = -3.8$, $df = 10$, $p = <0.000$), and control treatments (Mann Whitney U; $t = -3.8$, $df = 10$, $p = <0.000$).

Viability Adjusted Germination

To better understand the germination output we analyse the germination results based on viability through the Viability Adjusted Germination (VAG), calculated using the following equation (Sweedman and Merritt, 1980):

$$VAG = \frac{Final\ Germination\ (\%)}{Mean\ Viability\ (\%)}\ x\ 100$$

Table 2.4 compares the best germination treatment to the control based off our viability results for all species. This calculation indicates treatment success in terms of biological limitations naturally present in seeds. We observe that although best germination through sand scarification in *D. virgatus* produces only ~20% germination, according to their viability this treatment results in 86% germinability. *P. bicolor* excels beyond viability with 146% adjusted germination when the aerated hydroprime treatment is applied. According to their viability threshold, *C. cucullata* produces 100% germination in both acid and control treatments. *R. columnifera* reaches 89% germination with the aerated hydroprime treatment. *S. calva* only produces 50% germination capacity with the cold stratification treatment but 19% with no treatment.

Discussion

Pretreatment of seeds to enhance germination is essential for the successful use of native seeds (Elzenga et al., 2019). Our germination results suggest the best pre-sow treatment, if any, of these species based of total germination, early germination, and viability adjusted germination. We use these findings to discuss tradeoffs of the different species in terms of return of investment for implementation.

P. bicolor

Based on the findings in our study, the aerated hydroprime treatment supported significant germination for *P. bicolor*. If incorporated as a pre-seed treatment, the germination doubles, which increases success in competing with invasive grasses, providing native forage for livestock, and establishing dense stands for habitat restoration in the region (Llyod-Reilley 2010). In our observation recording radicle and cotleydon growth, there were multiple events of emergence from a single seed head. As *P. bicolor* is a bunchgrass, its seed head contains >1 seed and due to this morphology, its final germination reached 100%. The viability results do not measure up with only 75.2% indication of potential germinability resulting in 146% viability adjusted germination through the aerated hydroprime treatment. We speculate that the water soak, exclusive to the aerated hydroprime, may have enhanced the endosperm through imbibition. The TTC stain may have penetrated the seed dormancy mechanisms more accurately with a pre-soak treatment or if seeds were soaked in the TTC solution beyond our 4mL treatment. Experiments should be executed to confirm these hypotheses. The USDA-NRCS plant guide for *P. bicolor* reports viability of ~55% and germination rates of 40% (Lloyd-Reilley 2010), contrary to our results. There are no details on germination treatments of this species published, indicating that the aerated hydroprime can be an explanatory factor correlated to our high germination results but call for further research to confirm.

C. cucullata

As seen in figure 2.2, the total germination of *C. cucullata* shows comparable final germination between control, acid scarification, and aerated hydroprime treatments. However, the acid scarification treatment in *C. cucullata* amounts to a high standard error indicating a variable range. Some replications dip < 30% germination, which increases risk of implementing this treatment. The control and acid treatment displayed no significant difference between final germination, but control did show a lower standard error and thus a steadier, more reliable rate of germination. However, the aerated hydroprime treatment had the lowest risk in terms of standard error and variation of all treatments, with less germination but not significantly so. In this case, the tradeoff for treatments do not pay itself back, meaning the most economic investment would be to sow the seeds without treatment but with irrigation.

Regarding the viability adjusted germination, this species shows a lot of promise for implementation with 100% germination of control. During the viability dissection, we found that this species of native grass contained a large quantity of empty seed heads but the majority of seeds that were present were viable. If implementing *C. cucullata* in the field there are several techniques to remove empty seeds such as winnowing or aspirating to ensure best germination results (Houseal, 2007).

R. columnifera

The wide range and high standard error of aerated hydroprime results demonstrates irregularity, especially next to the control, with insignificantly lower germination but a stable consistency per replication. Although some species may not show significant difference in final germination between treatments, the time-to-germination analysis examining day two results shares the advantage of treating seeds for quicker germination between time intervals.

Overall, *R. columnifera* did not statistically differ between control and the aerated hydroprime treatment but the aerated hydroprime treated seeds germinated 5x faster by the second day of our experiment (Aligned Rank ANOVA: p = <0.000). Treating seeds to favor rapid results is favorable to utilize limited resources, such as available soil moisture, which is especially important in south Texas. The early onset of plant establishment may also be necessary if the threat of seed predators, pathogens (Beckman and Muller-Landau 2011), or highly competitive plants is a high risk in planting. Earlier germination also favors the prevention of soil erosion and water body pollution through runoff, where native plants are implemented in filter strips within the field of agricultural (Helmers et al. 2012).

S. calva

Based on our results, cold stratification and acid scarification were the two treatments with highest germination output, indicating that if the investment of 60 days in cold storage or H_2SO_4 materials are available for pre-seed treatment, the germination yield will increase notably from no treatment. With the cold stratification, the viability adjusted germination was 50%, demonstrating a need for further research on variable temperature schemes that might stimulate higher germination.

L. texensis

In our findings L. texensis showed no significant difference between the top treatment of acid scarification to control in both early germination on the second day or in the final germination on the tenth day. When analyzing our results through the VAG calculations we see that acid scarification only has 1% higher germination output than control with 54% (Table 2.4). Our results indicate that the most cost-effective sow-method would be to directly seed and irrigate. Our results meet our hypothesis, informed by TAMU Horticulture who report 20-60% germination (Parson et al.)

Leguminous species such as *L. texensis* offer nitrogen fixation, contributing a valuable soil service to disturbed areas (Andrews 1986). The short bloom period of *L. texensis* and its annual duration are important consideration depending on the project of application. Nevertheless, it does provide showy flowers appealing to insects and people and could act as a resourceful addition to seed mixes.

D. virgatus* var *depressus

With a median germination of 8%, *D. virgatus* was included in statistical analysis despite the >10% standard set. In comparing the highest germination by treatment between *D. virgatus* and *L. texensis,* sand scarification produced significant difference to *L. texensis* in the control treatment (Aligned Rank ANOVA: $p = 0.000$), justifying its inclusion.

D. virgatus offers the same nitrogen fixation soil services as *L. texensis*, but with a longer seasonality it has been implemented as green manure, amplifies this ecosystem service and reduces both economic and environmental costs of synthetic fertilizers (Fontenele et al. 2009; Bauddh et al. 2020). As a perennial plant, it also creates permanent habitat and adds structural diversity to ecosystems, which could be an asset to native hedgerows (). Furthermore, *D. virgatus* has been utilized in and shows promise as livestock forage (Kharat et al. 1980). However, in arid environments this species has been recorded thickening seed layers, increasing the need for treatments to break the enhanced dormancy, especially in the south Texas semi-arid environment (Richard et al. 2018).

G. pulchella

Though *G. pulchella* demonstrated low germination in our study, its colorful flower and wide native range can still serve as a promising candidate for attracting insects and increasing biodiversity of systems. While all other seed treatments did not result in seed germination within our 10-day study period, the AH treatment resulted in ~20% germination, 64% viability adjusted germination. Between the TAMU Horticulture documentation of 80% germination and its popular cultivation, we hypothesized it would be a strong contender in our germination assays and future field application. However, our results of low germination state otherwise.

One possibility to explain our findings may be due to the length of our study period. We suggest follow up research with a longer study duration to investigate further. Experimenting with a wider range of cold stratification temperatures may also provide higher germination results and should be tested to confirm (Rosbakh and Poschlod 2015). As our research concentrates on investigating suitability for agricultural restoration, our study length was determined to reduce seed predation and other factors. However, based off our findings, this species can be included in seed mix, allowing a more cost-effective investment with the aerated hydroprime treatment.

Wedelia acapulcensis var. *texensis*

The reported germination rate for *W. acapulcensis* is documented as highly variable with a range from 1-73% (Lloyd-Reilley and Maher 2008). Our findings are on the low end of the spectrum published. In a field trial testing various native mixes of grasses and forbs, *W. acapulcensis* germinated and established making up 12% of the plot cover, even in drought conditions (Lloyd-Reilley and Maher 2008). These findings combined with our sterile experiment results suggest that there are other environmental factors stimulating germination, such as soil microbes. A longer study period to observe delayed germination may also be necessary for this wildflower.

Acaciella angustissima

Our results show viability of ~50% with best viability adjusted germination results with the sand scarification treatment reaching 86%, the USDA-NRCS reports a germination rate with scarification treatments reaching 50-80% (Lloyd-Reilley 2011). Our findings support the treatment method of scarification as documented in the *Acacia angustissima* plant guide.

Conclusions

Through the lens of nature we observe tactics to break dormancy and induce germination, foundational stages in plant growth. Understanding these mechanisms are essential in establishing vegetative communities, whether temporary as seen in food production, or permanent as intended in ecological restoration. By employing germination treatments on native plants we create better accessibility and use for native plants. The expenses for investing in native flora become reduced and thus application of native species grows.

Tables and Figures

Table 2.1 Germination Treatments

Some, non-exhaustive pre-seed treatment techniques applied throughout a few of Earths ecosystems. Some of these treatments are combined for best results.

Treatment	**Environ Mimic**	**Seed Type**	**Dormancy**	**References**
Sand Scarification	Animal interactions (digging, trampling, etc.)	Fabaceae	Exogenous Physical	Abari et al. 2012; Olszewski et al. 2010
Acid Scarification	Chemical exposure (digestive tracts, soil microbes)	Malvaceae, Pocaeae, Rhamaceae, Fabaceae, Celtidaceae, Arecaceae	Exogenous Physical	Pedrini et al. 2018; Ansari et al. 2016; Majd et al. 2013; Varela and Bucher 2006
Hydroprime	Heavy rains	Gossypium, Brassicaceae, *Z. mays*, *C. cajan, G. max*, Sorghum, Triticum and *H. vulgare*	Physiological	Casenave and Toselli 2007; Ashraf and Foolad 2005
Thermo Priming	Seasonal changes, forest fires	*Z. mays,* Sapindaceae, Fabaceae, Rhamnaceae, Malvaceae, Sterculiaceae, Cistaceae, Convolulaceae	Physiological	Anwer and Shabbir 2019; Nasr et al. 2013; Keeley and

				Fotheringham 2000
Light Exposure	Day lengths, sun exposure (canopy openings)	Arabidopsis, *Lactuca*, *S. lycopersicum*, Nicotiana	Non-deep Physiological (Photo Dormant)	Seo et al. 2009; Lopez del Egido et al. 2018; Geneve, 1998
Gibberellic Acid (GA_3)	Naturally occurring plant hormone (stimulated by light and temperature)	Arabidopsis, *Brassica tournefortii*, *Lactuca*, *Plantago*	Endogenous Morphological	D'Este et al. 2019; Mahajan 2018; Chunmei et al. 2015; Saruhan and Durmus 2002; Briggs 1963
Smoke	Forest Fires	Pinus, Malvaceae, Scrophulariaceae,Asteraceae Boraginaceae, Brassivaceae Caryopohyllaceae, Laminaceae, Onagraceae, Solanaceae, Poaceae, Rutaceae, Thymelaceae, Nictotiana	Physiological	Adkins and Peters 2001; Keeley and Fotheringham 2000; Baxter and Van Staden 1994

Table 2.2 Study Species in Germination Trails

Descriptions of study species discussed throughout this research. The table consists of the abbreviated USDA ID code, scientific name, family, and common name. Ecological and economic value supporting relevancy of species selection is also included with bloom dates. Growing duration and growth habit are listed as recorded on plants.usda.gov. Seeding rate (# = acres) and references conclude the contents of this table.

ID	**Name**	**Economic and Ecological Value**	**Plant Type**	**Seeding Rate**	**References**
ACAN	*Acaciella angustissima* Prairie Acacia Fabacaea	Wildlife and livestock forage. Blooms from June to September.	Perennial shrub	5lb PLS/#	Lloyd-Reilley, 2011
BORE	*Bouteloua repens* Slender Grama Poaceae	Livestock forage that is grows competitively with buffelgrass. Blooms April - December	Perennial graminoid	8lbs/#	Heuzé et al., 2017; Smith, 2007
CHCU	*Chloris Cuculllata* Hooded Windmill Grass Poaceae	Larval host plant for branded skipper moth & satyr butterfly, grazing for livestock, and quail habitat. Blooms from March – November.	Perennial graminoid	2lbs PLS/#	Native American Seed, 2020
CHSU	*Chloris subdolistachya*, Shortspike Windmill Grass Poaceae	Competitive with buffelgrass, Blooms from May - October	Perennial graminoid	1/4 - 1/2lbs PLS/#	USDA NRCS 2007
,DAPU	*Dalea purpurea* Purple Prairie Clover Fabaceae	Wildlife food and habitat, attractive to pollinators, livestock forage. Blooms from May – July.	Perennial subshrub herb	2lbs PLS/#	Henr, 2006
DEVID	*Desmanthus virgatus* var	Forage and seeds for bobwhite	Perennial	5-10lbs PLS/#	Lloyd-

	depressus Prostrate Bundleflower Fabaceae	quail, Rio Grande turkey, white-tailed deer, and livestock.	subshrub herb		Reilley and Maher, 2013
GAPU	*Gaillardia pulchella* Indian Blanket Asteraceae	Attractive to pollinators. Blooms from May – August, but will flower longer with irrigation.	Perennial subshrub herb	10lbs PLS/#	TAMU Horticulture
LUTE	*Lupinus texensis* Blue Bonnet Fabaceae	Attractive to pollinators and livestock forage.	Annual herb	35lbs PLS/#	Parson et al., TAMU Horticulture
PABI	*Pappophorum bicolor* Pink Pappusgrass Poaceae	Livestock forage. Blooms from April - November	Perennial graminoid	3lbs PLS/#	Lloyd-Reilley, 2010
RACO	*Ratibidia columnifera*, Mexican Hat Asteraceae	Young leaves used for livestock grazing and browse for big game animals. The seeds feed birds and small mammals. They also provide nesting for upland birds and is an attractive pollinator plant. Blooms from May – October.	Perennial herb	2lbs PLS/#	Winslow, 2006
SICA	*Simsia calva*, Bush Sunflower Asteraceae	Palatable to sheep, goat, deer, and bird. The border patch butterfly caterpillar feed on the leaves. The followers are attractants to pollinators. Blooms from May – November.	Annual-perennial subshrub herb	2.6lbs PLS/#	Smith, 2012

WEACH	*Wedelia acapulcensis* var. *hispida,* Orange Zexmenia Asteraceae	Browse for deer, cattle, sheep, goats, and bobwhite quail. Attracts insect. Blooms from May – November.	Annual-perennial subshrub herb	1/3 – 2/3lbs PLS/#	Lloyd-Reilley and Maher, 2008

Table 2.3. Total median germination and viability for the 12 study species.

Species	n	Total Germination	Median Germination Rate (%)	Median Viability (%)
R. colunnifera	50	2738	62	78.7
C. cucullata	50	1835	40	50.5
P. bicolor	50	2321	32.5	75.2
S. calva	50	1100	21.5	76.3
L. texensis	50	652	13	36.7
D. virgatus	50	580	8	21.4
B. repens	50	369	6.5	49.2
A. angustissima	50	305	3	12.3
C. subdolistachya	50	239	2	24.8
D. purpurea	50	119	2	59.0
G. pulchella	50	230	0	35.5
W. acapulcensis	50	21	0	36.6

Table 2.4 viability adjusted germination (VAG) for all study species displaying the best treatment and control results.

Species	Treatment	VAG
A. angustissima	Sand Scarification	86%
A. angustissima	Control	16%
B. repens	Aerated Hydroprime	24%
B. repens	Control	39%
C. cuculatta	Acid Scarification	100%
C. cuculatta	Control	100%
C. subdolistachya	Control	111%
C. subdolistachya	Sand Scarification	61%
D. purpurea	Cold Stratification	8%
D. purpurea	Control	2%
D. virgatus	Control	32%
D. virgatus	Sand Scarification	86%
G. pulchella	Aerated Hydroprime	64%
G. pulchella	Control	0.28%
L. texensis	Acid Scarification	54%
L. texensis	Control	53%
P. bicolor	Aerated Hydroprime	146%
P. bicolor	Control	69%
R. columnifera	Aerated Hydroprime	89%
R. columnifera	Control	85%
S. calva	Cold Stratification	50%
S. calva	Control	19%
W. acapulcensis	Acid Scarification	6%
W. acapulcensis	Control	0%

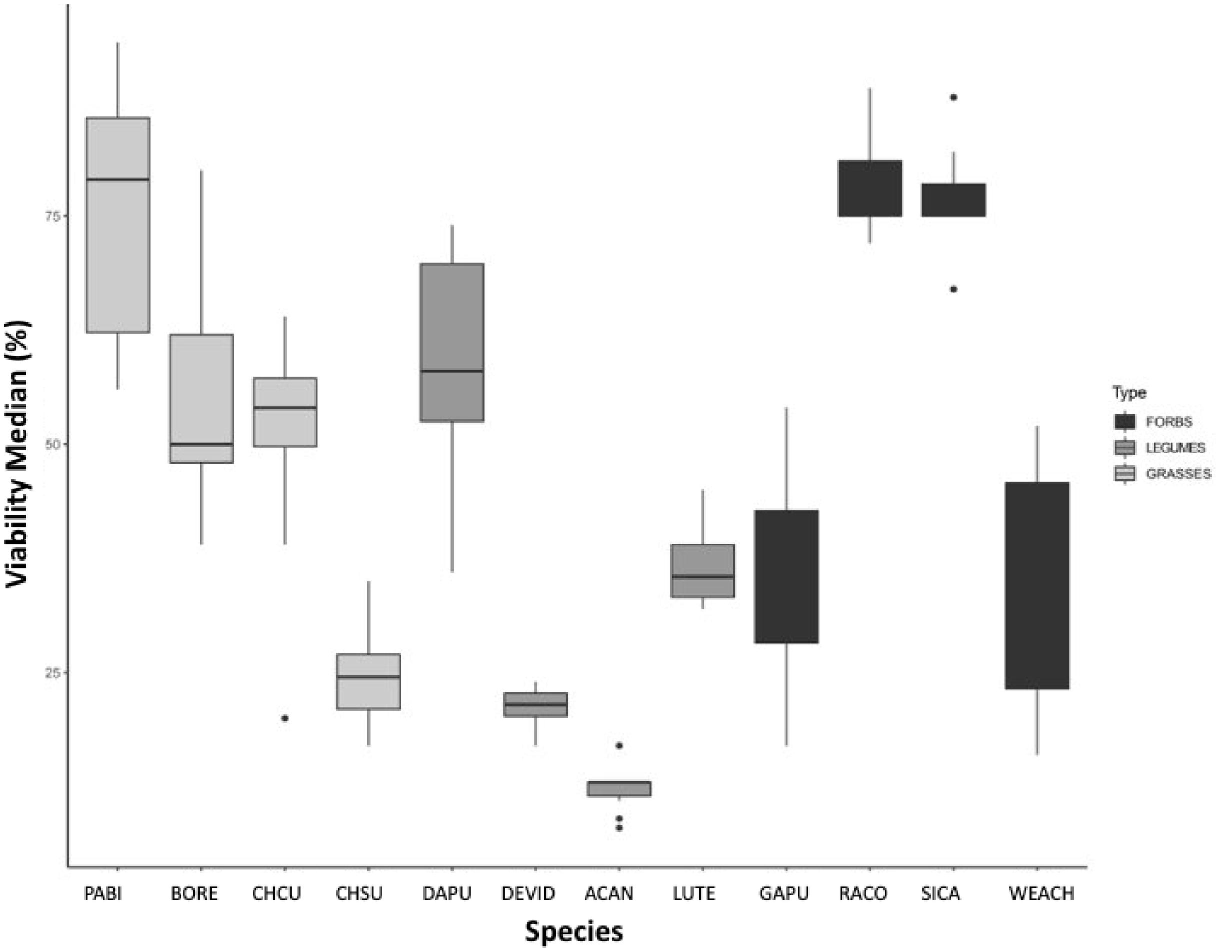

Figure 2.1 An illustration of the viability percentage of each specis. Species are subcategorized by plant type: black = forbs (Asteraceae), dark grey = legumes (Fabaceae), and light grey = grasses (Poaceae).

