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**Soil Systems Recuperation and Seeding Methods for Improved Revegetation of
Two Native Grasses in Kuwait Desert Lands**

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Outline

- **Introduction and Problem**
 - **Objective**
 - **Materials and Methods**
 - **Results**
 - **Discussion and Conclusion**
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- An abstract graphic on the right side of the slide, consisting of several overlapping, translucent, light blue and white geometric shapes that resemble stylized leaves or petals, pointing towards the bottom right corner.

Introduction

Native Plants of Kuwait

Annuals	256
Herbaceous perennials	83
Shrubs and under-shrubs	34
Trees	1
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Total	374

Omar et al., 2007



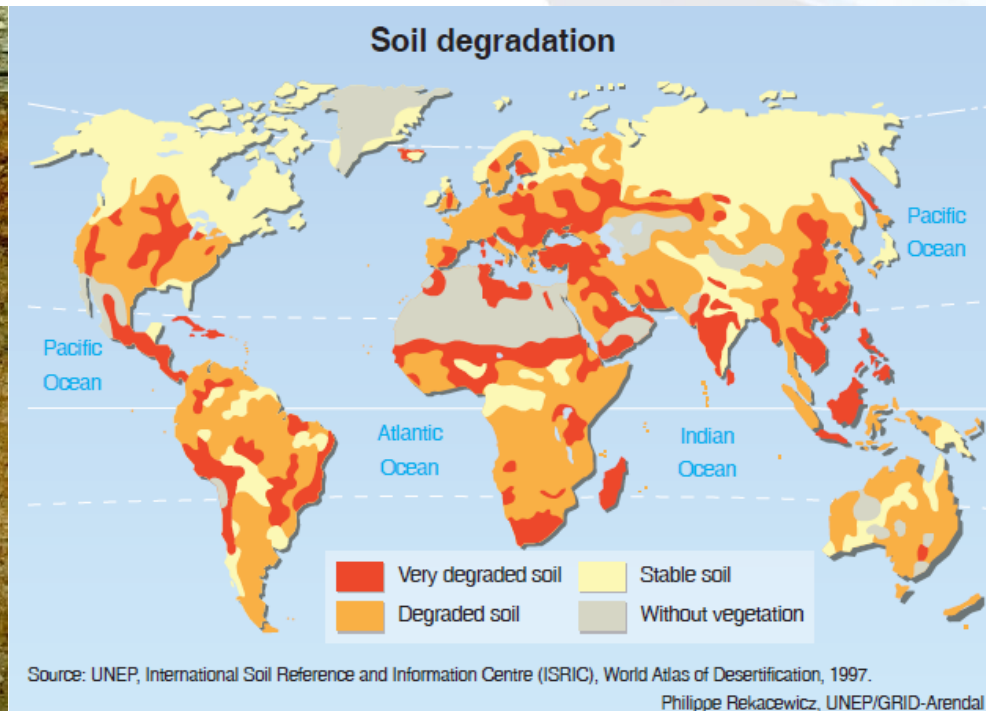
Land Degradation in Kuwait

- Prolonged drought
- Extreme weather conditions
- Anthropogenic factors caused by Iraqi invasion
- Land degradation is enhanced by the inherent fragility of soils
- Sand movements due to wind erosion
- Loss of native vegetation cover.

Soil of Kuwait

- Generally sandy with extremely low organic matter,
- Very low nutrients and high amount of calcareous material
- Low in moisture availability as well as low water-holding capacity.
- The organic matter content is found to be as low as $<1\%$.

(Mahdi and Suleiman, 2002).



Problem??

- Desert plants are under tremendous pressure and are subjected to large fluctuations over time due to highly unpredictable environment with respect to water availability, a relatively short growth period, and extreme aridity.
- Therefore, specific restoration measures are required to promote quick establishment of initial native cover plants.

One of the Solutions

- improving the quality of soil
- Hence, in our study the aim was to investigate the possibility of quick establishment of cover crops of native **grass and shrub** species using different levels of Alfalfa green pellets as an organic amendment.



