Ph.D Research Proposal Defense

"Evaluating crop growth & yield response to invasive algae as a source of potassium & its impact on free-living nematode communities in soil"

Tuesday December 16th at 9.00 am

St. John Room 302

Presented by Chandrappa Gangaiah

Department of Tropical Plant & Soil Sciences,
University of Hawaii at Manoa

Outline

- Introduction
- 1st Greenhouse trial (peat moss)
- 2nd Greenhouse trial (peat & soil)
- Results and findings
- Conclusions
- Proposed studies (Field trials)
- Time line

Introduction

* Some Alien Algae species have become invasive in Hawaii: *Acanthophora spicifera, Eucheuma denticulatum, Gracilaria salicornia & Kappaphycus.*

* Most of these arrived to Hawaii on the bottom of a shipping barge in 1950's & after.

* Kappaphycus & Eucheuma were intentionally introduced on Oahu and Molokai in the 1970's for providing Carrageenan agar industry.

Introduction – Invasive Species:

The spread of invasive, non-native marine algae is one of the greatest threats to Hawai'i's coral reefs and near shore marine ecosystems.

A sustained effort to remove the algae by various groups has produced millions of pounds of the wet weight biomass that must be disposed.

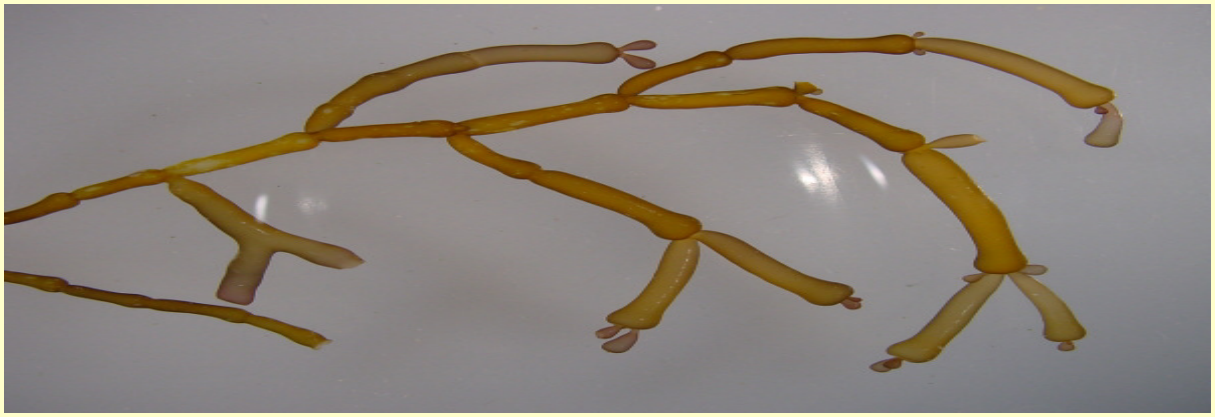
The biomass of these invasive algae species have Potassium(K) concentration ranging from 10-20% depending on species. Recycling them & using it in crop production may address the problems of Hawaiian farmers reliance on expensive inorganic fertilizers.

Source courtesy of :http://www.nceas.ucsb.edu/

Introduction

Study species

Gracilaria salicornia
(Gorilla Ogo)



Kappaphycus alvarezii
(Kappaphycus)

Eucheuma denticulatum
(Eucheuma)

Introduction

- On-going project funded by : Project # SW11-055

"Reducing Pacific Island Growers reliance on off-island fertilizer sources through improved awareness and efficient use of locally available inputs"

- One of the key study area of the project is to "Quantify the independent and interactive effect three algae species collected from multiple sites for their nutrient (K) availability, impact on crop yield & nutrition"

Information Gaps in Literature

- The literature is mostly related to use of brown algae such as A*scophyllum nodosum* & others.

- Scientific studies in the past using algal seaweeds & their extracts for crop production.

- Majority are plant growth stimulants & not directly as a source of nutrient.

- Many of these products has not been fully exploited due to the lack of scientific data on growth factors present in seaweeds & their mode of action.