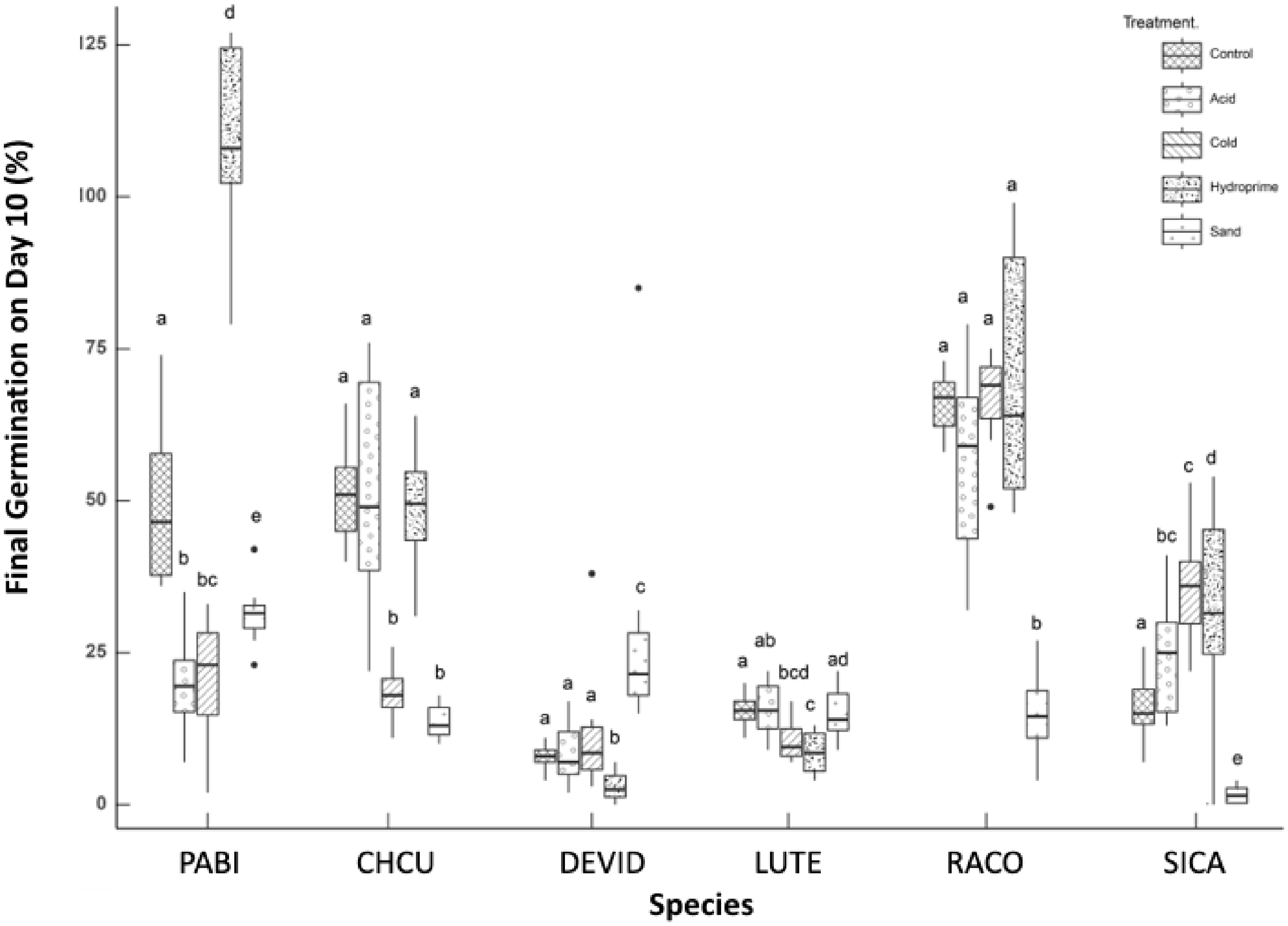

Figure 2.2. A depiction for the final germination on the tenth day for select speices of germination >10%. Species meeting the standards and included in this analysis from left to right are *P. bicolor, C. cucullata, D. virgatus, L. texensis, R. columnifera,* and *S. calva.* Significant determinants (p = <0.050) are denoted within species with letter characters.

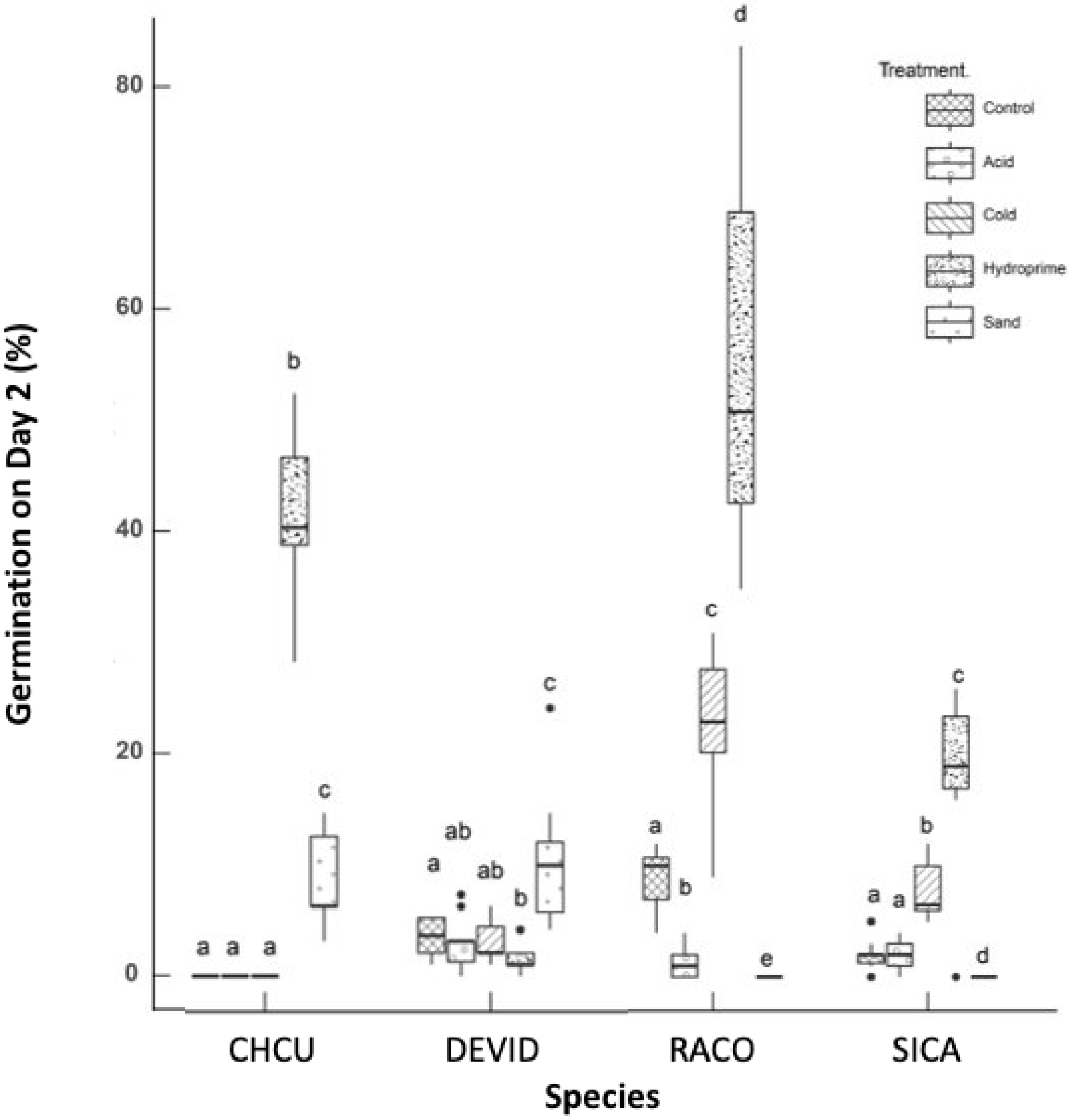

Figure 2.3 A representation of differences in germination on the second day analysing significance within treatments. Significant determinants (p = <0.050) are denoted within species with letter characters.

CHAPTER III

NATIVE PLANT IMPACT ON PEST, NATURAL ENEMY, AND POLLINATOR ARTHROPODS IN EGGPLANT PRODUCTION

Abstract

Agroecological practices such as the incorporation of native habitat within agroecosystems are increasingly associated with ecosystem services that offer financial rewards, stability, and reliability in agricultural systems. Land sharing habitat management provides adequate sustenance, nesting, and refuge for beneficial insects, which in turn offer improved pest management. In this project, we investigate the impact plants native to south Texas have on arthropod communities by analyzing arthropod abundance and diversity as well as associated crop damage to eggplant (*Solanum melongena* L.) in a small-scale field study. We compare our findings to non-native *Lobularia maritima* L. Desv. (sweet alyssum*)*, an effective insectary flower. We employ pan, pit, and sticky traps and to collect data on arthropod presence each month from April – July (4 collections). Additionally, we collect arthropods from eggplants directly extracted from the plots and measure plant health and fitness parameters.We identified a total of 21,583 arthropods to family, separating them into functional guilds (chewing herbivore, sucking herbivore, parasitoid, pollinator, and predator) and ecosystem roles (pest and beneficial).

We find significantly higher densities of pests, specifically Hemiptera: Aleyrodidae whitefly) on *Desmanthus virgatus* var. *epressus (*Willd.) B.L. Turner (prostrate bundle flower*)* . Beneficial arthropod abundance is significantly higher in June, which decline in July concurrent with a major storm event. July reports the highest eggplant damage suggesting ineffective biocontrol, high resilience in pests responding to extreme weather events, and plant stress. We conclude with future research and application to continue developing the use of native plants in agroecosystems in the Lower Rio Grande Valley, Texas.

Introduction

The most foundational purpose of the agriculture is to cultivate food and feed the growing population. However, efforts to improve agricultural output are associated with considerable consequences, including damage to hydrologic systems, soil health, and the precipitous loss of biodiversity, most notably insects (Forister et al., 2019; Goulson 2019; Habel et al., 2019; Ortiz-Reyes and Anex, 2018; Nath and, Lal 2017). Practices associated with conventional agriculture—including habitat loss, heavy reliance on insecticides, and monoculture—have been linked to a rapid decline in population of pollinators and other beneficial insects (Habel et al., 2019). Arthropods play a critical role in sustaining healthy, functional ecosystems and through arthropod-mediates ecosystem services (AMES), their contributions are being designated conservation economic values. For example, beneficial significantly impact food production through natural pest control, equating to U.S. $4.5 billion in annual savings to farmers (Nuñez, 2020; Woodcock et al., 2019; Lichtenberg et al., 2017; Hoehn et al., 2008; Schweiger et al., 2005) Recent studies predict that this positive impact will further increase with effective habitat management and reducing losses by herbivore pests through biological control (Isaacs et al., 2009). Herbivore crop damage is estimated to decimate 13% of U.S. crops resulting in losses up to US $18.77 billion in crop yield every year (Jones and Snyder, 2018).

AMES is not only critical to crop protection, but also essential to food production. Pollination services of insects contribute to fruit yield of 70% of global crops, and 15% - 30% of the U.S. diet amounting to a worldwide worth of U.S. $235-577 billion (Lorenzo-Felipe et al., 2020; Lautenbach et al., 2012; Klein 2007; Losey and Vaugh, 2006). Insect-pollinated crops source 90% vitamin C and 50-69% vitamin A in the human diet (Chaplin-Kramer et al., 2014; Eilers, 2011), highlighting the critical role insect pollinators play in human nutrition. As such, recent dramatic declines in the population of these beneficial insects have generated global concern for the maintenance of supporting AMES (García et al., 2014; Ollerton et al., 2014; Butchart et al., 2010; Genersch, 2010; Potts, 2010; Cox-Foster et al., 2007; Kluser et al., 2007; Biesmeijer et al., 2006). A growing body of evidence supports the impact of agroecological practices that encourage stability and reliability of AMES as habitat management provides adequate sustenance, nesting, and refuges for beneficial organisms (Hudewenz, 2012; Jauker et al., 2012; Kremen et al., 2004; Kremen et al., 2002).

In this project, we investigate how incorporation of native and non-native plants in eggplant production influence arthropod presence and diversity, particularly of pests and beneficial insects. We also document associated crop damage to eggplant in our trials to explore the agroecological practice of companion plantings with native species. In this study, we include four species native to Texas, *Ratibidia columnifera* (Nutt.) wooton & Standl. (Mexican hat) hat), *Helianthus anuus L. (*wild sunflower), *Desmanthus virgatus* var *depressus*

(Willd.) B.L. Turner (prostrate bundleflower), and *Pappophorum bicolor* Fourn. (pink pappusgrass). We compare these results *Lobularia maritima (L.) Desv.* (sweet alyssum, commonly applied as an intercrop to attract beneficial insects (Chen et al., 2020; Tiwari et al., 2020; Brennan, 2016; Brennan, 2013). We predict a shorter bloom period in response to the long, hot summers in the subtropical climate will reduce overall arthropod densities. We suspect the flowering forbs (*R. columnifera* and *H. annuus*) will support higher densities of parasitoids and pollinators owed to their asynchronous nectar offerings and local adaptations supporting longer bloom periods (Berndt and Wratten, 2003; Johanowitz and Mitchell, 2000). We hypothesize that the native pink pappusgrass will attract predaceous arthropods. As a bunchgrass with tussock growth, we suspect this species has the potential to mimic the graminoid species in European beetle banks that have successfully provided habitat for predators (Macleod et al., 2004; Collins et al., 2002; Thomas et al., 2002).

Methods

Study Site

This experiment is designed to explore the influence of four south Texas native plants and one commonly use intercrop plant (table 3.2) in facilitating arthropod abundance and diversity, particularly of beneficial insects and pests, in south Texas agroecosystems. This data will be compared to arthropod-associated damage to eggplant. The experiment took place from late January until the middle of August at a 5-acre urban working farm in Edinburg, TX (26°8’78” N -98°12’406” W). In this setting, this experiment was nested among other production crops, within a 150-m^2 block that had been fallowed for 5-year prior to planting (see design below). Prior to planting the block was tilled three times to reduce the persistence of bermudagrass (*Synodon dactylon)*.

Table 3.1. Soil properties of our study site compared to optimal levels that are common in the subtropical region of the Rio Grande Valley, TX. Soil analysis conducted by Texas Plant and Soil Lab in the summer of 2020, during this experiment.

	OM (%)	pH	NO3 (lbs/#)
Study Site	0.84	7.94	0.35
Optimal	2.8-4.8	6.3-6.8	35-90

Species Selection and Experimental Design

Plant species included in this study are listed in table 3.2. The species were chosen based on commercial availability and their potential to succeed in agricultural landscapes (Lavallee, 2020 (Ch. 2)).

Eggplant was chosen as a test crop based on local availability and as per recommendation from local farmers. Black beauty seedlings of eggplant used in this study were purchased from Waugh's Nursery, Edinburg, TX. Eggplant was incorporated in the four corners of the 3 replications used for arthropod collection in March allowing healthy establishments of plant treatments before planting to avoid any competition.

Using a randomized block transect design (Hoshmand, 2006), plots were 1-m^2 (Isaacs et al. 2009) and separated by 1-m^2 borders with black plastic mulch and wood chips to prevent the invasion of bermudagrass as well as establish clear boundaries between treatments. Seeds of our five treatments were broadcast by hand and harrowed in late January 2020. We installed sprinklers (Orbit Irrigation Products, Inc, FL, USA) with 1-m^2 reach in the center of the plot and irrigated twice daily for 30-minutes to ensure optimal growth. Each of the six treatments (including control) was replicated 5 times (6 X 5 block design). Of these, 3 blocks within each treatment were randomly selected for data collection.

Table 3.2. Summary on of study species, their origin, plant type, and seeding rate.

Treatment name	Common Name	Origin	Plant Type	Seeding Rate (lb/#)
Control	Sunflower + Bermuda grass	Native + non-native	Aster, Grass	—
Crotalaria juncea	Sunn Hemp	Non-native	Legume	4 PLS
Desmanthus virgatus var. depressus	Bundleflower	Native	Legume	5 PLS
Lobularia maritima	Sweet Alyssum	Non-native	Flowering Brassica	2.5
Native Mix		Native	Aster, Grass, Legume	0.33 + 1 + 1.5
Pappophorum bicolor	Pink Pappusgrass	Native	Grass	3 PLS
Ratibida columnifera	Mexican Hat	Native	Aster	2 PLS

Sampling Methods

We utilized a comprehensive trapping method, modified from Kariyat et al., 2018, to collect community level data on arthropod populations present. A 1-m tall chicken wire cage enclosed a section of the plant of interest. Equipped with a single aluminum pie pan filled 3/4ths with water and a couple drops of odorless detergent (Cole-Parmer Instrument Company, LLC, Vernon Hills, Il, USA) to break surface tension and securing two unbaited sticky traps (Pherocon® AM Yellow; Trece, Inc., Adair, OK, USA) to the northeast and southwest sides of the cage. Two pit fall traps (8oz plastic cups 3/4ths full of water with a couple drops of detergent) were tucked into the ground nearby. Traps were strategically set for 48-hrs on days with predicted clear weather where average temperatures ranged from 27°C – 29°C. Pit fall and pan traps were transferred into 50-mL falcon tubes (Fisher Scientific Waltham, MA, USA) and preserved in 80% ethanol (Fisher Scientific Waltham, MA, USA).

We collected specimen directly associated with eggplant by extracting it from the plot a day prior to setting the traps. We quickly covered the cash crop with a plastic recycling bag, sealed at the base trapping any arthropods present, cut at the stem, and secured it shut to record weight and store in a refrigerator at 4°C for at least 24-hrs. Arthropods were extracted from all plant parts. Three leaves were randomly selected to average plant metrics such as surface area and damage through the ImageJ computer software (NIH, Rockville, MD, USA). Most specimens were identified to the family under a stereoscopic microscope (Leica, EZ4HD, Wetzlar, Germany). Arthropods from eggplant, pit, and pan remain preserved in 80% ethanol by treatment and replication, sticky traps are stored in 4°C. All arthropods used in this research are stored as a reference collection.