Objectives

- To evaluate the effectiveness of AG pellets in the successful establishment of mixed native shrubs and grass species on sandy desert soils;
- To assess the efficacy of AG pellets to enhance soil structure, moisture retention capacity in the soil, plant nutrition, and soil microbial activity; and
- To determine the most efficient rates of AG pellets application per hectare for optimum benefits.

Details of Native Plant Seeds Selected for the Present Study

Native Plant	Life Form	Collected from	Year of Collection
<i>Rhanterium eppaposum</i>	Shrub	Julai'a	2014
<i>Calligonum polygonoides</i>	Shrub	Outside premises of Sabah Al-Ahmed National Park	2014
<i>Farsetia aegyptia</i>	Shrub	Wafra	2014
<i>Pennisetum divisum</i>	Grass	Sabhan	2013
<i>Panicum turgidum</i>	Grass	Sabhan	2014
<i>Cenchrus ciliaris</i>	Grass	Benaider	2012

Plant Species Selected



Rhanterium epapposum



Panicum turgidum



Cenchrus ciliaris



Pennisetum divisum



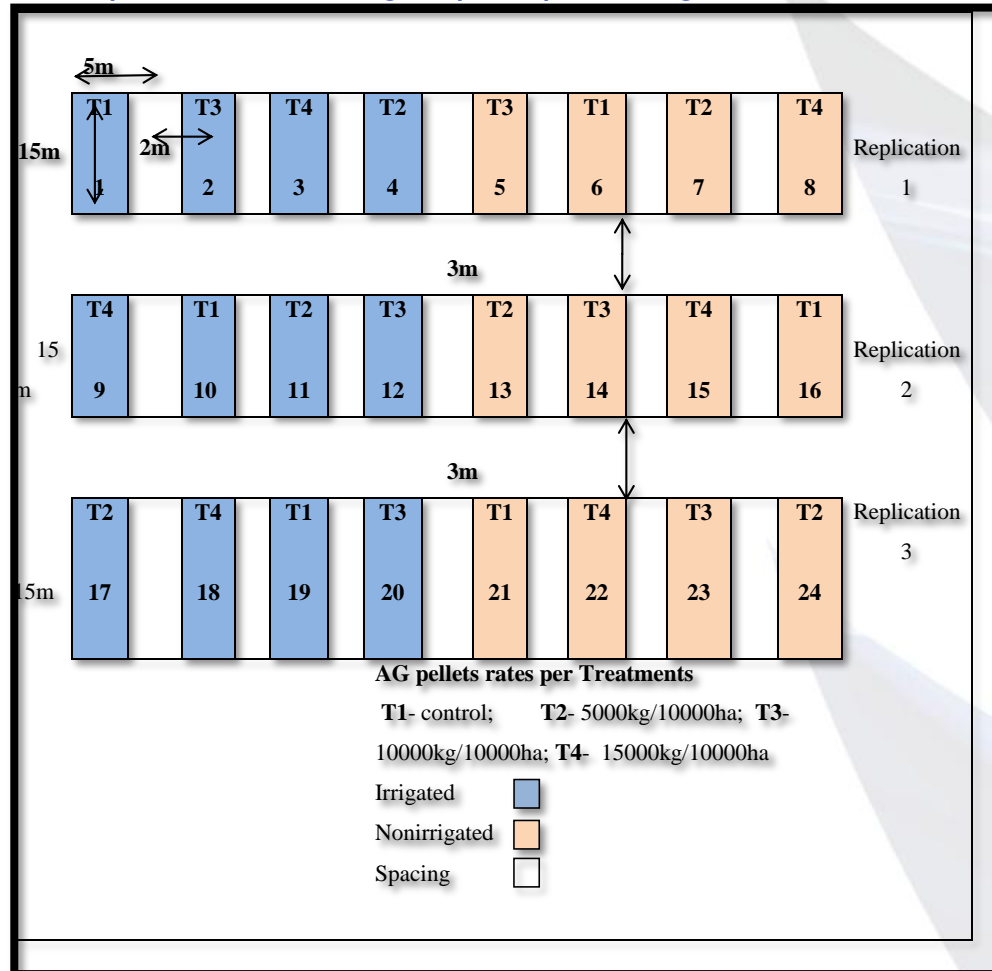
Farsetia aegyptia



Calligonum comosum

Experimental layout

- An area of 3900 m² (N29° 09.806' E 047° 40.873') at KISR Station for Research and Innovation (KSRI), Sulaibiya
- The experimental design of this pilot study consists of three replicate blocks, with each main plot split into two subplots, irrigated and non-irrigated. Each subplot is then split into four sub-subplots constituting a split-split design.