Objectives

"Overall objective is to evaluate the invasive algae species as a potential K source for crop growth, yield & quality in Hawai'i"

Specific objectives include:

1. Develop a yield response curve of pak choi to application of 3 invasive algae species at 5 rates of K

2. Validate yield response curve from the first objective under different field conditions and soil types

3. Evaluate the impact of algae on free-living nematode communities in soil

Objective 1:Completed - 1st GH trial

Design:

- 3 species, 5 reps & 5 rates (0, 84, 168,252, and 336 kgs) K/ha.
- N & P at constant rates for all.

N - tankage and urea

P - tankage and triple super phosphate.

K - invasive algae dried powder

Photo showing the greenhouse trial 1 pots sown with pak choi!

Table 1: N: P: K content in Kappaphycus, Eucheuma, and Ogo algae tissues collected at two different times.

Samples 1st bacth		%	
Description	N*	P	K
Kappaphycus	0.68	0.04	19.52
Eucheuma	1.01	0.06	18.38
Ogo	1.41	0.11	12.48
Samples 2nd batch		%	
Description	N*	P	K
Kappaphycus	0.62	0.06	24.85
Eucheuma	0.84	0.07	17.6
Ogo	1.33	0.1	13.9

The tissue samples were analyzed at the Agricultural Diagnostic Service Center of the University of Hawaii.

Table 2: Displaying the F-statistics of ANOVA on the invasive algae effects on fresh wt. dry wt. and leaf K content at 5 different rates and among the three species & their interaction from 1st GH trial:

		P - values	Pr > F	
Sources of variation	DF	**Fresh** wt	**Dry** wt	Leaf **K**
Rates	3	0.0111	0.0131	< 0.0001
Species	2	0.1013	0.1857	0.4084
Rates* Species	6	0.3111	0.266	0.4559