Arthropods were identified through three primary resources: the Peterson Insect Field Guide (Borror and White, 1970), A Field Guide to Common Texas Insects (Drees and Jackman, 1998), and through online reference (BugGuide.com). From families, arthropods were categorized into six feeding guilds (sucking herbivore, chewing herbivore, predator, parasitoid, pollinator, and decomposers), and further functionally classified in ecosystem role as pest or beneficial.

Statistical Analysis

Unidentifiable arthropods (n=114) and decomposers (n= 416) composed small portions of our total collection (<1%, and <2% respectively) and are omitted from analysis. As to be expected from entomological field research we observed high variance within our data. Due to the non-normal nature of our data, we conducted generalized linear regression (GLR) with negative binomial distribution with post-hoc Tukey Kramer HSD using JMP statistical software (JMP, Version 15, SAS Institute Inc., NC, USA). The significance level for all our statistical analysis was set to 0.05. Figure graphics were developed using GraphPad Prism (GraphPad Software, CA, USA). Our data analysis includes all organisms collected from the eggplant extraction, pan, pit, and sticky traps collectively to better understand diversity dynamics. We examined total arthropod abundance as the response based on functional guilds across all six treatments and four collection dates, which each contribute as factors. We ran ten models for the accumulative arthropod collection. The first compares pest and beneficial arthropod abundance as the response variable with role, treatment, role x treatment, and month as explanatory variables. The second compares pest guild abundance as the response and factored by guild, treatment, guild x treatment, and month. The third compares beneficial guilds as the response with guild, treatment, guild x treatment, and month as factored variables. The fourth model analyses the top four pest families where abundance is the response and family, treatment, family x treatment, and month are all factors. The fifth model explores beneficial families with abundance as the response variable and family, treatment, family x treatment, and month are factored. To understand cash crop impact, we compare leaf surface area missing (%) factored with pest abundance, month, and guild. Although we did not collect many fruit, we also investigated correlation between fruit set as the response to pollinator and pest abundance, month, and . We factored the number of eggplant leaves, eggplant weight, and eggplant total leaf surface area as individual response variables by treatment, month, and treatment x month.

We conducted diversity calculations using the following formulas:

Shannon-Wiener Diversity Index:

$$H' = \Sigma\, p_i[(\ln p_i)]$$

Simpson's Index: $D = \frac{1}{\sum_{i=1}^{s} pi2}$

Where p_i is the proportion of total abundance documented by i^{th} family. N is the total arthropod abundance and N_i is the number of organisms recorded in family *i*. s is the total number of families in the sample.

Results

Arthropods identified as pests accounted for 66.3% of the total insects analysed. Sucking and piercing pests comprise 66.31% and chewing and biting herbivores composing 1.1%. Beneficial arthropods constitute the remaining 32.5% with 5.4 % parasitoid, 11.5% predators, and 15.7 % pollinators.

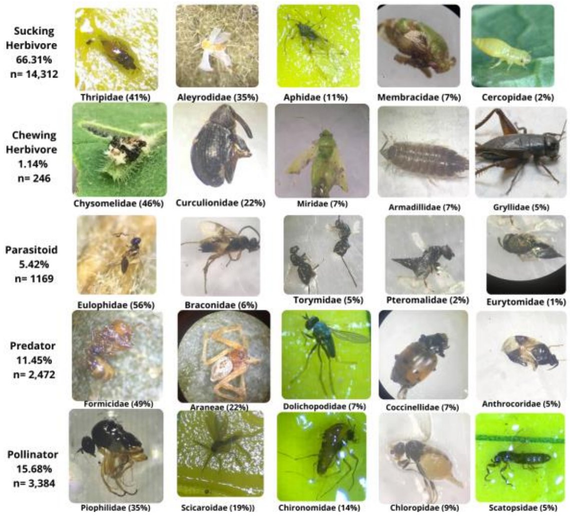

Figure 3.1 Photo compilation of the five most abundant families of each functional guild, where n = all trapping methods. The left column introduces the functional guild, the percentage of total collection, and the sample size. The rows running left of the title include families and their frequency listed as guild. Photo credit to Kaitlynn Lavallee.

Diversity

Table 3.3 summarizes diversity indicators for all six treatments including family and order richness, and Shannon Wiener and Simpson's Diversity Index results. An ANOVA analysis resulted in *P. bicolor* producing significantly greater diversity than *D. virgatus* (Tukey; $q = 3.18$, $p = 0.0088$) (Figure 3.7). The Simpson's index reported no significance between all treatments.

Eggplant Fitness and Health

Table 3.4 summarizes cash crop success indictors of fruit yield and crop damage represented as leaf surface area missing. Comparing pollinator and pest abundance, treatment, and month with fruit set yielded no significance. Multiple comparisons on pest, predator, parasitoid, and treatment reported no significance. However, comparing leaf damage to collection dates reports significance with July experiencing greatest damage (Tukey; $F = 16.2$, $p = <0.0001$) (Figure 3.8).

Plant Species Comparisons

At 0.05 level of significance, the GLR and Tukey HSD reported significantly higher pest presence in *D. virgatus* compared to control (Tukey; $t = -4.50$, $df = 15$, $p = 0.0039$) (Figure 3.2). We found significantly higher sucking herbivore densities on *D. virgatus* than *P. bicolor* (Tukey; $t = 3.55$, $df = 33$, $p = 0.0457$) and control (Tukey; $t = -4.87$, $df = 33$, $p = 0.0014$) (Figure 3.3). Of the sucking herbivore functional guild, the Aleyrodidae family (whitefly) resulted in significantly higher abundance in *D. virgatus* over control (Tukey; $t = -3.99$, $df = 51$ $p = 0.0206$) (Figure 3.4). We documented significantly higher populations of chewing herbivores on *L. maritima* than the native mix (Tukey; $t = 3.77$ $df = 33$ p

= 0.0269) (Figure 3.5). No significance was reported between treatments in beneficial functional guilds or families.

Table 3.5 summarizes the effect of specific arthropod abundance to month, treatment, arthropod grouping, and a combination of treatment x arthropod group. This table includes the five most abundant pest and beneficial families relating to Figure 3.1. Significant differences are seen between months when investigating arthropod interactions except for pest families (p = <0.0001). Pest arthropods are significantly greater than beneficial arthropods (GLR; $\chi2$ = 14.3, *df* = 1, *p* = 0.0002), and of this, sucking herbivores have significantly larger populations than chewing herbivores (GLR; $\chi2$ = 315, *df* = 3, *p* = <0.0001). There is significance noted between beneficial guilds (GLR; $\chi2$ = 14.3, *df* = 2, *p* = 0.0008), and between beneficial families (GLR; $\chi2$ = 2.5, *df* = 4, *p* = 0.0004). The table displays significant differences between treatments for beneficial and pest comparisons (GLR; $\chi2$ = 16.7, *df* = 5, p = 0.0052), chewing and sucking herbivores (GLR; $\chi2$ = 26.1, *df* = 5, p = <0.0001), and beneficial guilds (GLR; $\chi2$ = 14.7, *df* = 5, *p* = 0.0119). Finally, significant difference is noted for treatment and arthropod groups between beneficial and pest (GLR; $\chi2$ = 13.0, *df* = 5, *p* = 0.0234).

Collection Dates

Arthropod pest populations jump significantly from April to May but stabilize in June and July (Tukey; *t* = 9.06, *df* = 40, *p* = <0.0001). In response, the beneficial populations collected significantly rise in June (Tukey; *t* = 11.81, *df* = 40, *p* = <0.0001*)* but fall back in July.

Discussion

Groups of Interest

Aleyrodidae, the family of white flies, are a persistent pest to many crops with a long history coupled with eggplant. Eggplant is considered a host to white flies (Tsai and Wang

1996), where a quarter of our data is recorded as larval stages from the eggplant extract, supporting these claims. *D. virgatus* supported the largest quantities of white fly (Figure 3.4). Overall, of all Aleyrodidae captured, 25% were associated with the cash crop and the other 75% were collected through the sticky trap. Eggplant extraction accounted for 13% of whitefly in *D. virgatus.* Although we found no statistical significance correlating eggplant size (plant weight, number of leaves, leaf surface area) (table 3.4), our raw data documents a replicate producing 71 leaves, where 449 whiteflies were recorded in the *D. virgatus* treatment. Furthermore, the slow growth of this leguminous species prevented competition for space and sunlight, which consequently favored a visibly healthy establishment of eggplant within our study (although statistically insignificant). These factors influence the significant amount of whitefly and call for follow up studies to determine whitefly host preference with *D. virgatus.* Eggplant has been utilized as a trap crop for this whitefly (Smith and McSorley 2000), however, the value of eggplant as a cash crop itself calls for adapted cultural approaches ie. trap cropping with native plants (Kalloo, 1993). Our findings suggest that *D. virgatus* could be an effective pull-crop attracting Aleyrodidae away from eggplant. Further research to rule out these confounding factors should be experimented through controlled laboratory preference trials.

Eulophidae, a large Hymenopterous family, was the most abundant parasitoid in our study. Although there were no statistical differences between treatments, June produced significantly higher amounts of Eulophids (Tukey; t = -8.83, df = 75 p = <0.0001). We speculate that their population increase was influenced by the rise of prey populations as demonstrated with Aleyrodidae, as well as the increase of floral availability. Examining our raw data in June, we find the control plot, dominated by *H. annuus*, consisted of the highest abundance of Eulophidae populations with 27%, followed by *R. columnifera* at 20%. These two flowering forbs offer necessary nectar, which enhances overall fitness of these parasitoids (Zehnder et al 2007; Wäckers 2003; Berndt and Wratten 2001; Wratten 2001; Johanowitz and Mithcell 2000). As *D. virgatus* contained the highest abundance of Aleyrodidae, a host for ectoparasitoic hyperparsitoid Eulophids, but our findings suggest that nectar rewards may be preferred for this parasitoid family in our region, especially during the hottest month of June (Rasplus et al. 2020; Lahey and Polaszek 2016; Hernándex-Suárez et al. 2003). However, prey food is necessary for the emergence of offspring, where synovigenic parasitoids are dependent on the nourishment the host offers to gain full access to their egg load and thus fecundity success, which is a driving factor for biocontrol (Ye et al. 2018; Wang et al. 2014; Zhang et al. 2011; Kidd and Jervis 1989). Less than 1% of Eulophidae captures were extracted from eggplant, where trichomes are known to disrupt parasitoid productivity (Kennedy 2003; Bottrell and Gould 1998). Due to this morphological defense that, enhancing agroecosystems with non-crop native vegetation such as *D. virgatus* and *H. annuus* (ie. trap crops and insectary strips), may prove to increase the efficiency of AMES offerings from parasitoids to control whitefly pests in eggplant. We observe the parasitoid populations plummet from June to July (Tukey; $t = 7.87$, $df = 75$, $p = <0.0001$), following the trend of beneficial arthropods as seen in figure 3.7A. At this time, the research ecosystem experienced a category one hurricane before the final trapping date, which may have impacted the beneficial arthropod community. In contrast we examine pest populations by month in figure 3.7.B, which remained steady from June to July, implying high resiliency in the face of extreme weather events compared to higher levels of vulnerability observed in parasitoid populations (Niranjana et al., 2016; Romo and Tylianakis, 2013). Pollinators can also be negatively impacted by excessive precipitation as it dilutes nectar rewards, degrades pollen, overwhelms plant-pollinator communication modalities, and increases thermoregulatory costs (Lawson and Rands, 2019). With increasing risks of climate change and predicted associated pest outbreaks the need to create more sustainable food systems to support natural predators grows (Stireman et al. 2005). A branch worth exploring is through the implementation of diverse native habitat can help stabilize agroecosystems in stressful situations.

The myophilic fly family, Piophilidae, was our most profuse pollinator captured. Dipteran insects are largely generalist pollinators, which are often underrepresented and poorly studied but contribute as the second most important insect order to animal-pollination worldwide (Larson et al. 2001). Although anthophilic flies aren't designed as efficient pollen collectors, they still greatly to biodiversity in ecosystems and in sustaining food production with their copious visitation (Ssymank et al. 2008). Statistically there were no differences to denote among treatments within this family or within the pollinator functional guild. This may be partially explained through the many mechanisms of plant-arthropod communication that can be overwhelmed by sensory noise. Olfactory cues are functional traits in plant reproduction and have evolved to attract pollinators from a distance, however visual cues are a localized backup that can help the pollinating arthropods home in on their food source (Lawson et al., 2017). Arthropods interact with chemical signals in numbers that are still yet unfathomable to science (Haverkamp et al., 2018) and in combination with our crowded experimental design, the pollinators may have not been able to distinguish from preferential plants.

Considerations

Low numbers of Hymenoptera pollinators (bees) were collected in our field trial but as obligate florivores, arguably the most recurrent pollinators, and certainly the selective pollinator for mass-management, I expected to record more visitation (Hung et al. 2018; Potts et al., 2016; White, 2016; Wingree, 2010). Although most utilized, consensus on efficacy of pan traps continues to evolve (Portman et al., 2020; Roulston et al., 2007; Cane et al., 2000), more recently favoring an adaptive vane traps and sweep netting (Prendergast et al., 2020; McCravy et al., 2016). When employing pan traps blue, yellow, or white colorations are often used but the impact on bees, and more largely arthropods, from the reflective silver from the shallow aluminum pie pans we utilized are less studied. Hymenoptera color preferences have been recorded as group-specific (Moreira et al., 2016) where achromatic colored flowers are often avoided by bees suggesting potential sensitivity to silver (Lunau et al., 2011). We speculate that these visual factors could have deterred bee species from our traps. There are several studies comparing trapping methods for bee species (McCravy et al., 2016; Joshi et al., 2015) but since our project aimed to collect a more inclusive population of arthropods present, we did not equip these specifics strategies.

A potential risk to employing floral resources in crop systems are their unbiased offering of pollen and nectar food sources. Alternate life histories of some pests often double as pollinators in adult form but herbivores as larvae (Diptera: Chloropidae, Lepidoptera: Crambidae). The symbiotic exchange of nectar for pollen provides the necessary nutrients for the life cycle to endure another generation and pose a threat to future production (Bigger and Chaney, 1998). Using native plants, which offer a season of scouting before full implementation, can minimize these risks. When recording observations of volunteer plant and arthropod interactions, growers can make informed decisions on species selection, also reducing costs in investing in non-native seeds.

As per our hypothesis, *L. maritima* died back from 100% flower to only 40% due heat stress by June. The native plant species re-established themselves after biomass collection in but *L. maritima* was collected as dead and dried material and never returned. These observations exemplify the risk of relying only on non-native flowers, which are not equipped to offer the floral resources needed in the subtropical year-round growing system experienced in the LRGV. However, the native study species, with asynchronous flowering, contribution continuous habitat, food, and refuge for arthropod allies. With this comes seasonal reseeding, which saves on future costs but could potentially encroach on the cash crop and would require arthropod-appropriate management. Where *L. maritima* is already used additional native plants will add diversity and increase availability to floral resources. However, a shift to provide native flowers in nurseries and garden centers where *L. maritima* is commonly distributed, will increase accessibility to implementing native plants in the household and community level.

Arthropod response to vegetation is variable and a single species may not create the interactive dynamics to meet the AMES desired in food production. Structural diversity is imperative to provide an array of habitat types to support an assortment of arthropods. A general guideline we applied is to combine at least three species. We included a flowering forb to assure carbohydrate sources are available, a grass for shelter and biomass, and a legume to improve soil and thus terrestrial and subterranean arthropods. Although the native mix did not perform significantly well as we had initially suggested, the establishment of a more complex vegetative community takes longer to form where accommodation for resources are at play.

This experiment was conducted on a shared urban farm with neighboring row crops of tomatoes and basil, a hedgerow of native trees, dominated by *Prosopis glandulosa* Torr. (honey mesquite) growing 100m south, and various combinations of cover crops including *Crotalaria juncea* L. *(*sunn hemp)*, Vigna ungiculata* L. (cowpea), *Sorghum drummondii* (Steud.) Millsp. & Chas *(*sudangrass*)*, and *Mucuna pruriens* L. DC. (velvet bean), on the west, north, and east throughout the summer months. A spring and a fall insectary strip were planted on the property as well. Although our experimental design contained a buffer between research plots as well as between farm plots, these surrounding habitats influenced the arthropod assemblages we collected. For example, with a diversity of floral resources and nesting opportunity available nearby, arthropods may already present (Morandin and Kremen, 2013). In this case, the arthropods we report may be displaying preferential choice for our study species and the need for diversity and abundance in food and refuge in an ever-growing fragmented habitat. To better understand community dynamics, this site, designated for research, can be examined through a lens focused on foraging behavior and heterogenous habitat connectivity, both which significantly contribute to biodiversity conservation. Mapping these relationships can create a more thorough understanding on how to attract beneficial insects to cash crops using natural, native ecosystems in restorative food production in the LRGV.

Recommended Research

The nature of our single season study is to confirm and recommend field application of native species with favorable germination potential and beneficial arthropod interactions. There is opportunity to expand on the research of native plants in agriculture in the LRGV over spatial and temporal scales to develop a more systematic understanding on biodiversity conservation in food production (Alignier et al. 2014). Environmental factors vary season-by-season, especially as degraded ecosystems become more vulnerable to alteration and the rapid onset of climate change. Although we analyzed three replications, confidence in field findings increases with seasonal replications. In the season of our trials our final collection was delayed due to category 1 Hurricane Hannah, which released 8-12" of rain and unleashed 90mph winds on our community and our research. These elements impacted both plant and arthropod and thus influenced our results. Conducting follow up research for more than one season will address confounding variables such as these.

Implementing native species on a farm-scale will allow for more accurate fruit yield findings. Because our research focused on arthropod abundance, diversity, and function, the cash crop did not grow as it would in a realistic food system. However, planting beetle banks, floral strips, or a combination of the two, and collecting data without crop collection, will provide valuable information to add to the growing local understanding on restoring biodiversity in agroecosystems. Insect traps and sweep nets should still be used in to analyze arthropod assemblages in habitat strips and observational surveys and scouting should be conducted on the crop with final yield weight for comparison of treatments. Although controversial to our research goals, when applying this research concept on a larger scale, a double control treatment of leaving a plot entirely fallow can be managed more efficiently through accessible tillage. Including this treatment will provide comparable insight on common conventional practices of over tillage and seasonal fallows, which have contributed to global arthropod declines (Zahn et al., 2010). We would have benefited by having a "sterile" double control without the volunteer sunflower and had we incorporated this treatment we may have statistically different results to report. Even though our datasets display high variance generating low statistical significance our raw data indicates that arthropod allies of interest were present.

Conclusions

Although our treatments comparing native, a non-native, and volunteer plants generally show show comparable results, we recorded highest pest pressures associated with native legume *D. virgatus* lowest and lowest in our control. The crowded research plot did not allow foreggplant to grow well alongside *H. annuus* in the control, but the creeping growth of *D.*

virgatus supported healthy eggplants, although statistically insignificant. Although our results on eggplant fitness through fruit yield do not report significance, research on a farm-scale may provide more thorough results regarding cash crops. With significant difference only between months in eggplant health through percent missing leaf surface area a more appropriate experimental design providing ample space for the cash crops to grow as suggested in discussion may result differently. We observed highest densities of arthropods of all classes during the month of June, a peak flowering period, supporting the literature claiming that floral diversity and density support AMES (Egan et al. 2020). In the light of disruptive changes and instability, effecting ecological principles into food production practices are more widely accepted and adopted, however, the case for native plants to support agroecosystems in the LRGV is only just being made. Future research in this field, specific to the subtropic region of south Texas will help inform implementation.