Application and mixing of Alfalfa pellets using a rotovator.



- Each application rate of AG pellets in both irrigated and non-irrigated group had three replicates for a total of 24 experimental units.
- Each group was treated with AG pellets at the following rates: 0, 5, 10, and 15 t/ha.
- The pellets were applied as top dressing and then incorporated into the desert sand using a PTO driven, 2-m wide Howard rotavator at an approximately 30-cm depth.
- There were no alfalfa pellets incorporated into the control plots.

Broadcasting of seeds in rows.



- A seed mix of *all the selected species* were selected for this study and applied to all treatments.
- Irrigated plots were irrigated two to three times a week during winter and daily during summer.

Observations

- Soon after plant establishment the plant vigor was assessed by assigning scores from 1 to 5, with a rating of 5 being excellent vigor based on visual observation.
- Percent plant cover was measured based on visual observation
- Initial germination after sowing and final survival at the termination of the task was recorded.
- Plant height was measured at site using measuring tape. Thereafter, individual plants were dug out from the soil to measure rooting depth and root length. For the measurement of root surface area and root volume, the root samples were washed carefully and measured on the root scanner.
- After root morphological parameters were measured, plant samples (root and shoot) were placed in the oven at 72° C for 48 h for total determination of root, shoot, and total plant biomass.
- Representative dry plant samples were then sent to Wet Chemistry Laboratory of ELSRC for total carbon (C) and nitrogen (N) analysis and to Soil Science Laboratory for phosphorous (P) and potassium (K) analysis.

RESULTS



General view showing both irrigated (left) and nonirrigated plots (right)



Irrigated plots



Nonirrigated plots

Overview of the experimental site at KSRI, Sulaibiya.



Plot amended with 10 t/ha;



Plot amended with 15 t/ha.

Closer view of irrigated experimental plots amended with alfalfa pellets.



Nonirrigated plot completely devoid of vegetation
when no alfalfa pellets applied.