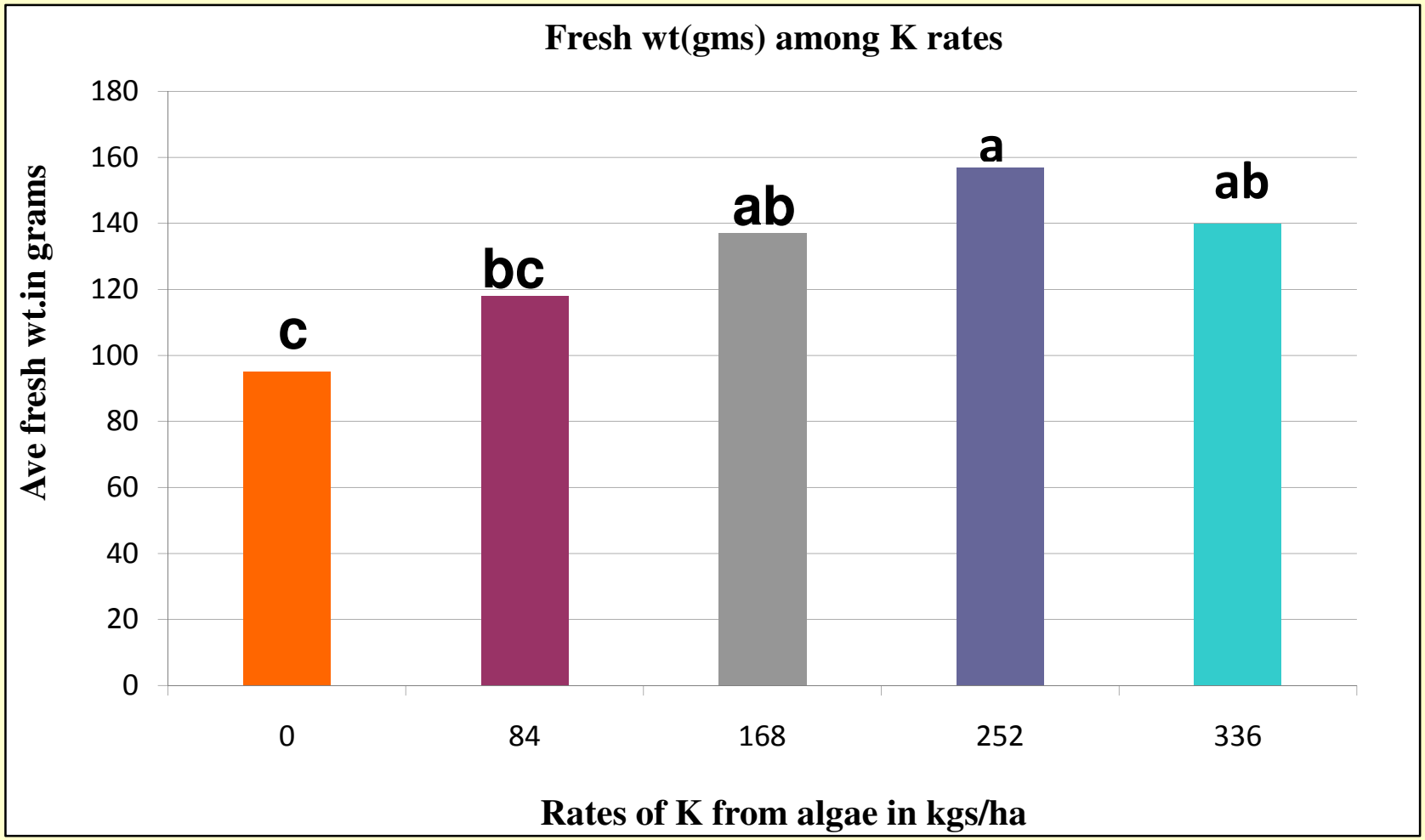


Figure 1: The bar diagrams comparing the average **Fresh wt.**(gms) among the **5** different **rates of Algae** (K in kgs/ha) provided through 3 invasive species of Algae from the **1st greenhouse** trial. Means followed by the same letter are not significantly different ($P < 0.05$) using Duncan's multiple range test.