List of Tables and Figures

Table 3.3. Summary table on diversity indicators including the number of families and number of orders to represent richness. Shannon-Weiner and Simpson's diversity results are also calculated with the four temporal replicates. The Tukey HSD analysis reported significant difference between *P. bicolor* and *D. viragtus* in the Shannon-Wiener test (Tukey; q = , df = 5, p = 0.0088) (Figure 3.6) Significance of p = <0.05 are in bold with different letters.

Treatment	**Families**	**Orders**	**H'**	**D**
C	72	11	**2.77** ab	0.11 a
Dv	57	10	2.17 b	0.22 a
Lm	66	12	2.46 ab	0.4 a
M	64	12	2.47 ab	0.15 a
Pb	65	11	2.51 a	0.16 a
Rc	67	9	2.49 ab	0.84 a

Table 3.4. Details of statistical analyses examining effect of eggplant health and fitness on relative traits including treatment, month, and appropriate guild. Eggplant leaf damage (%) reported significant differences between months (Figure 3.8) However, all other traits analysed showed no significance in post-hoc tests.
d*f* = degrees of freedom, χ2 = Wald ChiSquare. Significance of *p* = <0.05 bolded.

Trait	***df***	**χ2**	***p***
	Eggplant Fruit		
Treatment	5	0.47	0.993
Month	3	0.02	0.995
Trt x Month	15	1.66	1
Pollinator Abundance	1	0	0.98
Trt x Pollinator	5	75	0.98
Pest Abundance	1	0.02	0.937
Trt x Pest	5	1.98	0.852
Pest x Pollinator	1	<0.00	0.992
	Eggplant Leaf Damage (% missing)		
Treatment	5	3.04	0.69
Month	3	16.2	**< 0.000**
Trt x Month	15	12.32	0.655
Pest Abundance	1	<0.00	0.952
Trt x Pest	5	0.54	0.99
Month x Pest	3	0.36	0.949
Parasitoid Abundance	1	0.01	0.932
Trt x Parasitoid	5	0.3	0.998
Month x Parasitoid	3	0.09	0.994
Predator Abundance	1	0.03	0.857
Trt x Predator	5	1.15	0.95
Month x Predator	3	0.88	0.831
Parasitoid x Pest x Predator	1	0.05	0.827
	Eggplant Leaf Surface Area		
Treatment	5	0.55	0.9900
Month	3	0.55	0.99
Trt x Month	15	2.13	1.000
	Number of Eggplant Leaves		
Treatment	5	6.99	0.543
Month	3	9.91	**0.019**
Trt x Month	15	13.78	0.543
	Eggplant Weight		
Treatment	15	13.4	**0.02**
Month	3	18.3	**0.0004**
Trt x Month	15	96.7	**<0.0001**

Table 3.5. Summary of the statistics examining the effects of arthropods on various factors such as collection date, arthropod classification, treatment, and combination of treatment and class. d*f* = degrees of freedom, χ2 = Wald ChiSquare. Significance of *p* = <0.05 bolded.-

Trait	***df***	**χ2**	***p*-Value**
Beneficial v. Pest			
Month	3	47.3	**<0.0001**
Arthropod Role	1	14.3	**0.0002**
Treatment	5	16.7	**0.0052**
Trt x Role	5	13	**0.0234**
Pest Guilds			
Month	1	73.3	**<0.0001**
Guild	1	315	**<0.0001**
Treatment	5	26.1	**<0.0001**
Trt x Guild	5	11.6	0.0415
Beneficial Guilds			
Month	3	120.7	**<0.0001**
Guild	2	14.3	**0.0008**
Treatment	5	14.7	**0.0119**
Trt x Guild	10	17.9	0.0559
Most Abundant Pest Families			
Month	3	61.2	0.1319
Family	4	78.5	0.0813
Treatment	5	0.72	0.9223
Trt x Family	20	30.1	0.9998
Most Abundant Beneficial Families			
Month	3	58.7	**<0.0001**
Family	4	2.5	**0.0004**
Treatment	5	2.7	0.4806
Trt x Family	20	24.4	0.8782

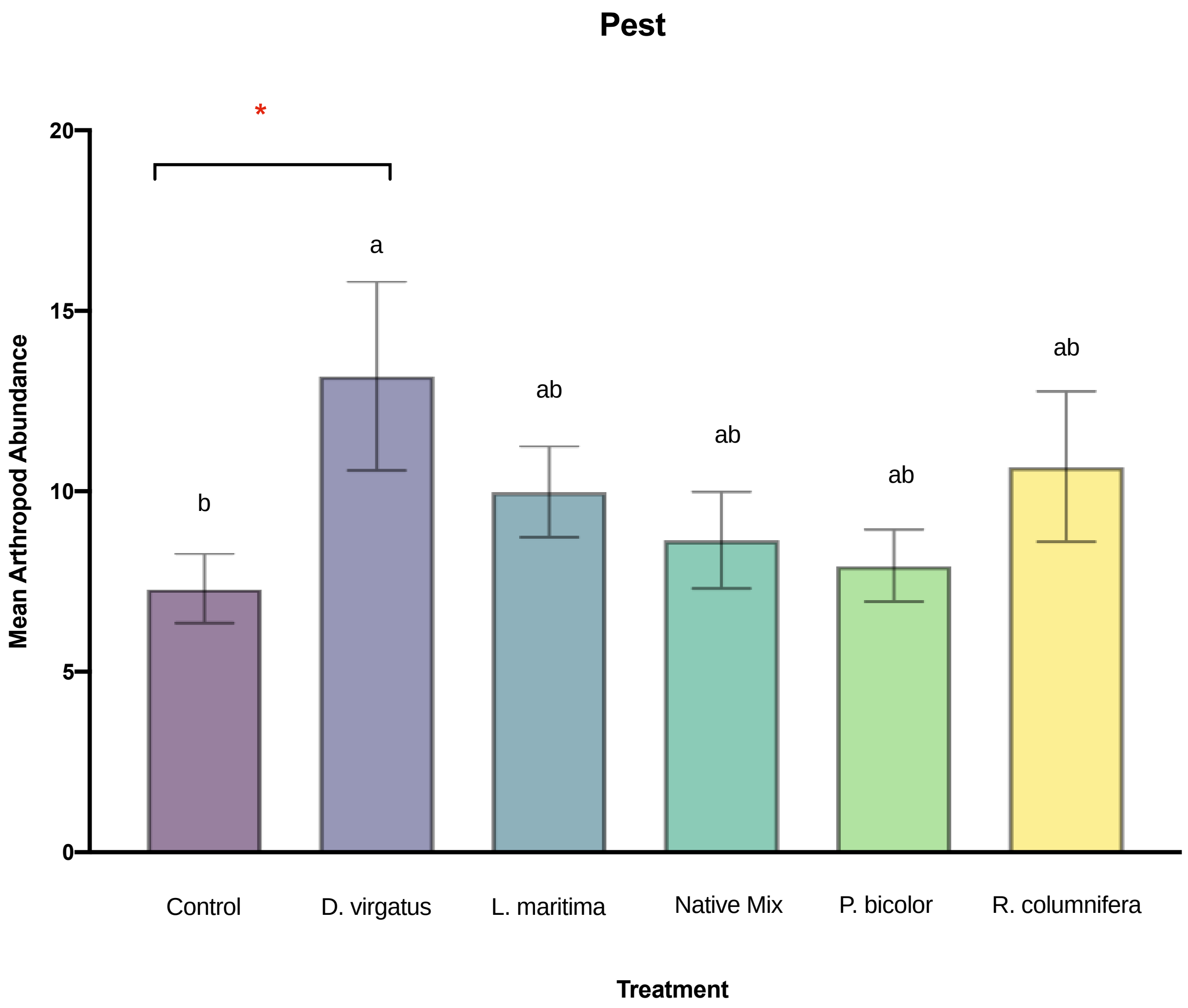

Figure 3.2. Mean arthropod pest arthropod abundance factored by treatment. *D. virgatus* shows significantly higher densities than the control (Tukey; *t* = -4.5, *df* = 33, p = 0.0199) (n = 14,558). Significance differences of *p* = <0.05 denoted by differing letters.

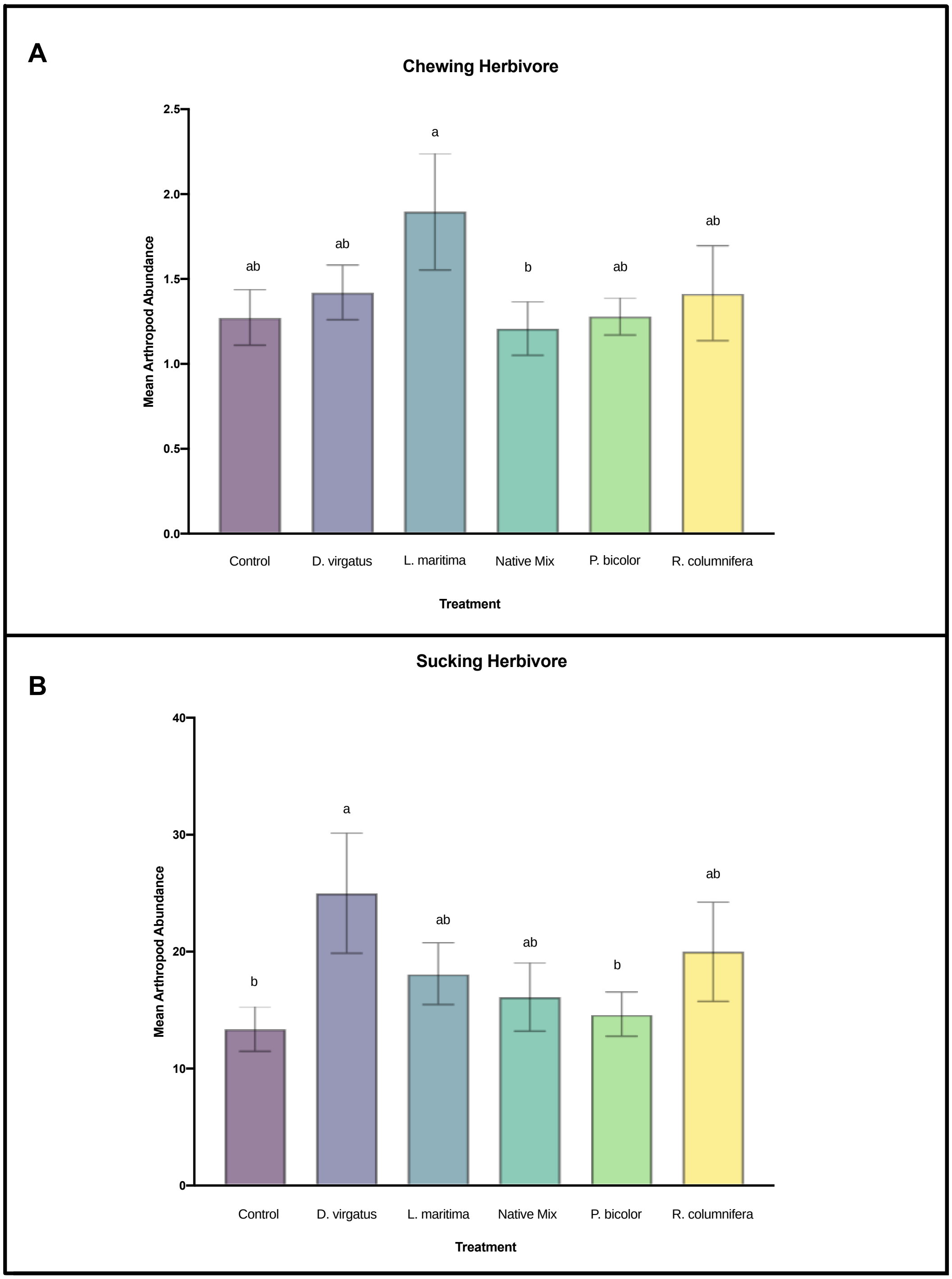

Figure 3.3. Mean arthropod abundance of pests by guild factored by treatment. **A**. Chewing herbivore pests were significantly higher in *L. maritima* than the control (Tukey; *t* =, *df* =, *p* =) and the native mix (Tukey; *t* = 3.77, *df* = 33, *p* = 0.0269) (n=246). **B**. Sucking herbivore pests show significantly higher densities in *D. virgatus* than the control (Tukey; *t* = -4.87, df = *33, p* = 0.0014) and *P. bicolor* (Tukey; *t* = 3.55, *df* = 33, *p* = 0.0457) (n = 14,312). Significance of *p* = <0.05 denoted by differing letters.

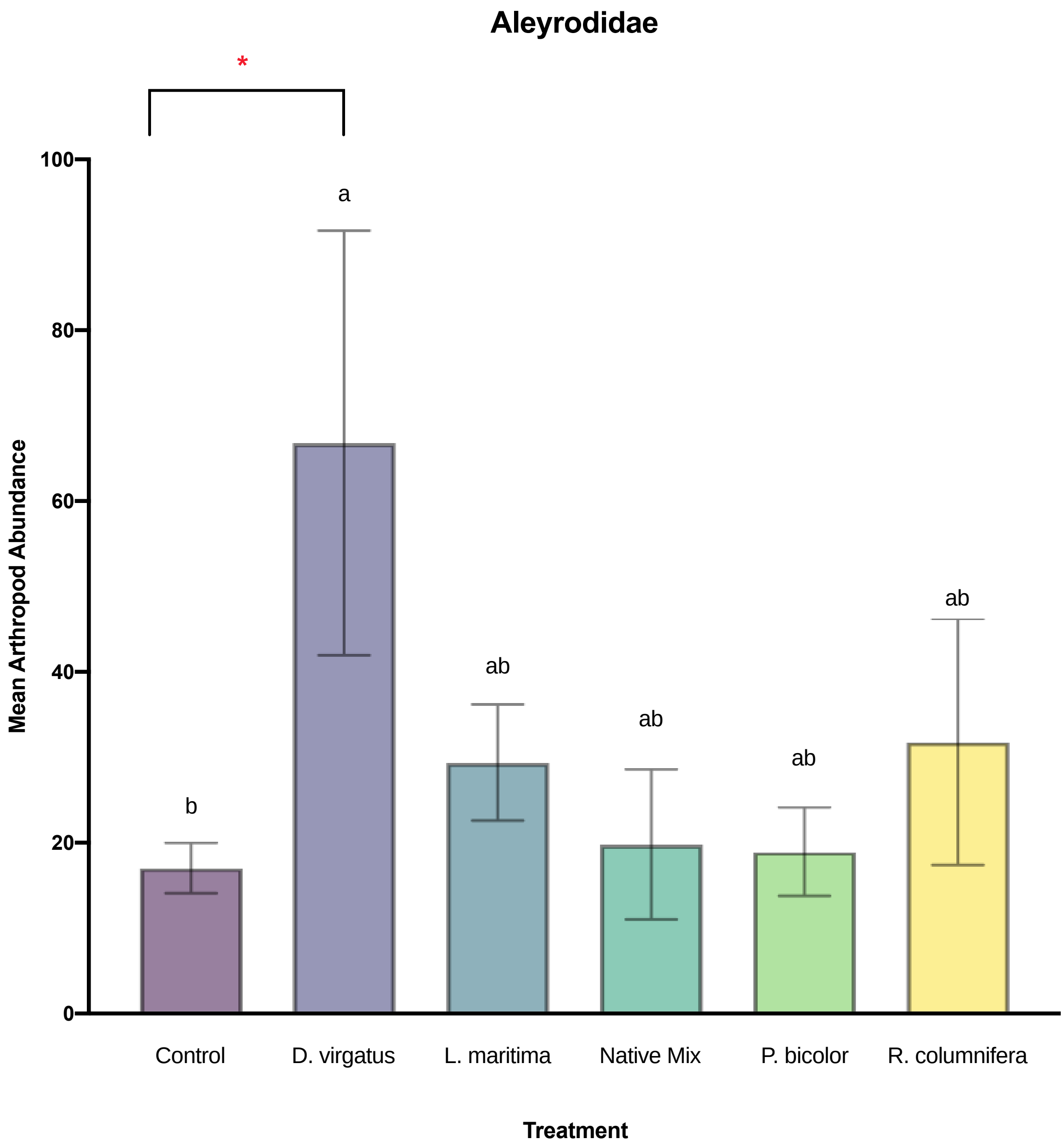

Figure 3.4. Mean arthropod abundance of the sucking pest Aleyrodidae family factored by treatment. *D. virgatus* contained significantly higher densities of whitefly than the control (Tukey; $t = -3.99$, $df = 51$, $p = 0.0206$). Significance of $p = <0.05$ is displayed with different letters.

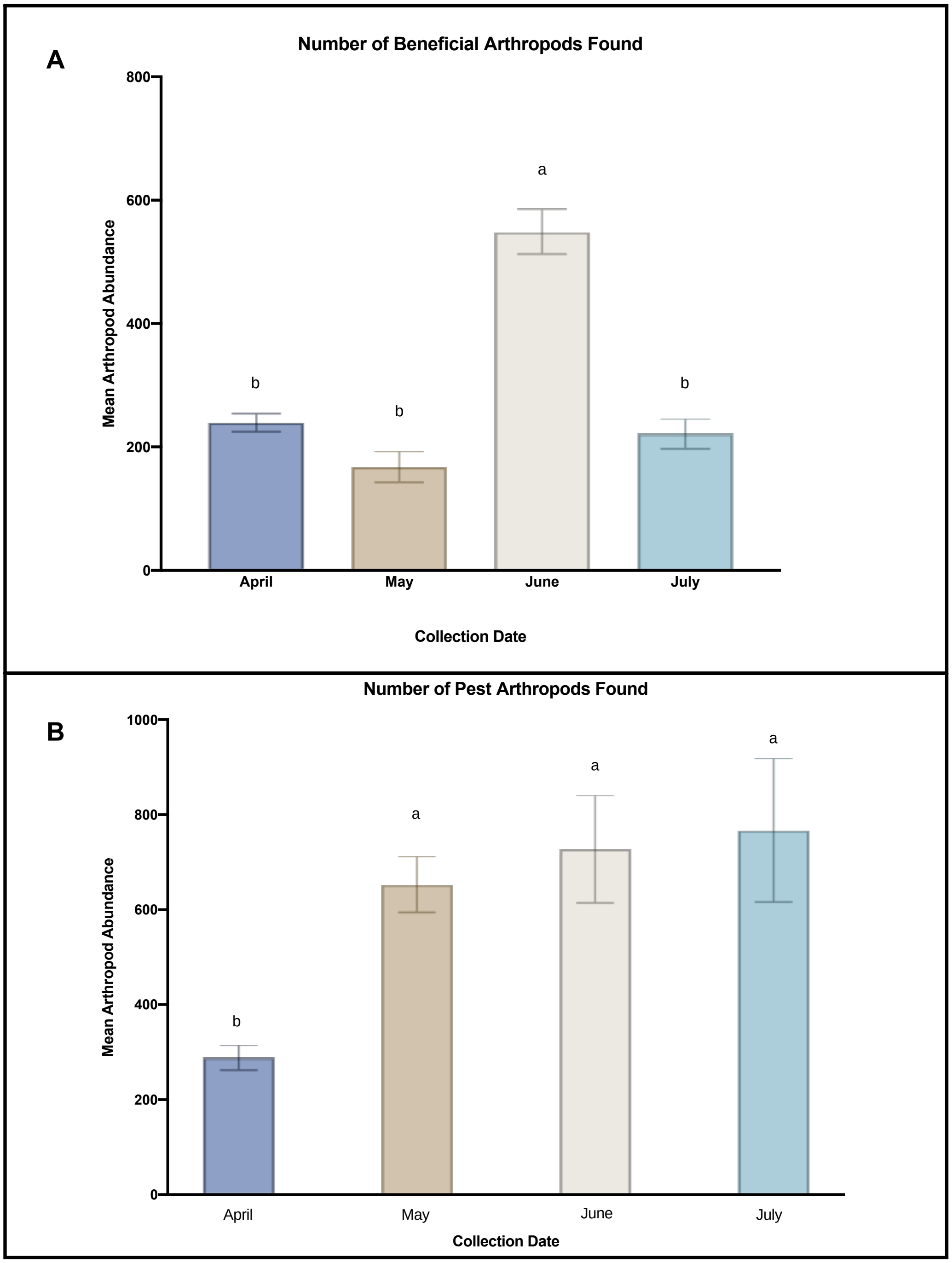

Figure 3.5.**A**. Mean beneficial arthropods found factored by month with June supporting significantly larger densities (Tukey; *t* = -9.06, *df* = 40, *p* = <0.0001). **B**. Mean pest arthropod abundance factored by collection date with April reporting significantly lower pest abundance (Tukey; *t* = 11.81, *df* = 40, *p* = <0.0001). Significance of *p* = <0.05 differing letters.