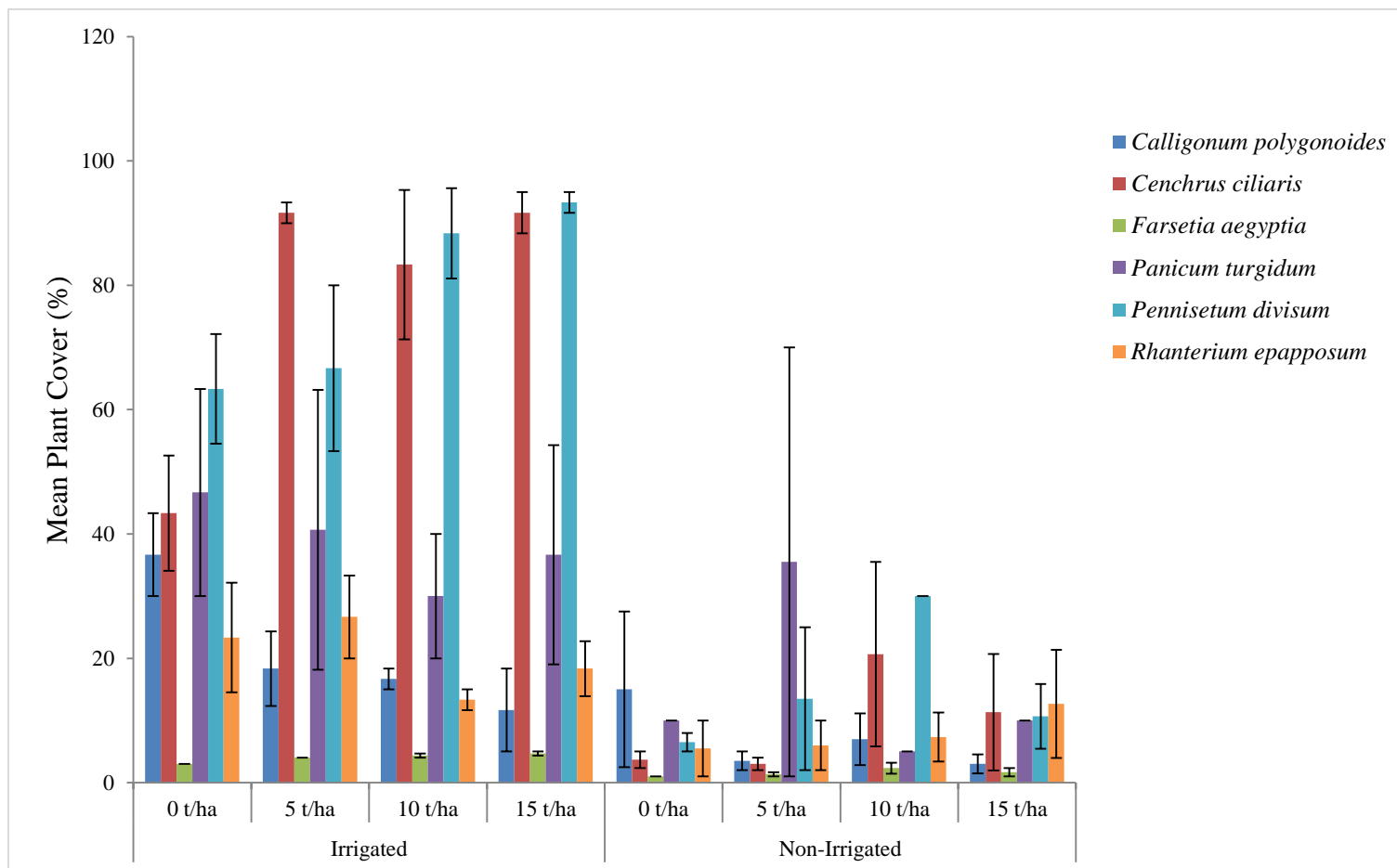
Irrigated plot without alfalfa pellets
application.

Closer view of non-amended experimental plots.