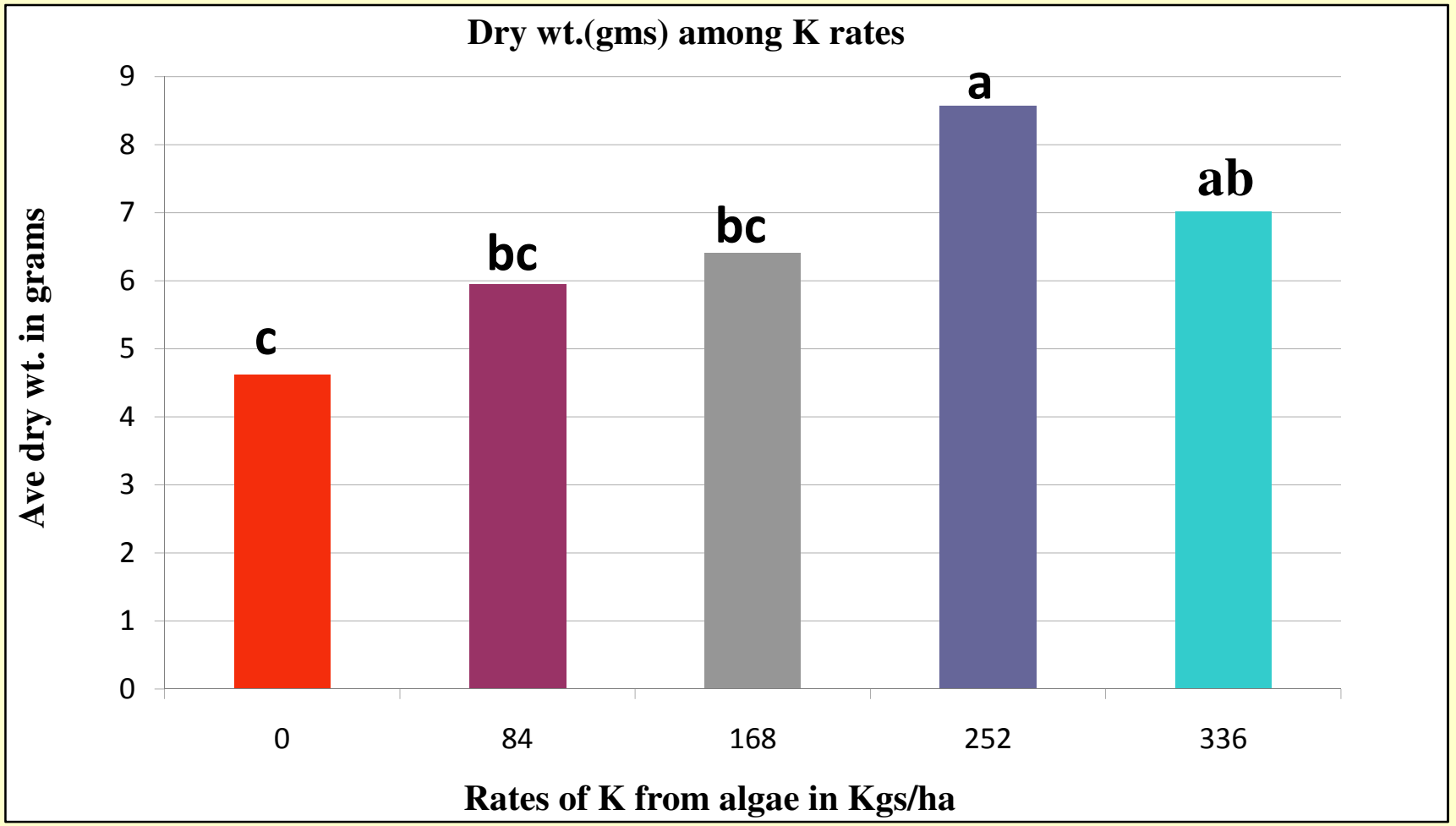


Figure 2: The bar diagrams comparing the **Dry wt.**(gms) among the **5** different **rates of Algae** (K in kgs/ha) provided through 3 invasive species of Algae from the **1st greenhouse** trial. Means followed by the same letter are not significantly different ($P < 0.05$) using Duncan's multiple range test.