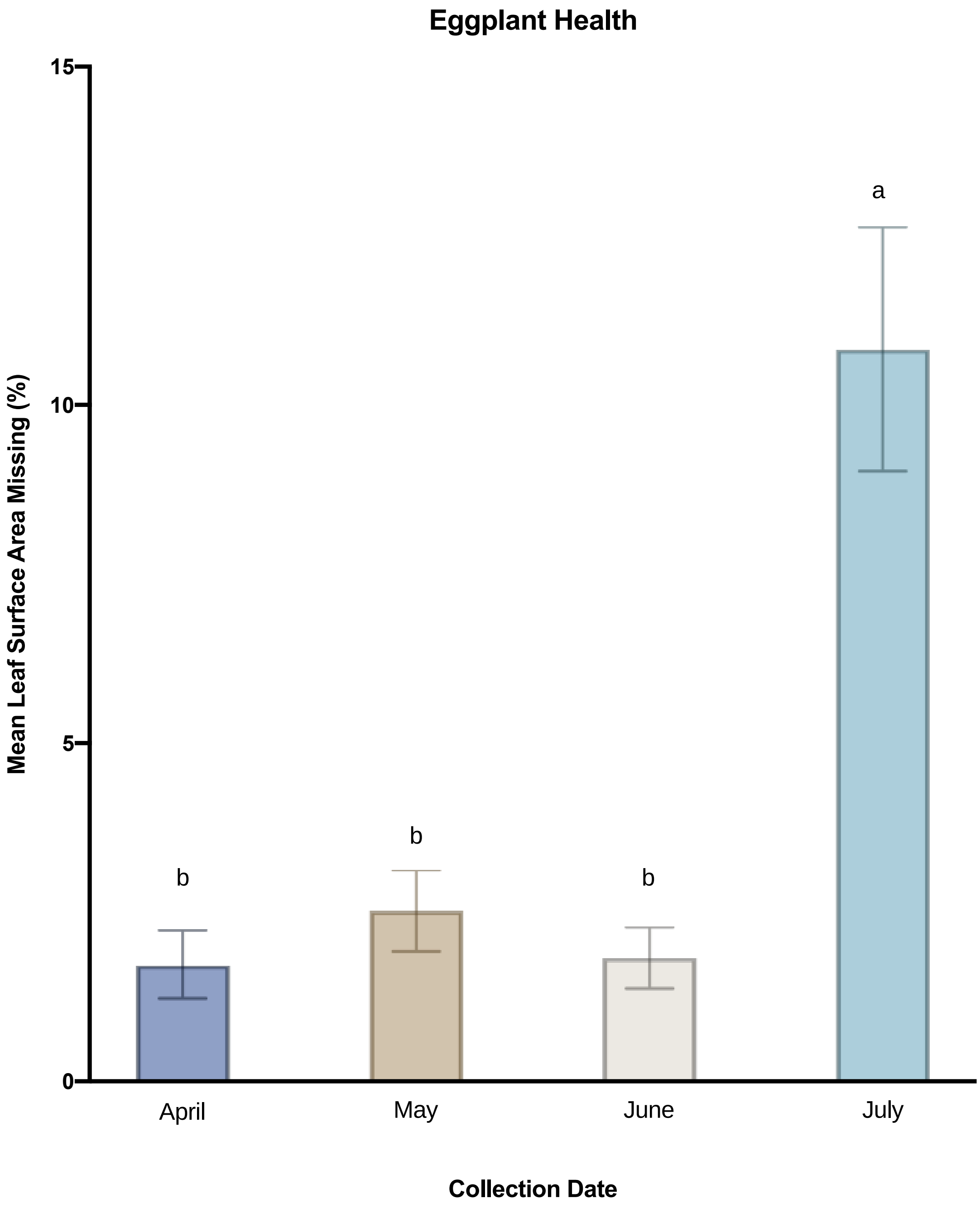

Figure 3.6 Eggplant leaf surface area missing factored by collection date. July crop damage is significantly higher than the other months (Tukey; *t* = 16.2, *df* = 3, *p* = <0.0001). Significance of p = <0.05 indicated by differing letters.

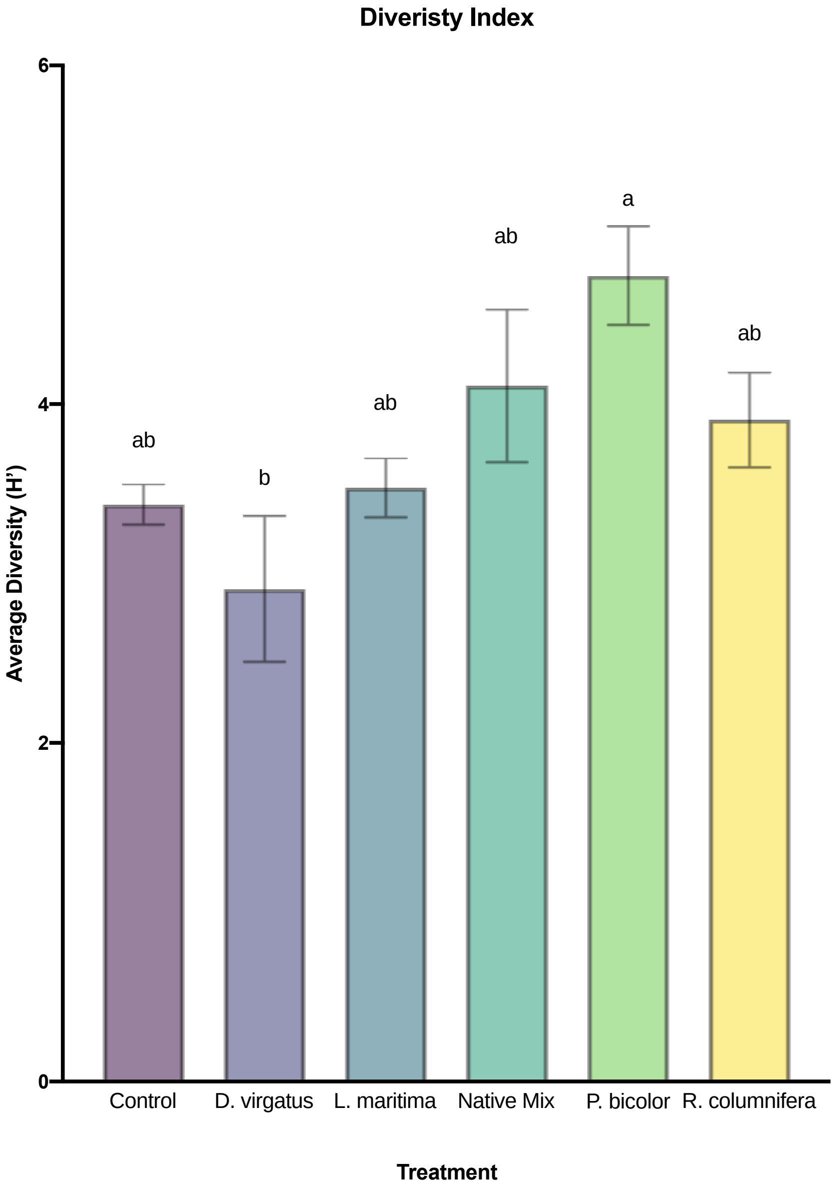

Figure 3.7 Diversity calculated through the Shannon-Wiener index factored by treatment. *P. bicolor* had significantly higher diversity (H') than *D. virgatus* (Tukey; *q* = , *df* = 5, *p* = 0.0088).
Significance of *p* = <0.05 denoted with differing letters.

CHAPTER IV

CONCLUSION

There is an urgent need to restore the environment and the natural processes that maintain and stabilize food systems. Coupling regenerative agriculture with ecological knowledge provides adaptive opportunities to improve land use and food production. Food production management must expand beyond feeding people by offering sustenance to the life forces that fuel the supporting ecological processes that feed humans. The mechanistic, linear approach is damaging to the natural flow of life. In contrast, adaptive habitat management integrates all parts of the ecosystem in cultivating food and in doing so ensure resilient foundations for future production. Although increasingly studied throughout the country and around the globe, there is no research centering native plants as biodiversity conservation mediators within food systems in the LRGV. To fill this niche, this thesis takes the first of many steps down the path of progress to implementing naturally available resources to revitalize our local agroecosystems.

Cost-Benefit Analysis

Based on our highest germination results, we recommend including *R. columnifera* (66-70%) and *P. bicolor* (52-100%) in habitat strips. *P. bicolor* doubles in germination when exposed to the aerated hydrorpime treatment, which may require extra resources but will cut costs on seeds overall through increased germination.

In contrast, *R. columnifera* did not show significant difference between no treatment and that of hydroprime, where it can be broadcast directly with irrigation and establish effectively. Although commericially sourced seds tend to have higher germination based off strategic selective breeding, growers can further reduce costs and increase biodiversity by collecting wild seeds. Many native plants are pioneer species growing in disturbed soils in the natural process of primary succession (Tilman 1985). Depending on the planting scale, one can gather seeds form field edges, along roadsides, and in vacant lots to intentionally sow and establish perennial habitat near food systems. Due to their perennial reseeding growth an initial seeding should sustain itself naturally. For land managers that are interested in adopting native habitat, the option of maintaining field edges with the elimination of pesticides and reduced mowing can provide a natural ecosystem free of charge. Due to the asynchronous seeding nature of many native plants, potential infringement may need to be managed in the most natural way possible to still preserve wildlife.

Arthropod interactions compared among all field species. Using *L. maritima* as a reference for successful insectary use, our results suggest that all native species, including *H. annuus* in the control plot, serve biological value through pollination and natural pest management. *P. bicolor* offers structural diversity for nesting and/or resting arthropods to seek refuge. *R. columnifera* provides nectar sources for parasitoids, pollinators, and predators that require energy to fulfill their essential roles in natural food systems. *D. virgatus* is a slower growing legume, which did not fully develop throughout our field season. At its growth rate we observed positive interactions favoring the cultivation of eggplant, potentially from fixed nitrogen but also likely from reduced competition for space and sun. The opposite was seen in *H. annuus*, which outcompeted the cash crop as it towered >8ft high but demonstrated potential use through its provision of habitat and could also serve as wind barriers (Radke and Hagstrom 1974), run-off buffers, and a source for bioremediation (Forte et al. 2017; Cutright et al. 2010; January et al. 2008;). Although this wild sunflower cultivar is locally considered a nuisance and has invaded beyond its native range, its practical interactions are a response to disturbance initially onset by humans.

We conclude with the cost of allocating land to preserve ecosystem services, which are a public gain but come at a private cost. However, an upsurge of reimbursement programs like the Conservation Research Program (CRP), the Agricultural Conservation Easement Program (ACEP), the Environmental Quality Incentives Program (EQIP), and the Conservation Stewardship Program (CSP), which offer varied contracts to compensate yield losses. Regenerative management provides a noble and necessary service by protecting and preserving common goods that merits further subsidization through policy. With increased awareness and demand for climate smart action as seen in the Paris Agreement, sponsorship of destructive industrial practices needs to be substituted by regenerative practices (Valentini et al. 2019). Radical growers that are leading this movement will receive the rewards resilient ecosystems offer, which often pay the yield loss back through reduced pest damage (Landis 2000). Pesticides use amounts to an annual cost of $40 billion each year, and does not include the consequential health or environmental expenses associated with it option (Bourguet and Guillemaud 2016). Implementing native habitat to host beneficial arthropods is unquestionably the cheaper.

Recommended Research

Our research investigates a local practice using a general approach that will provide ample opportunities to concentrate on specific features of conservation biodiversity through native plants. I present a few options to elaborate and extend this continued effort to restore habitat and improve local food production.

Each of our germination treatments could be broken down and analysed at different exposure times, concentrations, study duration, and/or a combination of these methods. We recommend continued research on the germination for *G. pulchella* with unexpectedly low output of only 22% using the aerated hydroprime treatment and 0% germination from any of the other treatments. *D. purpurea* initially showed promise with >50% viability, but <5% germination in the cold stratification. Variable temperature schemes and lengths of exposure may produce strategies that can improve germination and ultimately include another native plant to build a diverse community. *W. acapulensis* results were generally null, which could suggest that other environmental cues such as soil microbes play a vital role in breaking seed dormancy for this flowering forb. This species has been implemented in landscaping at the Edinburg UTRGV campus and would benefit from further experimentation to determine better germination and increased application. All three of these wildflowers could beautify home gardens, urban landscapes, and rural farms but based off our research the high cost for investment could act as deferent for implementation. Through continued research on specialized bioassays informed treatment methods can reduce the risk and encourage planting these native species.

We developed this research to act as steppingstone for further application and analysis on the abundance of native flora and their associated arthropod-mediate ecosystem services (AMES). Scaling up our research plots to replicate habitat strips will advance this research to a realistic realm that is understood and utilized by farmers. Inviting participatory partnership with local growers will continue to enhance the diversity and potential of this restorative method of food production in the LRGV. From their cumulative experience in the field, farmers can advise on what cash crops to research to make meaningful impact to local growers, markets, and consumers. Although our research design concentrated on arthropod collection over crop yield, when working with farmers the final harvest will likely take priority so the collection methods will need to be adapted. Other methods to employ without removal of the crop include focal observations, the use of sweep nets, suction samplers (ie. vacuum or aspirator), or the shaking and beating technique (McCravy 2018). On our eggplant extraction we recorded an abundance of microscopic whitefly eggs and subsequent parasitism over our collection dates, which would not be easily removed through the tactics mentioned above. Using a magnifying loop to inspect the plant, although labor and time intensive, could be a crop preservation method to pursue.

Seasonal replicates of established perennial habitat strips will contribute to a more holistic understanding of successional growth, arthropod interactions, boundary maintenance, and agricultural advantages. Environmental factors are highly variable, especially with extreme weather events becoming a more frequent occurrence. Seasonal replicates will represent the natural variation of population and community dynamics by reducing the occurrence of outliers.

Including belowground biodiversity and functional soil health associated with native plants is another research angle that will contribute to the larger puzzle of agroecosystems in the LRGV. Recording soil respiration activated by detritivore organisms, soil microbes, and plant roots, measure levels CO_2 and soil organic manner (Gougoulias et al 2014). These results can further justify the need for perennial habitat management in food production as a potential form of carbon farming and restore natural microbe communities (Andreote and Pereira 2017).

There is opportunity to build on this research by studying secondary consumers, such as birds or bats, which also offer valuable ecosystem services that could benefit food systems. With aviation populations declining globally, ecosystems are facing threats due to reduced resilience, function, and services (Rosenberg et al., 2019; Lundberg and Moberg, 2003). More than 50% of bird species consume insects and can balance pest outbreaks resulting in higher crop yields (Wenny et al., 2011; Whelan et al., 2008). Agriculture is the major culprit, with agricultural intensification practices linked to population declines of ~74% of birds associated with farmland, and 40% surviving on insectivorous diets (Stanton et al., 2018). Neonicotinoid insecticides, the leading agrochemical on the market, are predicted to reduce grassland and insectivorous populations by 12% and 5% respectively (Li et al., 2020). The alarming population trends call for research coupled with participatory action to study and apply effective methods to mitigate irrevocable damage through conservation of land-use and development decisions. Similarly, bats contribute to pest management through their insectivorous diets and correlations to land-use and agricultural inputs impact bat assemblages (Aizpurua and Alberdi 2020). Like arthropods and birds, bats respond to heterogenic landscapes, which engage with the ecosystem to provide diversity and opportunity via food and habitat (Put et al. 2019). Bat activity is greater in organic systems, that lack exposure to synthetic sprays, which affect non-target organisms, like bats (Wickramasinghe et al., 2003). In order to maintain and improve the estimated US $3.7-$53 billion annual worth of ecosystem services provided by bats, appropriate conservation in agriculture needs to be better informed through research and practice (Harms et al. 2020).

Indigenizing Food Systems

The field of agroecology strives to mutually merge scientific studies with local and indigenous knowledge of land stewards and food producers (Gliessman et al. 1981, Altieri and Toledo 2011). Agroecology also encompasses the social movement of securing sovereignty, justice, and returning power to communities. The First Peoples of North America have long lived their own version of the restorative agricultural practices I discussed throughout my thesis. Unfortunately, the sustainable lifestyles and food production of Indigenous People of North America continues to be repressed by modern colonization (Bowman 2016). But I believe that the Traditional Ecological Knowledge and culture of Indigenous People can propagate the sustainable shift in agroecology. Indigenous People understand themselves rooted in nature, recognizing that the wellbeing of one reflects the wellbeing of all. Their actions reverberate their holistic life view through responsible land stewardship honoring relationships of reciprocity, humility, and respect to maintain balance. Through their cultural perspective of borrowing land and shared common goods (soil, air, water) from their grandchildren, they actively ensure regeneration and conservation of ecosystem services. Traditional practices of seed saving are especially applicable to our study, which will further promote accessibility to applying native plants to restore ecological stability and the services they offer to food production.