Percent cover

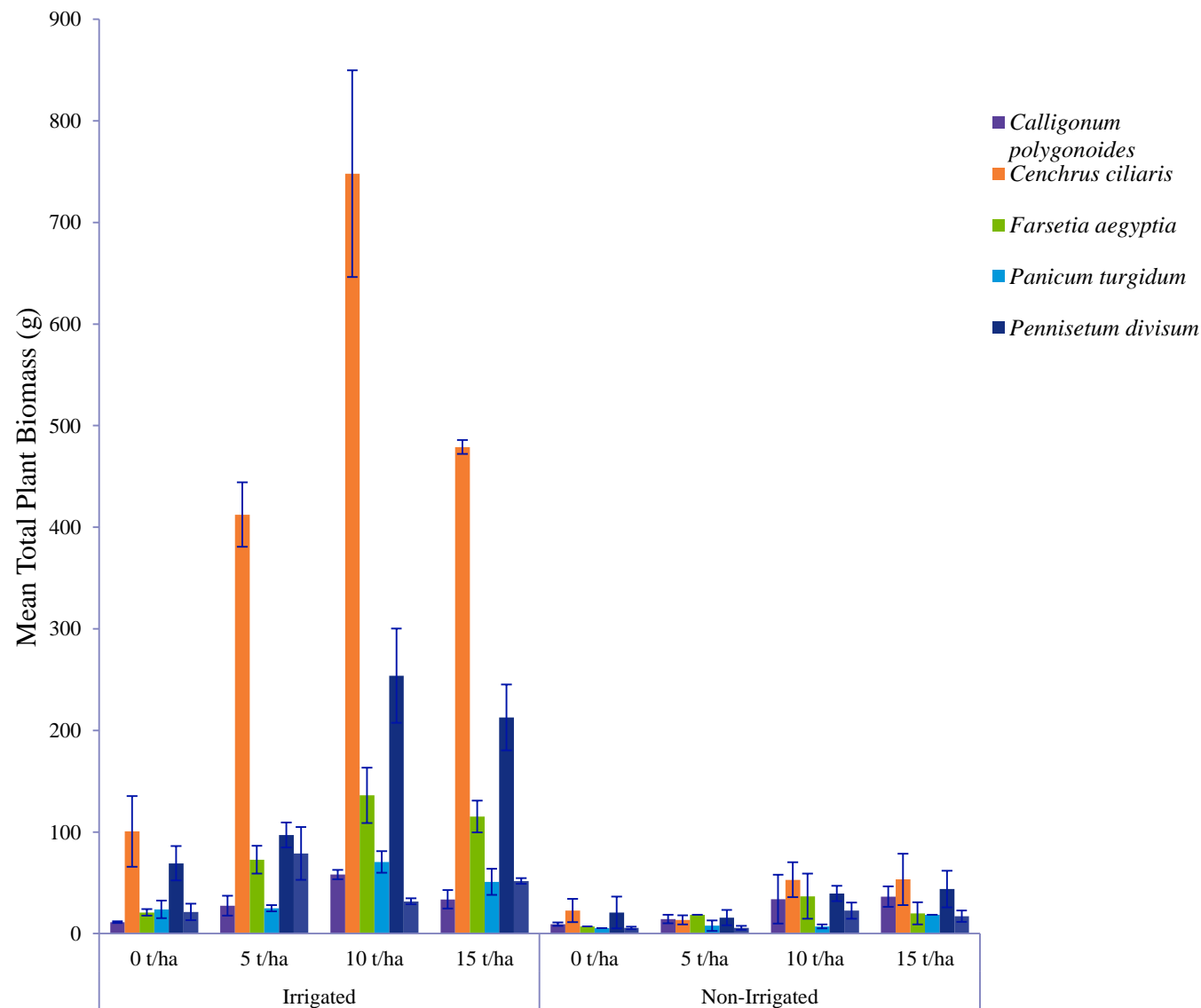
- Incorporation of alfalfa pellets into the soil increased percent cover by 50% under non-irrigated conditions.
- Percent cover was maximum under 10 t/ha alfalfa application into the soil compared to 0 t/ha.
- Percent cover did not increase further with increased rate of alfalfa incorporation into the soil.
- When irrigated, percent cover increased by 18.5% under 15 t/ha alfalfa application into the soil compared to 0 t/ha
- Irrespective of irrigation regime, *Pennisetum divisum* and *Cenchrus ciliaris* exhibited the most increase in percent cover when alfalfa pellets were added to the soil (
- *Farsetia aegyptia* was the least responsive .

Mean plant cover of the selected native species under various irrigation and organic amendment treatments.