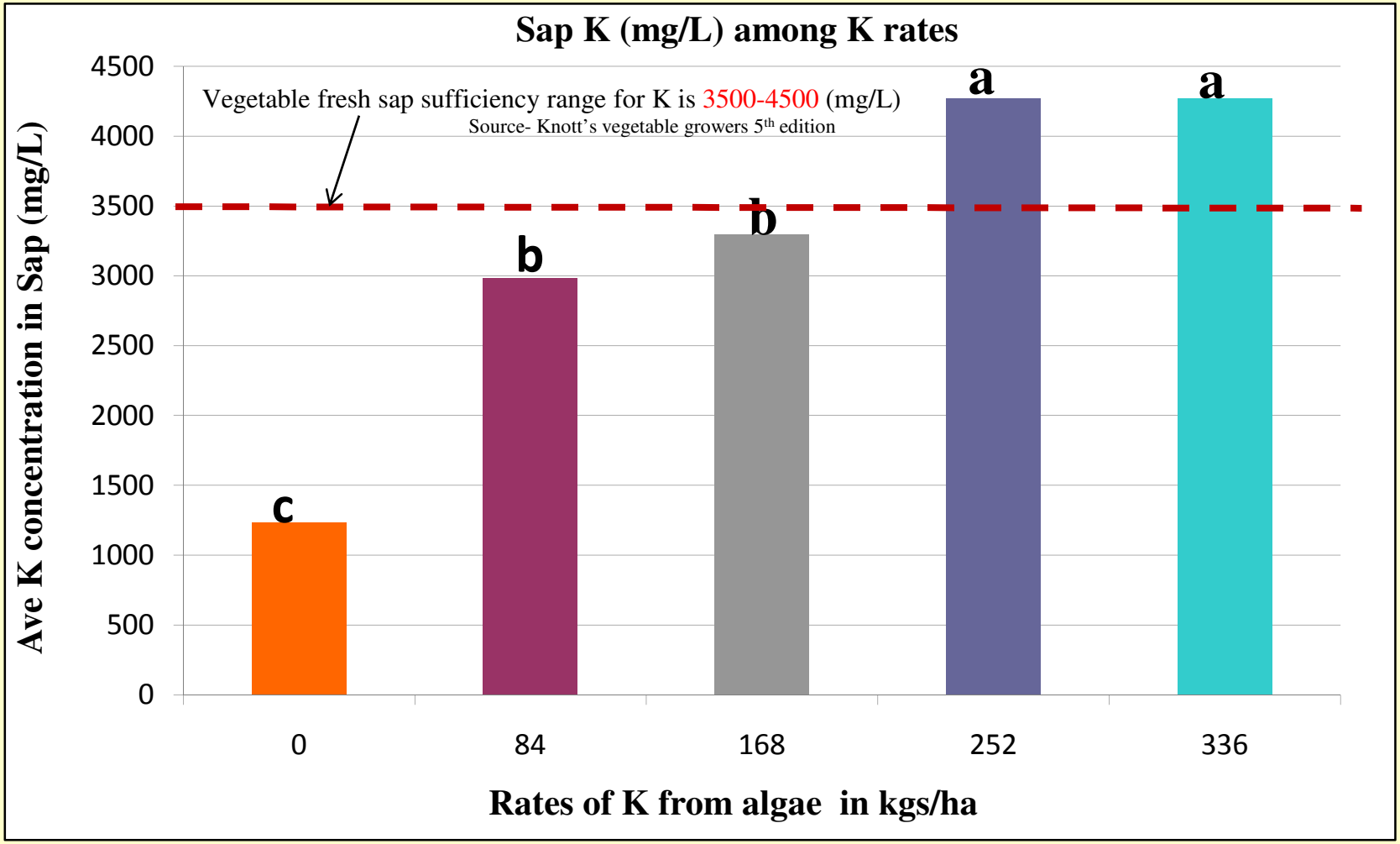


Figure 3: The bar diagrams comparing the average **sap K** content **(mg/L** among the **5** different **rates of Algae** (K in kgs/ha) provided through 3 invasive species of Algae from the 1st greenhouse trial. Means followed by the same letter are not significantly different ($P < 0.05$) using Duncan's multiple range test.

Greenhouse 1 – findings

- Based on statistical analysis of the data, the 3 species were non-significant to K content or yield levels.

- The algae rates were highly significant to leaf K content, Fresh wt. & Dry wt. The Leaf K increased with increasing algae rates & reached maximum at algae rates equivalent to 252 and 336 kgs of K/ha.

- The highest fresh & dry wt. were recorded at algae rates of 252 kgs of K/ha rate

Changes in second trial:

♦Single species (Eucheuma)

♦ Added Soil (Ultisol)

♦ Included synthetic treatments K from (KNO3) at same 5 rates

Objective 1:Completed – 2nd GH trial

Pak choi, Variety- Bonsai.

3 reps & 2 treatments

2 media types (Peat & ultisol soil)

5 rates (112, 168, 224, 280 & 336 kgs K/ha)

5x2x3x2= 60 +3(control) = total 63 pots.

N & P at constant rates for all pots and the application rates were calculated based on lab analysis results.

N - urea for all pots
P -triple super phosphate for all pots
K-organic by Eucheuma dried powder
K- Synthetic by potassium nitrate (KNO3)

Photo showing the pak choi plants as seen on the day before harvest from the 2nd greenhouse trial

Table 3: Displaying the F-statistics of ANOVA on fresh wt. dry wt. & leaf K content from the 2nd GH trial with plants grown on peat moss & soil media using Eucheuma algae & synthetic fertilizers at 5 different rates:

		P - values		
Sources of Variation	**DF**	**Fresh wt.**	**Dry wt.**	**Leaf K**
Media	1	<.0001	<.0001	<.0001
Fertilizer type	1	0.0001	<.0001	0.1661
Rates	4	<.0001	0.0002	<.0001
Media* Fertilizer type	1	0.0018	0.0017	0.0653
Media* Rate	4	0.0092	0.1177	0.9226
Fertilizer type* Rate	4	0.5422	0.6979	0.536
Media* Fertilizer type* Rate	4	0.2866	0.5883	0.938