By uplifting Indigenous culture and inviting their leadership in restorative food systems we can improve the health and wellbeing of our planet, people, and progress down the path of rightful reconciliation. Furthermore, we need to delve deeper and decolonize our food system, by removing the control governments and corporations have on the people’s food. The movement of food sovereignty and elevating indigenous leaders allows all people the rights to healthy, culturally appropriate foods produced through ecological sustainable practices. People have the right to self-determine their own food systems, which will be adapted locally through a collaborative, community effort. Food sovereignty centers the needs and desires of all players in the food system (farm-to-plate) at the heart of policy to equally distribute wealth and health. Upon returning to traditional practices, those that are not reliant on technology and non-renewable inputs, we can gain valuable lessons to support sustainable agriculture.

The Power in Civic Engagement

There is a pressing call for food sovereignty in the LRGV with some of the highest rates of obesity, diabetes, and poverty recorded (Rosenberg et al. 2019; Watt et al. 2016). The nutrition-related diseases afflicted across the LRGV correlate to food accessibility but are also a result of the industrialized food system. Although the residents of the LRGV don't directly receive the agricultural bounty of their region, the systems in place allow for year-round cultivation, which supports the prospect of subsistence farming. Producing food in urban centers is increasingly recognized as a sustainable alternative to reducing food insecurity, cutting back on food waste, supporting the local economy, and thus lowering poverty levels (Ladner 2011). With 3 million acres of farmland lost to development each year from 2002 to 2007, the demand for the integration of cultivation in city limits needs to be met (Ladner 2011). On a global-scale urban agriculture is predicted to produce 100-180 million tonnes of food, which translate to a worth a worth of $33 billion annually. Furthermore, the worth of ecosystem services associated with urban food production of nitrogen fixation, energy saving, pollination, climate regulation, soil formation, and bio control of pests are estimated to range from US $80-$160 billion annually (Clinton et al. 2018). Although biological diversity is already enhanced through home gardens, native flora in local food hubs throughout cities will increase a diversity of wild pollinators thereby increasing food security (Lowenstein et al. 2015; Galluzzi et al. 2010). This addition of natural perennial plants in agroecosystems will additionally counter the environmental hazards associated with urban expansion such as heat island effects (Wang and Upreti 2019), high rates of run off and consequent pollution (Müller et al. 2020.), and increased flooding (Jamali et al. 2018). An environmental and health expense subsequent from urbanization is soil contamination, emphasizing the need for native sunflowers to fulfill their role as hyperaccumulators to bioremediate the soils and create safer setting to grow food (Lal 2020; Youwakim 2020). Furthermore, they could be useful as a natural, free habitat management strategy where a volunteer establishment bordering crops provide pest and windbreak, refuge and nectar sources for parasitoids, and prevent field flooding with their deep taproots. However, wild sunflower can out compete crops and are considered a pest by agricultural producers. The cost for restoring biodiversity through land-sharing techniques in food systems should not be shouldered by the growers. The risk of implementing plants with that have proven or have the potential to persist and encroach are rightfully intimidating farmers, but with appropriate incentive and management native habitat can be rehabilitated through the field of food.

Conventional lawns are extremely require up to 60% of municipal water sources, $5.2 billion worth of fertilizers, 800 million gallons of gasoline, and apply $700 million in pesticides every year in the U.S.A. (Simmon et al. 2010). Urban agroecology can strengthen and stabilize our community to transpire change in the favor of people and planet. Participation in local governance to amend ordinances that relocate funds to support native polyculture lawns integrated with food and habitat rather than expensive, exotic, and toxic lawns is an approach that can help heal the LRGV. Barriers such as municipal policies that prohibit cultivating food within city limits must be changed to allow and encourage opportunities to grow. For residents that step into the role as restorative land managers their service to preserve common goods should be rewarded through reduced property taxes and related utility compensation. Similar moves are happening in the City of Edinburg, where Article 10 of the Edinburg Unified Development Code for landscaping entails at least 60% of vegetation removed must be replaced with native trees otherwise a penalty of $150 for every inch of diameter at breast height of trees removed will be allocated to the City's tree planting fund. This amendment of city ordinance demonstrates the incentive to adapt and provide residents a healthy environment.

Empowering civic engagement requires transdisciplinary approaches but agroecologically, the application of native plants is an accessible option to enhance participation, rehabilitate environmental systems, and feed our communities.

Native Plants: A Boundary Spanner between Food and Ecosystems

Industrialization has framed ecology and agriculture in opposing forces, but through the use of native plants a compromise can be found that unites the industry of food production and ecology. The importance of stability in all systems has been demonstrated historically when disrupted systems collapse. Pioneer native plants have adapted to disturbance and can act as successional stepping-stones to restore habitat loss, reconnect fragmentation, and increase ecosystem services that support food production.

REFERENCES

Abari, A.K., M.H. Nasr, M. Hodjati, D. Bayat, M. Radmehr. 2012. Maximixing seed germination in two *Acacia* species. J Forest Res 23(2): 241-244.

Adkins, S.W., S.M. Belliars, & D.S. Loch. 2002. Seed dormancy mechanisms in warm season grass species. Euphytica 126: 13-20.

Adkins, S.W., and N.C.B. Peters. 2001. Smoke derived from burnt vegetation stimulates germination of arable weeds. Seed Sci Res 11(3): 213-222.

Alderete-Chavez, A., Cruz-Landero, N., Guerra-Santos, J.J., Guevara, E., Gelabert, R., Cruz-Magaña, L.R., Núñez-Lara, E., and Brito, R. 2011. Promotion of germination of *Bauhina divaricata* L. seeds by effects of chemical scarification. Res. J. Seed. Sci. 4(1):51-57.

Alignier, A., Raymond, L., Deconchat, M., Menozzi, P., Monteil, C. Sarthou, J-P… Ouin, A. 2014. The effect of semi-natural habitats on aphids and their natural enemies across spatial and temporal scales. Biological Control 77: 76-82.

Allen, C.T. 2008. Boll weevil eradication: An areawide pest management effort.

Almaraz, M., Bai, E., Wang, C., Trousdell, J., Conley, S., Faloon, I., Houlton, B.Z. 2018. Agriculture is a major source of NOx pollution in California. Science Advances 4(1): 1-8.

Altieri, M. 2011. Modern agriculture: Ecological impacts and the possibilities for truly sustainable farming. Agroecology in Action. Areawide Pest Management Theory and Implementation. CABI.

An, S., Zheng, F., Zhang, F., Van Pelt, S., Hamer, U., Makeschin, F. 2008. Soil quality degradation processes along a deforestation chronosequence in the Ziwuling area, China. CATENA 75(3): 248-256.

Andreote, F.D., Pereira, D.M. de C. 2017. Microbial communities associated with plants: Learning from nature to apply it in agriculture. Current Opinion in Microbiol. 37: 29-34.

Andow, D. 1983. The extent of monoculture and its effects on insect pest populations with particular reference to wheat and cotton. Agri. Eco. Environ. 9(1): 25-35.

Andres, C., Comoé, H., Beerli, A., Schneider, M., Rist, S., Jacobi, J. 2016. Cocoa in monoculture and dynamic agroforestry. Sustain. Agric. Rev. 19: 121-153.

Ansari, O., J. Gherekhloo, B. Kamkar, F. Ghaderi-Far. 2016. Breaking seed dormancy and determining cardinal temperatures for *Malva sylvestris* using nonlinear regression. Seed Sci. Tech. 44(3): 447-460.

Anwer, Z., S. Shabbir. 2019. The morphological, anatomical and physiological aspects of maize plant after applying the different level of temperature treatments on pre-sowing maize seeds. Int. J. Biol. Med Res 10(1): 6576-6578

Aparicio, Y., Gabarra, R., Arnó, J. 2018. Attraction of *Aphidius ervi* (Hymenoptera: Braconidae) and *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae) to sweet alyssum and assessment of plant resources effects on their fitness. J. Econ. Entomol. 111(2): 533-541.

Asbjorsen, H., Hernandez-Santana, V., Liebman, M., Bayala, J., Chen, J., Helmers, M… Schulte, L.A. 2012. Targeting perennial vegetation in agricultural landscapes for enhancing ecosystems services. Renewable Agric. Food Sys. 29(02): 101-125.

Ashraf, M. & M.R. Foolad. 2005. Pre-Sowing Seed Treatment – A Shotgun Approach to Improve Germination, Plant Growth, and Crop Yield Under Saline and Non-Saline Conditions. Adv. Agron.: 223-271.

Avelino, J. Martijn ten Hoopen, G., DeClerk A.J. 2011. Ecological mechanisms for pest and disease control in coffee and cacao agroecosystems of the neotropics. Ecosystem Services from Agriculture and Agroforest. EarthScan, Ch. 4.

Bailey, A., Meyer, L., Pettingell, N., Macie, M., Korstad. J. 2020. Agricultural practices contributing to aquatic dead zones. Ecol. Pract. Appl. Sust. Agri. 3: 373-394.

Barnes, T.G., DeMaso, S.J., Bahm, M.A. 2013. Wildlife Society Bulletin 37(3): 497.

Baskin, C.C., and Baskin, J.M. 1998. Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination. San Diego*:* Academic Press.

Baskin, C.C., J.M. Baskin. 2004. Germinating seeds of wildflowers, an ecological perspective. Hort. Tech. 14(4): 467-473.

Baskin, C.C., Thompson, K., and Baskin, J.M. 2006. Mistakes in germination ecology and how to avoid them. Seed Sci. Res. 16: 165-168.

Baskin, C.C., J.M. Baskin. 2014. Seeds: ecology, biogeography, and evolution of dormancy and germination. 2nd edition. Elsevier, Academic Press, San Diego, CA

Bauddh, K., Kumar, S., Singh, R.P., Korstad, J. 2020. Ecological and practical applications for sustainable agriculture. Springer. eBook. Ch. 1, pg. 13.

Baudry, J., Bunce, R.G., Furel, F. 2000. Hedgerows: An international perspective on their origin, function, and management. J Environ. Manag. 60(1): 7-22.

Baxter, B.J.M., J. Van Staden. 1994. Plant-derived smoke: an effective seed pre-treatment. Plant Growth Regul. 14: 279-282.

Berndt, LA., Wratten, S.D., Hassan, P.G. Effects of buckwheat flowers on leafroller (Lepidoptera: Tortricidae) parasitoids in a New Zealand vineyard. Agric. For. Entomol. 4(1): 39-45.

Bennett, A.E., Strauss, S.Y. 2011. Response to soil biota by native, introduced non-pest, and pest grass species: Is responsiveness a mechanism for invasion? Biol. Invasions 15: 1343-1353.

Bhattacharyya, M. 2017. The push-pull strategy: A new approach to the eco-friendly method of pest management in agriculture. J. Entomol. Zoo. Studies 5(3): 604-607.

Bourguet, D., Guiellemaud, T. 2016. The hidden and external costs of pesticide use. Sustain. Agric. Rev. 19: 35-120.

Branstrom, C., Neuman, M. 2009. Inventing the 'Magic Valley' of South Texas, 1905-1941. Geogr Rev 99(2): 123-145.

Brennan, E.B. 2016. Agronomy of strip intercropping broccoli with alyssum for biological control of aphids. Biol. Control 97: 109-119.

Brennan, E.B. 2013. Agronomic aspects of strip intercropping lettuce with alyssum for biological control of aphids. Biol. Control 65(3): 302-311.

Briggs, D.E.1963. Biochemistry of Barley Germination Action of Gibberellic Acid on Varley Endosperm. J Inst Brew 69(1): 13-19.

Broholm, S.K Terri, T.H., and Elomaa, P. 2014. Molecular control of inflorescence development in Asteraceae. Adv. Bot. Res. 297-333.

Bruinsma, M., Ijdema, H., Van Loon, J.J.A., Dicke, M. 2008. Differential effect of jasmonic acid treatment of *Brassica nigra* on the attraction of pollinators, parasitoids, and butterflies. Entomologia Experimentalis et Applicata 128(1).

Bünemann, E.K., Schwenke, G.D., Van Zwieten, L. 2006. Impact of agricultural inputs on soil organisms – A review. Aust. J. Soil Res. 44(4): 379-406.

Butler, J., Bernal, J.S., Knutson, A.E. 2006. Effects of malathion ULV applied for boll weevil eradication on survival and foraging activity of the red imported fire ant, *Solenopsis invicta* Buren, in Texas (USA) cotton. Int J Pest Man 53(1).

Cane, J.H., Minckley, R.L., Kervin, L.J. 2000. Sampling bees (Hymenoptera: Apiformes) for pollinator community studies: Pitfalls of pan-trapping. J. Kans. Entomol. Soc. 73(4): 225-231.

Cardinale, B. 2012. Impacts of biodiversity loss. Science. 336(6081): 552-553.

Casenave, E.C., M.E. Toselli. 2007. Hydropriming as a pre-treatment for cotton germination under thermal and water stress conditions. Seed Sci. Tech. 35(1): 88-89.

Castro, B.A. 2010. Mexican rice borer (Lepidoptera: Crambidae) oviposition site selection stimuli on sugarcane, and potential field applications. J Econ. Ento. 103(4): 1180-1186.

Chambers, A.H., L. Demesyeux, & Y. Fu. 2018. Optimization of miracle fruit (*Synsepalum dulcificum)* seed germination and mutagenesis. African Journal of Food Science and Technology 9(2): 25-31.

Chaney, W.E. 2004. Insectary plants for vegetable crops. California Conference on Biological Control IV, Berkely, California, USA, 13-15 July, 2004: 53-54.

Chaplin-Kramer, R., de Valpine, P., Mills, N.J., C. Kremen. 2013. Detecting pest control services across spatial and temporal scales. Agriculture, Ecosystems, and Environment 181: 206-212.

Chaudhary, A., Kastner, T. 2016. Land use biodiversity impacts embodied in international food trade. 2016. Glob. Environ. Change 38: 195-204.

Chen, Y., Mao, J., Renolds, O.L., Chen, W., He, W., You, M., Gurr, G.M. 2020. Alyssum (*Lobularia maritima*) selectively attracts and enhances the performance of *Cotesia vestalis*, a parasitoid of *Plutella xylostella.* Sci. Rep. 10: 6447.

Chen, K.M.A., Shaw, M.R., Cameron, D.R., Underwood, E.C., Daily, G.C. 2006. Conservation planning for ecosystem services. PLoS Biol. 4(11): 2138-2152.

Choi, S., Sohngen, B., Rose, S., Hertel, T., Golub, A. 2011. Total factor productivity change in agriculture and emissions from deforestation. American Journal of Agricultural Economics 93(2): 349-355.

Chunmei, Z., et al., 2015. Gibberellic Acid-Stimulated *Arabidopsis*6 Serves as an Integrator of Gibberellin, Abscisic Acid, and Glucose Signalling during Seed Germination in *Arabidopsis*. Plant Physiol 169(3): 2288-2303.

Clarke, P.J., Latz, P.K., Albrecht, D.E. 2005. Long-term changes in semi-arid vegetation: Invasion of an exotic perennial grass has larger effects than rainfall variability. J. Veg. Sci. 16(2): 237-248.

Clinton, N., Stuhlmacher, M., Miles, A., Aragon, N.U., Wagner, M., Gorgescu, M…, Gong, P. 2018. A global geospatial ecosystem services estimate of urban agriculture. Earth's Future 6(1): 40-60.

Cohen J. 1988. Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge Academic

Cole, L.J., Stockan, J., Helliwell, R. 2020. Managing riparian buffer strips to optimize ecosystem services: A review. Agri. Eco. Environ. 296.

Cook, S.M., Khan, Z.R., Pickett, J.A. The use of push-pull strategies in integrated pest management. Ann. Rev. Entomol. 52: 375-400.

Cooperrider, M.C., Davenport, L., Goodwin, S., Ryden, L., Way, N., Korstad, J. 2020. Case studies on cultural eutrophication on watersheds around lakes that contribute to toxic blue-green algae blooms. Ecological and Practical Applications for Sustainable Agriculture 2: 357-372.

Collins, G.S., Lacewell, R.C., Norman, J. 1979. Economic implications of alternative cotton production practices: Texas Lower Rio Grande Valley. South. J. Agri. Econ.

Conley, D.J., Paerl, H.W., Howarth, R.W., Boesch, D.F., Seitzinger, S.P, Havens, K.E, … Likens, G.E. 2009. Controlling eutrophication: Nitrogen and phosphorus. Science 323 (5917): 1014-1015.

Cosyns, E.A., A. Delporte, L. Lens, & M. Hoffman. 2005. Germination success of temperature grassland species after passage through ungulate and rabbit guts. J Ecol 93**:** 353-361.

Craven, D., Eisenhauer, N., Pearse, W.D., Hautier, Y., Isbell, F., Roscher, C…, Manning, P. 2018. Multiple facets of biodiversity drive the diversity-stability relationship. Nat. Ecol. Evol. 2: 1579-1587.

Cutright, T. Gunda, N., Kurt, F. 2010. Simultaneous hyperaccumulation of multiple heavy metals by *Helianthus annuus* grown in a contaiminated sandy-loam soil. Int. J. Phytoremediation 12(6)

Davies, K.W. 2011. Plant community diversity and native plant abundance decline with increasing abundance of an exotic annual grass. Oceologia 167: 481-491.

De Boeck, H.J., Bloor, J.M.G., Kreyling, J., Ransijn, J.C.G., Nijs, I., Jentsch, A., Zeiter, M. 2017. Patterns and drivers of biodiversity-stability relationships under climate extremes. J. Ecol. 106(3): 890-902.

D'Este, V.R., J. Axelsson, F. Yndgaard, & S.Ø. Solberg. 2019. Stratification, scarification, and gibberellic acid treatments of garden angelica (*Angellica aracangelica*) seeds. Seed Sci. Tech. 47(3): 243-247.

Dirzo, R., Young, H.S., Galetti, M., Ceballos, G., Isaac, N.J.B., Collen, B. 2014. Defaunation in the Anthropocene. Science 345(6195): 401-406.

Donohue, K., R. Rubio de Casas, L. Burghardt, K. Kovach, & C.G. Willis. 2010. Germination, Postgermination Adapatation, and Species Ecological Ranges. Annu rev Ecol Evol Syst 41: 293-319.

Eddleman, L.E., Meinhardt, P.L., 1981. Seed viability and seedling vigor in selected prairie plants. OBS Notes 15: 1978.

Egan, P.A., Dicks, L.V., Hokkanen, H.M.T., Stenberg, J.A. 2020. Delivering integrated pest and pollinator management (IPPM). Trends Plant Sci. 25(6): 577-589.

Eigenbrode, S.D., Birch, A.N.E., Lindzey, S., Meadow, R., Snyder, W.E. 2015. Review: A mechanistic framework to improve understanding and applications of push-pull systems in pest management. J. Appl. Ecol. 53(1): 202-212.

Elias, S., A. Garay, L. Schweitzer, & S. Hanning. 2006. Seed Quality Testing of Native Species. Nat Plants J 7(1): 15-19.

Ellis-Felege, S.N., Dixon, C.S., Wilson, S.D. 2013. Impacts and management of invasive cool-season grasses in the Northern Great Plains: Challenges and opportunities for wildlife. Wildlife Society Bulletin 37(3): 510-516

Elser, J., Bennett, E. 2011. A broken biogeochemical cycle. Nature 478: 29-31.

Elzen, G.W., Maldonado, S.N., Rojas, M.G. 2000. Lethal and sublethal effects of selected insecticides and insect growth regulator on the boll weevil (Coleoptera:

Curulionidae) Ectoparasitoid *Catolaccus grandi* (Hymenoptera: Pteromalidae). J of Econ Ento 93(2): 300-303.