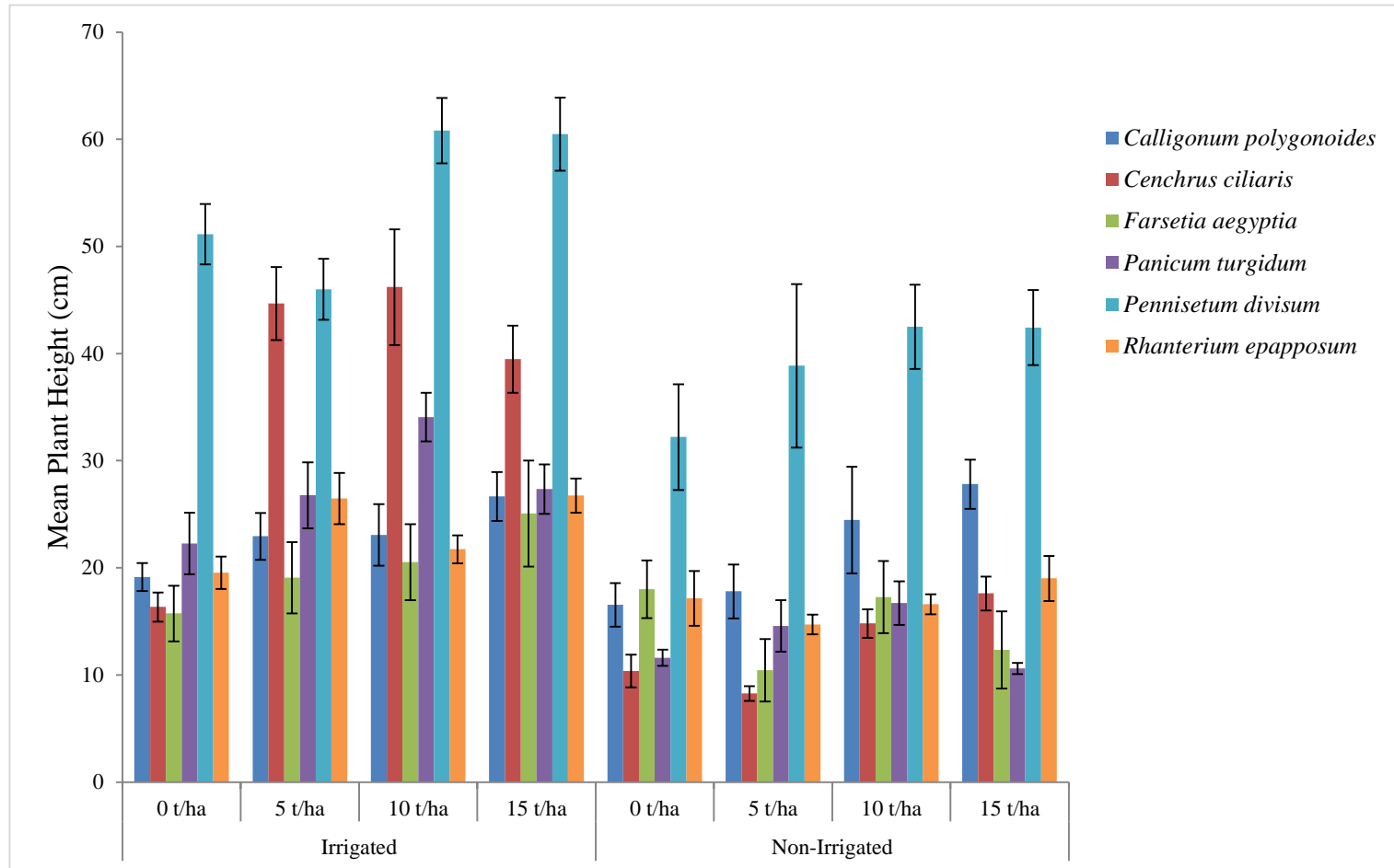
- Incorporation of alfalfa pellets into the soil increased total plant biomass in general across all species .
- The interactive effect of species*irrigation*organic amendment was highly significant [$p = <.001$]
- When irrigated, total plant biomass increased by 424% in plots incorporated with 10 t/ha alfalfa pellets compared to the control (0 t/ha) .
- Total plant biomass did not increase further with increased rate (15 t/ha) of alfalfa incorporation
- Under non-irrigated conditions, compared to control, total plant biomass increased by 147% under 10 t/ha alfalfa application into the soil.

Mean total plant biomass of the selected native species under various irrigation and organic amendment treatments.



- Incorporation of alfalfa pellets into the soil increased plant height across all species .
- The interactive effect of species*irrigation*organic amendment was highly significant [$p = <.001$]
- Irrigation clearly had noticeable effect on plant height. However, addition of organic amendment increased plant height as the rate of alfalfa incorporation rate increased
- Under both irrigated and nonirrigated conditions, highest mean height was recorded when 10 t/ha alfalfa were added, and the height increment lessened with more addition of alfalfa (i.e., 15 t/ha).
- *Pennisetum divisum* showed the most positive increase in height growth in response to organic amendment regardless of irrigation regime .