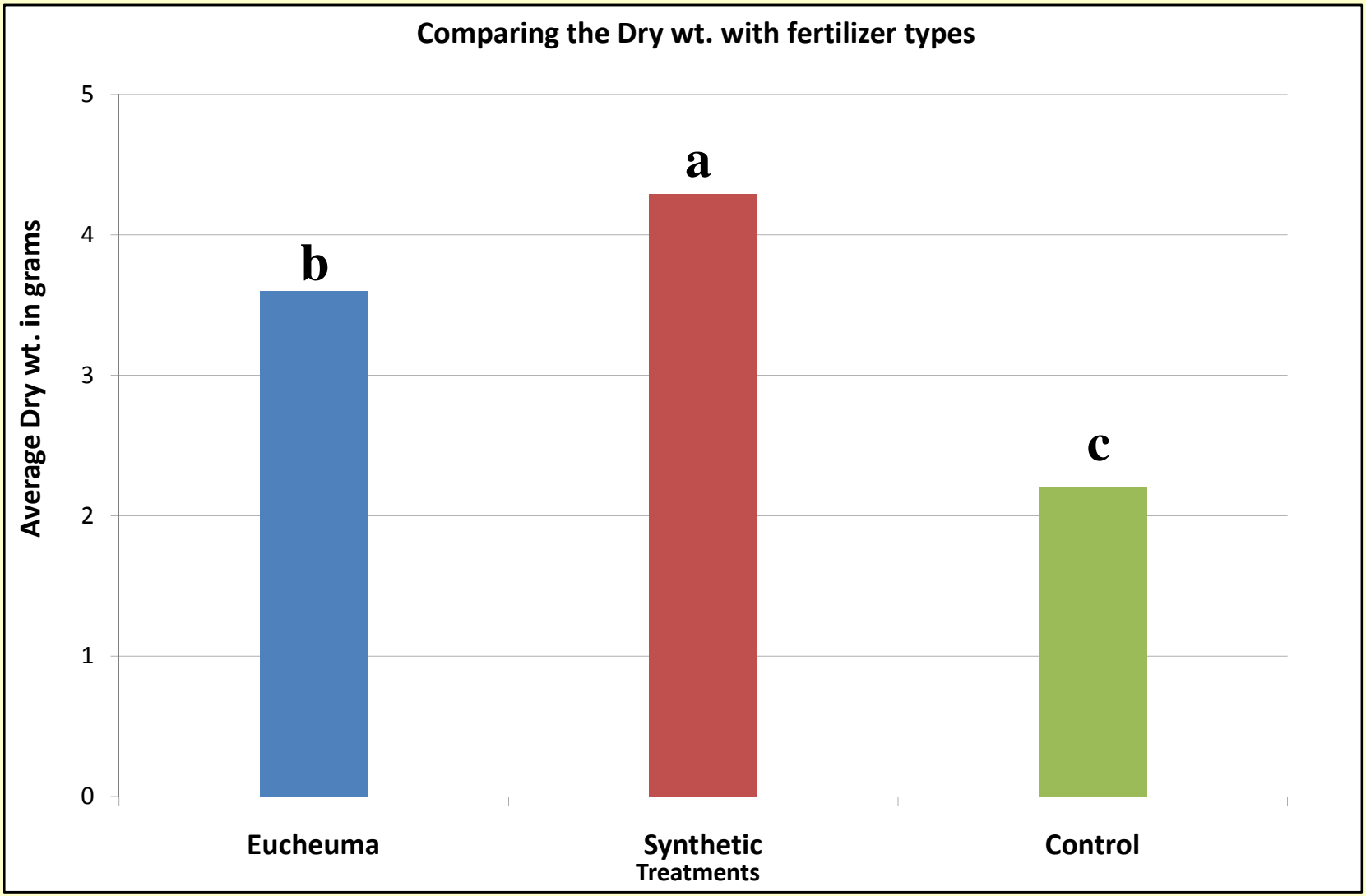


Figure 5: The bar diagram displaying the average **Dry wt.**(gms) of Pak choi plants grown with Eucheuma & synthetic fertilizers and control K from the 2nd GH trial. Means followed by the same letter are not significantly different ($P < 0.05$) using Duncan's multiple range test.