Elzenga, J.T.M., Bekker, R.M., Pritchard, H.W. 2019. Maximising the use of native seeds in restoration projects. Plant Biol 21(3): 377-379

Fielder AK, Landis DA. 2007. Attractiveness of Michigan native plants to arthropod natural enemies and herbivores. Environ Entomol 36(4): 751-765

Fontenele, A.C.F., Aragão, W.M., Rangel, J.G. de A., Almeida, S.A. 2009. Tropical legumes: *Desmanthus virgatus* (L.) Willd. A promisse forrage. Revista Brasileira de Agrociência 15(¼): 121-123.

Forister, M.L., Pelton, E.M., Black, S.H. 2019. Declines in insect abundance and diversity: We know enough to act now. J Soc. Conserv. Biol. 1(8): e80.

Forte, J., Mutiti, S. 2017. Phytoremediation potential of *Helianthus annuus* and *Hydrangea paniculata* in copper and lead-contaminated soil. Water Air Soil Pollut 228(77): 1-11.

Fowler, N.L, and Simmons, M.T. 2008. Savanna dynamics in central Texas: Just succession? Applied Vegetation Science 12: 23-31.

França-Neto, J. de B., & Krzyzanowski, F.C. 2019. Tetrazolium: an important test for physiological seed quality evaluation. J. Seed Sci. 41(3).

Galluzzi, G., Eyzaguirre, P., Negri, V. 2010. Home gardens: Neglected hotspots of agro-biodiversity and cultural diversity. Biodivers. Conserv. 19.

Garrido, E., Andraca-Gómez, G., Fornoni, J. 2011. Local adaptation: simultaneously considrating herbivores and their host plants. New Phytologist 193(2): 445-453.

Gemmil-Herren, B., Ochieng, A.O. 2008. Role of native bees and natural habitats in eggplant (*Solanum melongena*) pollination in Kenya. Agric. Eco. Environ. 127(1-2): 31-36.

Gene, S.M., Hoekstra, P.F., Hannam, C., White, M., Truman, C., Hanson, M.L., Prosser, R.S. The role of vegetated buffers in agriculture and their regulation across Canada and the United States. Journal of Environmental Management 243: 12-21.

Geneve, R.L.1998. Seed Dormancy in Commercial Vegetable and Flower Species. Seed Tech 20(2): 236-250.

Geertsema W, Rossing AHW, Landis DA, Bianchi FJJA, van Rijn PCJ, Schaminée JHJ, Tscharntke T, van der Werf W. 2016. Actionable knowledge for ecological intensification of agriculture. Front Ecol Environ 14(4): 209-216.

Gibson, A.L., Espeland, E.K., Wagner, V., Nelson, C.R. 2016. Can local adaptation research in plants inform selection of native plant materials? An analysis of experimental methodologies. Evol. Appl. 9(10): 1219-1228.

Gliessman, S., Tittonell, P. 2015. Agroecology for food security and nutrition. Agroecol. Sust. Food 39(2): 131-133.

Gougoulias, C. Clark, M.J., Shaw, L.J. 2014. The role of soil microbes in the global carbon cycle: Tracking the below-ground microbial processing of plant-derived carbon for manipulating carbon dynamics in agricultural systems. Sci. Food. Agric. 94(12): 2362-2371.

Govers, G., Van Oost, K., Wang, Z. Scratching the critical zone: The global footprint of agricultural soil erosion. Procedia Earth and Planetary Sci. 10: 313-318.

Govers, G., Merckx, R., van Wesemael, B., Van Oost, K. 2017. Soil conservation in the 21st century: Why we need smart agricultural intensification. SOIL 3: 45-59.

Habel, J.C., M.J. Samways, T. Schmitt. 2019. (a) Mitigating the precipitous decline of terrestrial European insects: Requirements for a new strategy. Biodivers. Conserv. 28: 1343-1360.

Habel, J.C., Ulrich, W., Biburger, N., Seibold, S., Schmitt, T. 2019. (b). Agricultural intensification drives butterfly decline. Insect Conserv. Divers. 12(4): 289-295.

Hallmann, C.A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H..., de Kroon, H. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS One 12(10).

Harris, M.K. 2001. IPM, what has it delivered? A Texas case history emphasizing cotton, sorghum, and pecan. Plant Disease 85(2): 112 – 121.

Hassanali, A., Herren, H., Khan, Z.R., Pickett, J.A., Woodcock, C.M. 2007. Integrated pest management: The push-pull approach for controlling insect pests and weeds of cereals, and its potential for other agricultural systems including animal husbandry. Philos. Trans. Royal Soc. B 363(1491)

Haverkamp, A., Hansson, B.S., Knaden, M. 2018. Combinatorial codes and labeled lines: How insects use olfactory cues to find and judge food, mates, and oviposition sites in complex environments. Front. Physiol. 9.

Hautier, Y., Tilman, D., Isbell, F., Seabloom, E.W., Borer, E.T., Reich, P.B. 2015. Anthropogenic environmental changes affect ecosystem stability via biodiversity. Science 348(6232): 336-340.

Heleno, R.H., Ross, G., Everard, A., Memmott, J., Ramos, J.A. 2010. The role of avian ‘seed predators’ as seed dispersers. Int. J. Avian Sci. 153: 199-203.

Helmers MJ, Zhou XB, Asbjornsen H, *et al*. 2012. Sediment removal by prairie filter strips in row-cropped ephemeral watersheds. J Environ Qual 41: 1531–39.

Hernández-Suárez, E., Carnero, A., Aguiar, A., Prinsloo, H.G., LaSalle, J., Polaszek, A. 2003. Parasitoids of whiteflies (Hymenoptera: Aphelinidae, Eulophidae, Platygastridae; Hemiptera: Aleyrodidae) from the Macaronesian archipelagos of the Canar Islands, Madeira and the Azores. System. Biodivers. 1(1): 55-108.

Herron-Sweet, C.R., Lehnhoff, E.A., Burkle, L.A., Littlefield, J.L., Mangold, J.M. 2016. Temporal- and density-dependent impacts of an invasive plant on pollinators and pollination services to a native plant. Ecosphere 7(2).

Heuzé V., G. Tran, P. Hassoun, & F. Lebas. 2017.

Slender grama (*Bouteloua repens)*. Feedipedia.

Hogg, B.N., Bugg., R.L., Daane, K.M. 2011. Attractiveness of common insectary and harvestable floral resources to beneficial insects. Biol. Control 56(1): 76-84.

Holm S. 1979. A simple sequentially rejective multiple test procedure. Scand. J. Stat. 6(2): 65-70.

Holzchuh, A., Dudenhöffer, J-H., Tscharntke, T. 2012. Landscapes with wild bee habitats enhance pollination, fruit set and yield of sweet cherry. Biol. Conserv. 153: 101-107.

Horn, D.J. 2002. Ecological aspects of pest management. Encyclopedia of Pest Management. Taylor & Francis.

Horrigan, L., Lawrence, R.S., Walker, P. 2002. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environ. Health Perspect. 110(5): 445-456.

Hu, W., Wu, Y.P., Wang, Y.R. 2009. Different requirements for physical dormancy release in two populations of *Sophora alopecuroidea* relation to burial depth. Ecol. Res. 24: 1051-1056.

Huang, Y.G., Flipps, G., Lacey, R., Thomson, S. 2011. Landsat satellite multi-spectral image classification of land cover and land use for GIS-based urbanization analysis in irrigation districts of lower Rio Grande Valley of Texas. *J.* Appl. Remote Sens. 2(1): 27-36.

Hung, K-L.J., Kingston, J.M., Albrecht, M., Holway, D.A., Kohn, J.R. 2018. The worldwide importance of honey bees as pollinatos in natural habitats. Proc. Royal Soc. Biol. Sci. 285(1870): 1-8.

Hunter, M.D. 2002. Ecological causes of pest outbreaks. Encyclopedia of Pest Management. Taylor & Francis.

Inouye, D.W., Larson, B.M.H., Ssymank, A., Kevan, P.G. 2015. Flies and flowers III: Ecology of foraging and pollination. J. Pollinat. Ecol. 16(16): 115-133.

Isbell, F., Calcagno, V., Hector, A., Connolly, J., Harpole, W.S., Reich, P.B…, Loreau, M. 2011. High plant diversity needed to maintain ecosystem services. Nature 477: 199-202.

Jain, H.K. 2010. Green revolution history, impact and future. Stadium Press LLC.

Jamali, B., Löwe, R., Bach, P.M., Urich, C., Arnbjerg-Nielsen, K., Deletic, A. 2018. A rapid urban flood inundation and damage assessment model. J. Hydrology 564: 1085-1098.

January, M.C., Cutright, T.J., Van Keulen, H., Wei, R. Hydroponic phytoremediation of Cd, Cr, Ni, As, and Fe: Can *Helianthus annuus* hyperaccumulate multiple heavy metals? Chemosphere 70(3): 531-537.

Jiménez-Alfaro, B., et al. 2016. Seed germination traits can contribute better to plant community ecology. J. Veg. Sci. 27: 637-645.

Johanowicz, D.L., Mitchell, E.R. 2000. Effects of sweet alyssum flowers on the longevity of the parasitoid wasps *Cotesia marginiventris* (Hymenoptera: Braconidae) and *Diadegma insulare* (Hymenoptera: Ichnumonidae). The Florida Entomologist 83(1): 41-47.

Jones, M.S., Snyder, W.E. Beneficial insects in agriculture: Enhancement of biodiversity and ecosystem services. Insect Biodiversity: Science and Society, Ch. 5: 105-122.

Jones, R.G., Wolfenbarger, D.A. 1997. Malathion ULV residual control efficacy under boll weevil eradication program conditions. 1997 Proceedings Beltwide Cotton conferences, New Orleans, LA, USA, Volume 2.

Joshi, N.K., Leslie, T., Rajotte, E.D., Kammerer, M.A., Otieno, M., Biddinger, D.J. 2015. Comparative tapping efficiency to characterize bee abundance, diversity, and community composition in apple orchards. Ann. Entomol. Soc. Am. 108(5): 785-799.

Kalloo, G. 1993 Eggplant: *Solanum melongena* L. Genetic Improvement of Vegetable Crops: 587-604

Karyiat, R., Chavana, J., Kaur, J. 2018. An inexpensive and comprehensive method to examine and quantify field insect community influenced by host plant olfactory cues. Bio-Protocol 8(16).

Kavian, A., Azmoodeh, A., Solaimani, K. 2014. Deforestation effects on soil properties, runoff, and erosion in northern Iran. Arabian Journal of Geosciences 7: 1941-1950.

Keeley, J.E., & C.J. Fotheringham. 2000. Role of Fire in Regeneration from Seed. CAB International, Seeds: The Ecology of Regeneration in Plant Communities, 2nd edition, ch. 13: 311-330.

Khan, Z., Midega, C.A.O., Hooper, A., Pickett, J. 2016. Push-Pull: Chemical ecology-based integrated pest management technology. J. Chem. Ecol.42: 689-697.

Khan, Z., Midega, C., Pittchar, J., Pickett, J., Bruce, T. 2011. Int. J. Agric. Sustain. 9(1).

Khan, Z.R., Pickett, J.A. 2004. The 'push-pull' strategy for stemborer management: A cas study in exploiting biodiversity and chemical ecology. Ecological Engineering for Pest Management Advances in Habitat Manipulation for Arthropods. Chapter 10. CSIRO Publishing.

Kharat, S.T., Prasad, V.L., Sobale, B.N., Sane, M.S., Joshi, A.L., Rangnekar, D.V. 1980. Note on comparative evaluation of *Leucaena leucocephala*, *Desmanthus virgatus*, and *Medicago sativa* for cattle. Indian J. Anim. Sci. 50(8): 638-639.

Kinzig, A. P., Ryan, P., Etienne, M., Allison, H., Elmqvist, T., Walker, B.H. 2006. Resilience and regime shifts assessing cascading effects.

Kleijn, D., Bommarco, R., Fijen, T.P.M., Garibaldi, L.A., Potts, S.G., van der Putten, W.H. 2019. Ecological intensification: Bridging the gap between science and practice. Trends in Ecol. Evol. 34(2): 154-166.

Kowalska, G. 2008. Flowering biology of eggplant and procedures intensifying fruit set – Review. Acta Sc. Pol. Hortorum Cultus 7(4): 63-76.

Kremen, C., Ilse, A., Bacon, C. 2012. Diversified farming systems: An agroecological, systems-based alternative to modern industrial agriculture. Ecol. Soc. 17(4): 44.

Ladner, P. 2011. The urban food revolution Changing the way we feed cities. New Society Publishers.

Lahey, Z.J., Polaszek, A. *Baeoentedon balios* (Hymenoptera: Eulophidae): A parasitoid of ficus whitefly, *Singhiella simplex* (Singh) (Hemiptera: Aleyrodidae), new to the United States. 2017. Int. J. Pest. Manag. 63(4): 349-351.

Lal, R. 2020. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Security 12: 871-876.

Landis, D.A., Wratten, S.D., Gurr, G.M. 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. Ann. Rev. Entomol. 45: 175-201.

Lankau, R.A. 2013. Species invasion alters local adaptation to soil communities in a native plant. Ecol. 94(1): 32-40.

Lankau, R.A. 2012. Coevolution between invasive and native plants driven by chemical competition and soil biota. PNAS 28: 11240-11245.

Lanz, B., Dietz, S., Swanson, T. 2018. The expansion of modern agriculture and global biodiversity decline: An integrated assessment. Ecol. Econ. 144: 260-277.

Lawrence, K., Hagan, A., Norton, R., Hu, Jiahuai, Faske, T., Hutmacher, R… Mehl, H.L. 2019. Cotton disease loss estimate committee report, 2018. Beltwide Cotton Conferences, New Orleans, LA: 54-56.

Lawson, D.A., Whitney, H.M., Rands, S.A. 2017. Colour as a back up for scent in the presence of olfactory noise: Testing the effiency backup hypothesis using bumblebees (*Bombus terrestris*). R. Soc. Open Sci. 4(11).

Leather, S.R. 2018. “Ecological Armageddon” – More evidence for the drastic decline in insect numbers. Ann. Appl. Biol. 172(1): 1-3.

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R.T., Haines, A., Ramanathan, V. 2019.Effects of fossil fuel and total anthropgenic emission removal on public health and climate. PNAS 116(15): 7192-7197.

Leslie, M.D., Jr. 2016. An international borderland of concern: Conservation of biodiversity in Lower Rio Grande Valley. U.S.G.S Scientific Investigation Report 2016-5078.

Lindsey III, B.E., et al. 2017. Standardized method for high-throughput sterilization of Arabidopsis seeds. J. Vis. Exp. 128.

Losey, J.E., Vaughan, M. 2006. The economic value of ecological services provided by insects. BioSci. 56(4):311-323.

Lowenstein, D.M., Matteson, K.C., Minor, E.S. 2015. Diversity of wild bees support pollination services in an urbanized landscape. Oecologia 179: 811-821.

Lloyd-Reilley, J. 2011. Plant guide for prairie acacia (*Acacia angustissima* var. *hirta)*. USDA Natural Resources Conservation Service, E. "Kika" de la Garza Plant Materials Center. Kingsville, TX 78363.

Lloyd-Reilley, J. 2010. Plant guide for pink pappusgrass (*Pappophorum bicolor*). USDA-NRCS, E. "Kika" de la Garza Plant Material Center. Kingsville, TX.

Lloyd-Reilley, J. & S.D. Maher. Plant Fact Sheet – Orange Zexmenia (*Wedelia texana)*(A.Gray) B.L. Turner. USDA-NRCS. E. "Kika" del la Garza Plant Material Center. Kingsville, TX.

Lloyd-Reilley, J. & S.D. Maher. 2013. Plant Guide – Prostrate Bundleflower. USDA-NRCS. E. "Kika" de la Garza Plant Materials Center. Kingsville, TX.

Lopez del Egido, L., Toorop, P.E., Lanfermeijer, F.C. 2018. Seed enhancing treatments: comparative analysis of germination characteristics of 23 key herbaceous species used in European restoration programmes. Plant Biol. 21(3): 398-408.

Lorenzo-Felipe, I., Blanco, C.A., Corona, M. 2020. Impact of Apoidea (Hymenoptera) on the world's food production and diets. Ann. Entomol. Soc. Am. 113(6): 407-424.

Lunau, K., Papiorek, S., Eltz, T., Sazima, M. 2011. Avoidance of achromatic colours by bees provides a private niche for hummingbirds. J. Exp. Biol. 214: 1607-1612.

Mahajan, G., N.K. Mutti, P. Jha, M. Walsh, & R.S. Chauhan. 2018. Evaluation of dormancy breaking methods for enhanced germination in four biotypes of *Brassica tournefortii*. Sci. Rep. 8

Majd, R., P. Aghaie, E.K. Mongared, & M.T. Alebrahim. 2013. Evaluating of Some Treatments on Breaking seed Dormancy in Mesquite. Int. J. Agron. Plant Produc. 4(7): 1433-1439.

McCravy, K.W. 2018. A review of sampling and monitoring methods for beneficial arthropods in agroecosystems. Insects 9(4).

McCravy, K.W., Geroff, R.K., Gibbs, J. 2016. Malaise trap spling efficiency for bees (Hymenoptera: Apoidea) in a restored tallgrass prairie. Fla. Entomol 99(2): 321-323.

McLaughlin, A., Mineau, P. 1995. The impact of agricultural practices on biodiversity. Agri. Eco. Environ. 55(3): 201-212.

Meyer, S. 2006. Strategies for Seed Propagation of Native Forbs. USDA Forest Service Proceedings *RMRS-P-43*.

Montgomery, D.R. 2007. Soil erosion and agricultural sustainability. PNAS 104(33):13268-13272.

Meagher,R.L., Smith, J.W., Browning, H.W., Saldana, R.R. 1998. Sugarcane stemborers and their parasites in southern Texas. Environmental Entomology 27(3): 759-766.

Menges, E.S. 2000. Population viability analyses in plants: Challenges and opportunities. Trends Ecol. Evol. 15: 51-56.

Moreira, E.F., Santos, R.L da. S., Penna, U.L., Angel-Coca, C. Oliveria, F.F. de. Viana, B.F. 2016. Are pan traps colors complementary to sample community of potential pollinator insects? J. Insect Conserv. 20: 583-596.

Müller, A., Osterlund, H., Marsalek, J., Viklander, M. 2020. The pollution conveyed by urban runoff: A review of sources. Sci. Total Environ. 709: 136125.

Nath, A.J., Lal, R. 2017. Effects of tillage practices and land use management on soil aggegates and soil organic carbon in the North Appalachian region, USA. Pedosphere 27(1): 172-176.

Nasr, S.M.H., S.K. Savadkoohi, & E. Ahmadi. 2013. Effect of different seed treatments on dormancy breaking germination in three species in arid and semi-arid lands. For. Sci. Practice 15(2): 130-136.

Native American Seed. 2020. *Chloris cuculatta* – Hooded Windmill Grass.

Nebel, S., Mills, A., McCracken, J.D., Taylor, D.P. 2010. Declines of aerial insectivores in North America follow a geographic gradient. Avian Conserv. Ecol. 5(2):1.