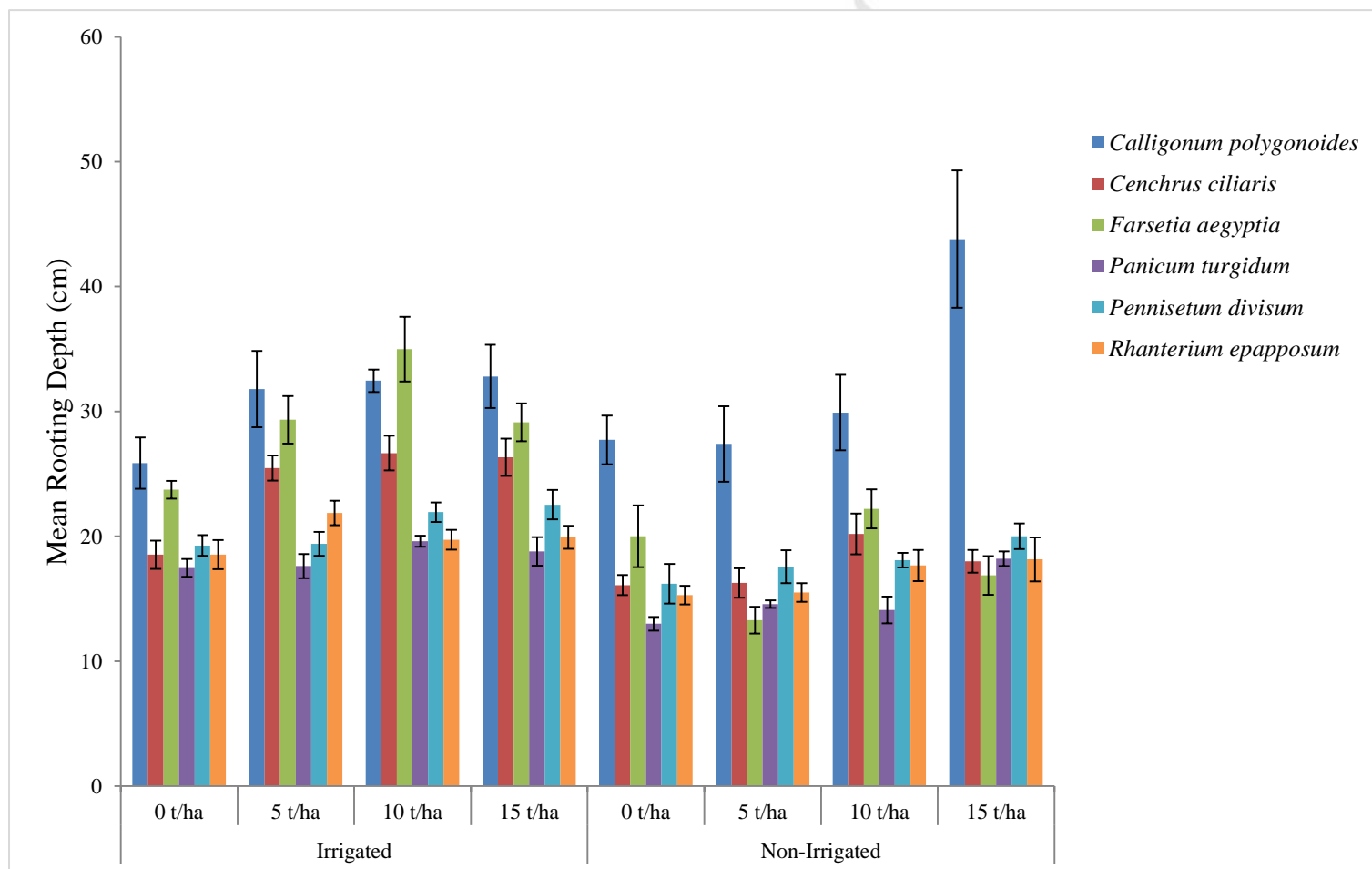
Mean plant height of the selected native species under various irrigation and organic amendment treatments.