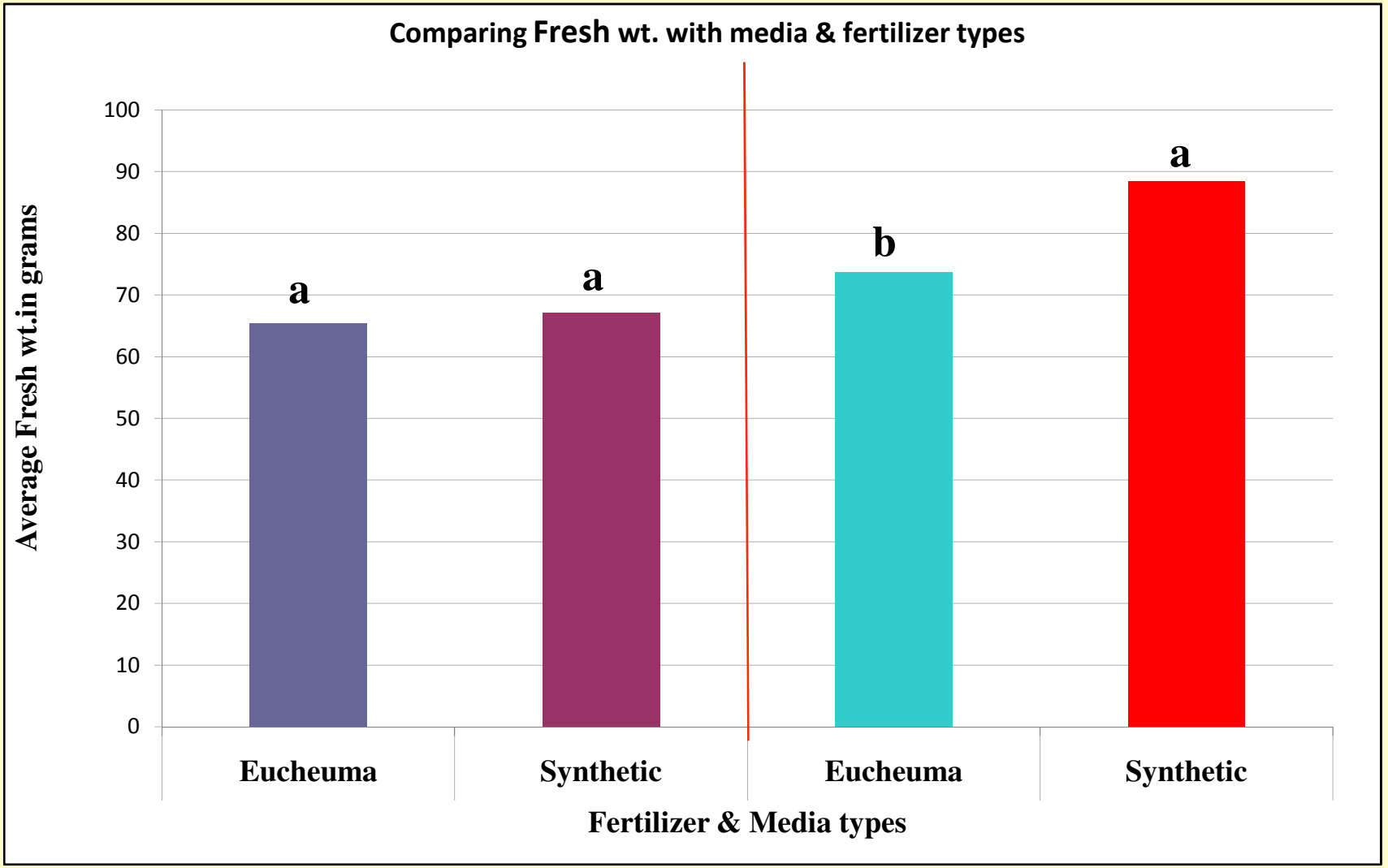


Figure 6: The bar diagram displaying the average **Fresh wt.**(gms) of Pak choi plants grown with Eucheuma & synthetic fertilizers under peat moss & soil media from the 2nd GH trial. Means followed by the same letter are not significantly different ($P < 0.05$) using Duncan's multiple range test