Nemoto, H. 1995. Pest management systems for eggplant arthropods: A plan to control pest resurgence resulting from the destruction of natural enemies. Japan Agric. Res. Quarterly 29: 25-29.

Niranjana, R.F., Devi, M., Shanika, W., Sridhar, R.P. 2015. Potential use of egg parasitoids, *Trichogramma pretiosum* Riley and *Trichogramma chilonis* Ishii against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenée. Trop. Agri. Res. 27(1): 88-94.

Ohno, K., Takemoto, H. 1997. Species composition and seasonal occurrence of Orius spp. (Heteroptera: Anthocoridae), predacious natural enemies of Thrips palmi (Thysanoptera: Thripidae), in eggplant fields and surrounding habitats. Appl. Entomol. Zoo. 32.

Olff, H., & M.E. Ritchie. 1998. Effects of herbivores on grassland plant diversity. Trends Ecol. Evol. 13: 261-265.

Olszeqski, M.W., C.A. Young, & J.B. Sheffield. 2010. Germination and Seedling Growth of *Desmanthus illinoensis* and *Desmodium canadense* in Response to Mechanical Scarification. Hort. Sci. 45(10): 1554-1558.

Ortiz-Reyes, E., Anex, R.P. 2018. A life cycle impact assessment method for freshwater eutrophication due to the transport of phosphorus from agricultural production. J. Clean. Produc. 177: 474-482.

Paredes, D., Rosenheim, J.A., Chaplin-Kramer, R., Winter, S., Karp, D.S. 2020. Landscape simplification increases vineyard pest outbreaks and insecticide use. Ecol Let.

Parsons, J.M., S. George, & G. Grant. Texas Bluebonnets – Texas Pride. Texas Cooperative Extension AgriLife

Patricio, G.B., Grisolia, B.B., Desuó, I.C., Montagnana, P.C., Brocanelli, F.G., Gomig, E.G, Campos, M.J.O. 2012.The importance of bees for eggplant cultivation (Hymenoptera: Apidae, Andrenidae, Halictidae. Sociobiology 59(3): 1037-1052.

Patt, J.M., Hamilton, G.C., Lashomb, J.H. 1997. Impact of strip-insectary intercropping with flowers on conservation biological control of the Colorado potato beetle. Adv. Hort. Sci. 11(4): 175-181.

Pedrini, S., W. Lewandrowski, J. Stevens, & K.W. Dixon. 2018. Optimizing seed processing techniques to improve germination and sowability of native grasses for ecological restoration. Plant Biol. 21: 415-424.

Pendrill, F., Persson, U.M., Godar, J., Kastner, T., Moran, D., Schmidt, S., Wood, R. 2019. Agricultural and forestry trade drives large share of tropical deforestation emissions. Glob. Environ. Change 56: 1-10.

Pimentel, D., Burgess, M. 2013. Soil erosion threatens food production. Agri. 3(3): 443-463.

Pimentel, D. 2005. Environmental and economic costs of the application of pesticides primarily in the United States. Environ. Develop. Sustain. 7: 229-252.

Pimentel, D., Kounang, N. 1998. Ecology of soil erosion in ecosystems. Ecosystems 1: 416-426.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D., Seidel, R. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. 2005. BioScience 55(7): 573-582.

Portman, Z.M., Bruninga-Socolar, B., Cariveau, D. 2020. The state of bee monitoring in the United States: A call to refocus away from bowl traps and towards more effective methods. Ann. Entomol. Soc. Am. 113(5): 337-342.

Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Scheweiger, O., Kunin, W.E. 2010. Trends Ecol. Evol. 25(6): 345-353.

Potts, S.G., Imperatrix-Fonseca, V., Ngo. H.T., Aizen, M.A., Biesmeijer, J.C., Breeze, T.D…, Vanbergen, A.J. 2016. Safeguarding pollinators and their values to human well-being. Nature 540: 220-229.

Prado-Lu, J.L.D. 2015. Insecticide residues in soil, water, and eggplant fruits and farmers' health effects due to exposure to pesticides. Environ. Health Prev. Med. 20:53-62.

Prendergast, K.S., Menz, M.H.M., Dixon, K.W., Bateman, P.W. 2020. The relative performance of sampling for native bees: An empirical test and review of the literature. Ecosphere 11(5): 1-22.

Pretty, J.N., Brett, C., Gee, D., Hine, R.E., Mason, C.F., Morison, J.I.L…, van der Bijl, G. 2000. An assessment of the total external costs of UK agriculture. Agric. Sys. 65(2): 113-136.

Qiao, H., Zheng, F., Jiang, H., Dong, K. 2019. The greenhouse effect of the agriculture-economic growth-renewable energy nexus: Evidence from G20 countries. Science of the Total Environment 671: 722-731.

Quershi, SA., Midmore, D.J., Syeda, S.S., Reid, D.J. 2010. A comparison of alternative plant mixes for conservation bio-control by native beneficial arthropods in vegetable cropping systems in Queensland Australia. Bull. Entomol. Res. 100(1): 67-73.

Radke, J.K., Hagstrom, R.T. 1974. Wind turbulence in a soybean fileld sheltered by four types of wind barriers. Agron. J. 66(2): 273-278.

Ramirez-Yañz, L.E. 2005. Prescribed fire and intensive grazing to control invasive Guinea grass on native pastures in south Texas. MS Thesis. ProQuest.

Ramos, M.E., A.B. Robles, & J. Castro. 2006. Efficiency of endozoochorous seed dispersal in six dry-fruited species (Cistaceae): from seed ingestion to early seedling establishment. Plant Ecol. 185: 97-106.

Rasplus, J-Y., Blaimer, B.B., Brady, S.G., Burks, R.A., Delvare, G., Fisher, N…, Cruaud, A. 2020. A first phylogenomic hypothesis for Eulophidae (Hymenoptera: Chalcidoidea). J. Nat. Hist. 54(9-12): 597-609.

Rehman, S. & I.H. Park. 2000. Effect of scarification, GA, and chilling on the germination of Goldenrain-tree (*Koelreuteria paniculata* Laxm.) seeds. Scientia Horticulturae 85: 319-324.

Renard, D., Tilman, D. 2019. National food production stabilized by crop diversity. Nature 571: 257-260.

Retallack, M., Thomson, L., Keller, M. 2019. Native insectary plants support populations of predatory arthropods for Australian vineyards. BIO Web of Conferences 15, 01004.

Ribeiro, A.L., Gontijo, L.M. 2017. Alyssum flowers promote biological control of collards pest. BioControl 62: 185-196.

Richards, A.J. 1990. Reproductive versatility in the grasses. Cambridge University Press, Ch. 6, 131-134

Richard, G.A., Zabala, J.M., Cerino, M.C., Marinoni, L. del R. Beutel, M.E., Pensirero, J.F. 2018. Variability in hardseededness and seed coat thickness of three populations of *Desmanthus virgatus* (Fabaceae, Mimosoideae). Grass Forage Sci. 73(4): 1-9.

Risch, S.J. 2012. Agricultural Ecology and Insect Outbreaks. Insect Outbreaks. Elsevier Science.

Roberts, D.E. 2015. Classical biological control of the cereal leaf beetle, *Oulema melanopus* (Coleoptera: Chyrsomelidae), in Washington State and role of field insectaries, a review. BioControl Sci. Tech. 26(7): 877-893.

Robertson, S.G., Hickan, K.R. 2012. Aboveground plant community and seed bank composition along an invasion gradient. Plant Ecol. 213: 1461-1475.

Roitberg, B.D. 2007. Why pest management needs behavioral ecology and vice versa. Entomol. Res. 37(1): 14-18.

Romo, C.M., Tylianakis, J.M. 2013. Elevated temperature and drought interact to reduce parasitoid effectiveness in suppressing hosts. PLoS ONE 8(3).

Rosenberg, J., Sudanagunta, S., Griffin, M. 2019. Survey of Latino/Hispanic adult immigrants living in the Colonias of Hidalgo county, Texas evaluating reported food insecurity and immigration-related fear. J Appl. Res. Child. 10(1).

Rosset, P. 2004. The multiple functions and benefits of small farm agriculture in the context of global trade negotiations. Dev. 43: 77-82.

Roulston, T.H., Smith, S.A., Brewster, A.L. 2007. A comparison of pan trap and intensive net sampling techniques for documenting a bee (Hymenoptera: Apiformes) fauna. J. Kans. Entomol. Soc. 80(2): 179-181.

Rubio, A., Racelis, A.E., Vaughan, T.C., Goolsby, J.A. 2014. Riparian soil seed banks and the potential for passive restoration of giant reed infested areas in Webb County, Texas. Ecol. Restor. 32(4): 347-349.

Salaheen, S., Biswas, D. 2019. Chapter 2 – Organic farming practices: Integrated culture versus monoculture. Safety and Practice for Organic Food: 23-32.

Sánchez-Bayo, F., Wyckhuys, K.A.G. 2019. Worldwide decline of the entomofauna: A review of its drivers. Biol. Conserv. 232: 8-27.

Sands, J.P., Brennan, L.A., Hernández, F., Kuvlesky, W.P., Gallagher, J.F., Ruthven, D.C., Pittman, J.E. 2009. Impacts of Buffelgrass (*Pennisetum ciliare*) on a forb community in South Texas. Invasive Plant Sci. Manag. 2(2): 130-140.

Santa Ana, R. 2011. South Texas agriculture: $1.6 billion and growing in four-county area. AgriLife Today.

Sartori, M., Philippids, G., Ferrari, E., Borrelli, P., Lugato, E., Montanarella, L., Panagos, P. 2019. A linkage between the biophysical and the economic: Assessing the global market impacts of soil erosion. Land Use Policy 86: 299-312.

Saruhan, N. & N. Durmus, 2002. Alleviation of seed dormancy in *Plantago major.* Israel Journal of Plant Sciences **50**(3): 177-179.

Schlenker, W., Lobell, D.B. 2010. Robust negative impacts of climate change on African agriculture. Environmental Research Letters 5(1).

Schmidt, M.H., Roschewitz, I., Thies, C., Tscharntke, T. 2005. Differential effects of landscape and management on diversity and density of ground-dwellings farmland spider. Appl. Ecol. 42(2): 281-287.

Schellhorn N, Glatz R. 2010. The risk of exotic and native plants as hosts for four pest thrips (Thysanoptera: Thripinae). Bull. Entomol. Res. 100: 501-510.

Seo, M., E. Nambara, G. Choi, & S. Yamaguchi. 2009. Interaction of light and hormone signals in germinating seeds. Plant Mol. Biol. 69

Showler, A.T., Wilson, B.E., Reagan, T.E. 2012. Mexican rice borer (Lepidoptera: Crambidae) injury to corn greater than to sorghum and sugarcane under field conditions. J. Econ. Ento. 105(5): 1597-1602.

Simmons, M., Bertelsen, M., Windhager, S., Zafian, H. 2011. The performance of native and non-native turfgrass monocultures and native turfgrass polycultures: An ecological approach to sustainable lawns. Ecol Eng 37: 1095-1103.

Smith, J.W. 1998. Boll weevil eradication: Area-wide pest management. Ann. Entomol. Soc. Am. 91(3): 239-247.

Smith, H.A., and McSorley, R. 2000. Potential of field corn as a barrier crop and eggplant as a trap crop for management of *Bemisia agentifolii* (Homoptera: Aleyrodidae) on common bean in north Florida. Fla Entomol. 83(2).

Smith, F. 2007. Plant Profile – Slender grama *(Bouteloua repens)*. South Texas Natives **5**(1): 1-23

Smith, J. 2012. Release Brochure for Plateau (*Simsia calva)*. USDA-NRCS, Plant Material Center, Knox City, TX.

Sondheimer, E., E.C. Galson. 1966. Effects of Abscisin II and other plant growth substances on germination of seeds with stratification requirements. Plant Physio. 41(8)

Stehle, S., Dabrowski, J.M., Bangert, U., Schulz, R. 2016. Erosion rills offset the efficacy of vegetated buffer strips to mitigate pesticide exposure in surface waters. Sci. Total Environ. 545-546: 171-183.

Stireman III, J.O., Dyer, L.A., Janzen, D.H., Singer, M.S., Lill, J.T., Marquis, R.J…, Diniz, I.R. 2005. Climatic unpredictability and parasitism of caterpillars: Implication of global warming. PNAS 102(48): 17384-17387.

TAMU Horticulture. Indian Blanket/Firewheel

TAMU Horticulture. Texas Bluebonnet

Thomas, S.R., Goulson, D., Holland, J.M. 2006. Resource provision for farmland gamebirds: the value of beetle banks. Ann. Appl. Biol. 139(1): 111-118.

Tilman, D. Reich, P.B., Knops, J.M.H. 2006. Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature 441: 629-632.

Tilman, D. 1985. The resource-ratio hypothesis of plant succession. The American Naturalist 125(6).

Tiwari, S., Sharma, S., Wratten, S.D. 2020. Flowering alyssum (*Lobularia maritima*) promote arthropod diversity and biological control of *Myzus persicae*. J Asia-Pacific Entomol. 23(3): 634-640.

Tognetti, P.M., Chanteon, E.J. 2012. Invasive exotic grasses and seed arrival limit native species establishment in an old-field grassland succession. Biol. Invasions 14:2521-2544.

Tognetti, P.M., Chanteon, E.J., Omacini, M., Trebino, H.J., León, R.J.C. 2010. Exotic vs. native plant dominance over 20 years of old-field succession on a set-aside farmland in Argentina. Biol. Conserv. 143(11): 2494-2503.

Tsai, J.H. Wang, K. 1996. Development and reproduction of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on five host plants. Environ. Entomol. 25(4): 810-816.

USDA-NRCS. 2007. Welder Germplasm – Shortspike Windmillgrass. E. “Kika” de la Garza Plant Materials Center. Kingsville, TX.

Valentini, R., Sievenpiper, J.L., Antonelli, M., Dembska, K. 2019. 2.2 Solutions and tools. Achieving the Sustainable Development Goals Through Sustainable Food Systems. Springer.

van Emben, H.F. 2003. Conservation biological control: From theory to practice. USDA Forest Service: 199-208.

Varela, O., E.H. Bucher. 2006. Passage time, viability, and germination of seeds ingested by foxes. J. Arid Environ. 67: 566-578.

Venier, P., Garcia, C., Cabido, M., Funes, G. 2012. Survival and germination of three hard-seeded Acacia species after simulated cattle ingestion: The important of the seed coat structure. S. Afr. J. Bot. 79: 19-24.

Verma, P., M. Majee. 2013. Seed Germination and Viability Test in Tetrazolium (TZ) Assay. Bio-Protocol 3(17).

Wäckers, F.L. 2004. Assessing the suitability of flowering herbs as parasitoid food sources: Flower attractiveness and nectar accessibility. Biol. Control 29(3): 307-314.

Wagner, D.L. 2020. Insect declines in the Anthropocene. Ann. Rev. Ento. 65: 457-480.

Waheed, R., D., Change, S., Sarwar, S., Chen, W. 2018. Forest, agriculture, renewable energy, and CO2 emission. Journal of Cleaner Production 172: 4231-4238.

Wang, H., et al. 2016. Effect of germination on lignin biosynthesis, and antioxidant and antiproliferative activities in flaxseed (*Linum usitatissimum* L.) Food Chem. 205(15): 170-177.

Wang, Z-H., Upreti, R. 2019. A scenario analysis of thermal environmental changes induced by urban growth in Colorado River Basin, USA. Landscape and Urban Planning 181: 125-138.

Watt, G.P., Vatcheva, K.P., Griffith, D.M., Reininger, B.M., Beretta, L., Fallon, M.B…, Fisher-Hoch, S.P. 2016. The precarious health of young Mexican American men in South Texas, Cameron county Hispanic cohort, 2004-2015. Prev. Chronic. Dis. 13.

Weid, J.P., Perotto-Baldivieso, H.L., Conkey, A.A.T., Brennan, L.A. 2020. Invasive grasses in South Texas rangelands: Historical perspective and future directions. Invasive Plant Sci. and Manag. 13(2): 41-58.

White, A.S. 2016. From nursery to nature: Evaluating native herbaceous flowering plants vs. native cultivars for pollinator habitat restoration. ScholarWorks University of Vermont Graduate College Dissertations and Theses. 626.

Winfree, R. 2010. The conservation and restoration of wild bees. Ann. N.Y. Acad. Sci.: 169-197.

Winslow, S. 2006. Plant Fact Sheet Prairie Coneflower (*Ratibida columnifera* (Nutt.) Woot. & Standl. USDA-NRCS. Bridger Plant Materials Center. Bridger, Montana

Withers, P.J.A., Vadas, P.A., Uusitalo, R., Forber, K.J., Hart, M., Foy, R.H…, Owens, P.R. 2019. A global perspective on integrated strategies to manage soil phosphorus status for eutrophication control without limiting land productivity. J. Environ. Quality. 48(5): 1234-1246.

Woodcock, B.A., Harrower, C., Redhead, J., Edwards, M., Vanbergen, A.J., Heard, M.S…, Pywell, R.F. 2013. National patterns of functional diversity and redundancy in predatory ground beetles and bees associated with key UK arable crops. J. Appl. Ecol. 51(1): 142-151.

Woo, B., Kravitz-Wirtz, N., Sass, Victoria, Crowder, K., Teixeria, S., Takeuchi, D.T. 2019. Residential segregation and racial/ethnic disparities in ambient air pollution. Race and Social Problems 11: 60-67.

Wurtsbaugh, W.A., Paerl, H.W., Dodds, W.K. 2019. Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum. Wiley Interdisciplinary Reviews: Water 6(5): 1-27.

Youwakim, J.Z. 2020. Predicting patterns of heavy metal contaimination in Rio Grande Valley agricultural soils. Proquest.

Zak, D., Kronvang, B., Carstensen, M.V., Hoffman, C.C., Kjeldgaard, A., Larsen, S.E… Jensen, H.S. 2018. Nitrogen and phosphorus removal from agricultural runoff in integrated buffer zones. Environ. Sci. Technol. 15(11): 6508-6517.

Zehnder, G., Gurr., G.M., Kühne, S., Wade, M.R., Wratten, S.D., Wyss, E. 2007. Arthropod pest management in organic crops. Annual Review of Entomology 52: 57-80.

BIOGRAPHICAL SKETCH

Kaitlynn M. Lavallee graduated from the University of Texas – Rio Grande Valley in 2016 with a B.S. in Biology, concentrating on plant science. She was the Agroecology lab assistant throughout her studies, founder of the UTRGV farmers market, and leader of the Environmental Awareness Club.

Born and raised in what is colonially known as Manitoba, Canada, she returned home to work in restoration at the Tall Grass Prairie Preserve. In the winter she travelled to Indonesia to contribute to rainforest and orangutan conservation with the Orangutan Health Project, the Batu Kapal Conservation Sanctuary, and the Friends of the National Parks Foundation. From these experiences Katie became evermore aware of the need for agroecological practices where her passion for bridging habitat restoration and sustainable, communal food systems continue to grow.

She graduated with her Masters of Science in in Agricultural, Environmental, and Sustainability Sciences in December 2020. She co-created her thesis research to understand biodiversity conservation through the use of native plants in food systems and looking forward to see how this research field evolves in this region.

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