- There were also significant interactive effect of species*irrigation*organic amendment on rooting depth [$p = <0.01$].
- Plant rooting depth increased with an increase in alfalfa application rate regardless of irrigation regime
- In general. *Calligonum polygonoides* and *Farsetia aegyptia* were more responsive to increase their rooting depth when alfalfa application rate was increased
- The increase in root depth was linear for *Calligonum polygonoides* under non-irrigated conditions when alfalfa application rate was increased

Root surface area increased with an increase in alfalfa application rate regardless of irrigation regime, Interestingly, *Cenchrus ciliaris* exhibited the highest root surface area among all species, especially under both irrigated and non-irrigated conditions with organic amendment.

Mean root surface area of the selected native species under various irrigation and organic amendment treatments.





Growth performance of *Cenchrus ciliaris* in response to different levels of alfalfa treatments under irrigated (left) and nonirrigated (right) conditions.



Growth performance of *Pennisetum divisum* in response to different levels of alfalfa treatments under irrigated (left) and nonirrigated (right) conditions.



Growth performance of *Panicum turgidum* in response to different levels of alfalfa treatments under irrigated (left) and nonirrigated (right) conditions.



Growth performance of *Rhanterium epapposum* in response to different levels of alfalfa treatments under irrigated (left) and nonirrigated (right) conditions.

Discussion and Conclusion

- When organic matter is added to soil, the microbial activities are improved and stimulated due to readily available nutrients and carbon compounds.
- Kuwait desert is depleted in organic matter and an organic amendment is likely to improve the soil bulk density as well as probably the soil microbial populations and nutrient availability.
- In this study, incorporation of alfalfa pellets as organic amendment improved the soil bulk density (1.5 g/ cm^3) compared to control plots (1.7 g/ cm^3).
- This short-term study results indicate that the addition of alfalfa pellets to desert soils may have enhances the bacterial and fungal population counts compared to no-alfalfa amended soil as reflected in higher numbers of CFUs and morphotypes

- In this study, it is apparent that incorporation of alfalfa pellets into the soil helped soils have higher moisture content compared to the one that did not have alfalfa treatment.
- The organic matter content of the alfalfa pellets must have contributed to moisture retention of the desert sands. Our results demonstrated that the desert soil organic matter content increased by 140% in irrigated plots where alfalfa was applied at 15 t/ha compared to control plots. T
- The effects of organic amendment of desert sand with alfalfa pellets and irrigation were significant on the plant morphological parameters of two selected species. However, the magnitude of main factors and their interactive effects varied between species.
- Among all the mineral nutrients nitrogen is the most important for plant growth and development. Our data demonstrated that plots receiving alfalfa pellets applied at 15 t/ha had 136% higher soil N compared to plots without alfalfa pellet. Similar increase in soil nutrients were also observed in P and K. Increased soil nutrients regardless of irrigation treatment when addition of alfalfa pellets at different rates reflected in higher plant biomass production.

- Native grass species performed satisfactory irrespective to irrigation treatments with various levels of alfalfa amendments at the end of the experiment.
- Besides other factors, improved performance of plants in this study may be attributed to improvement in general soil structure. In general, desert sandy soils have high bulk density. A high bulk density may cause soil compaction, which instigates poor movement of air and water through the soil, leading to poor plant growth and establishment.
- However, although not significant in all cases, the application of alfalfa pellets at rate of 15 t/ha demonstrated greater improvement of bulk density (1.5 g/ cm^3) of desert soils compared to control (1.7 g/ cm^3).
- Also, incorporation of alfalfa pellets in desert sand seemed to have facilitated moisture retention, resulting in better germination and providing the plants with improved basis of plant growth and establishment.

- Revegetation of eroded desert sands is no doubt challenging. The current research findings suggest that alfalfa pellets at 10 tons/ha may be sufficient for amendments and may offer the best potential for growth performance of tested native grass on desert sand in Kuwait.
- The short-term results of our study is encouraging, as it shows that two native grass species can grow well on desert sands when seedling approach was taken and with effort of using organic amendments and maintaining some moisture level (about 5-10%).
- However, it was too early to comprehend fully the benefits from organic amendments as the observation is only for two growing seasons and the alfalfa pellets have yet to decompose.
- Nevertheless, these are suitable plant species for quick establishment on desert sands.
- Knowledge gained from this pilot study research project will be used to improve reclamation and revegetation efforts in larger scale for the coming years.

THANK YOU