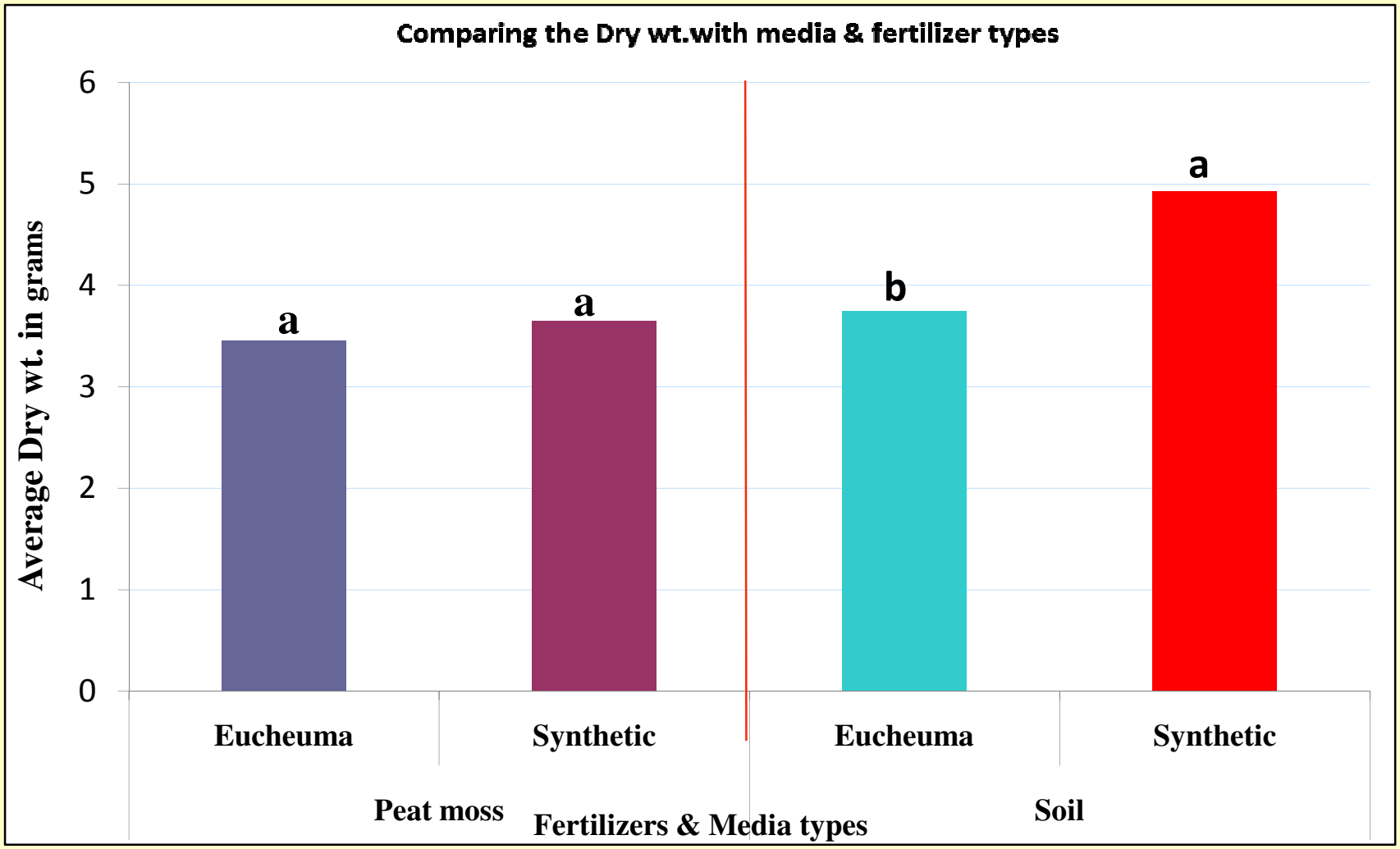


Figure 7: The bar diagram displaying the average **Dry wt.**(gms) of Pak choi plants grown with Eucheuma & synthetic fertilizers under peat moss & soil media from the 2nd GH trial. Means followed by the same letter are not significantly different ($P < 0.05$) among each media types using Duncan's multiple range test.

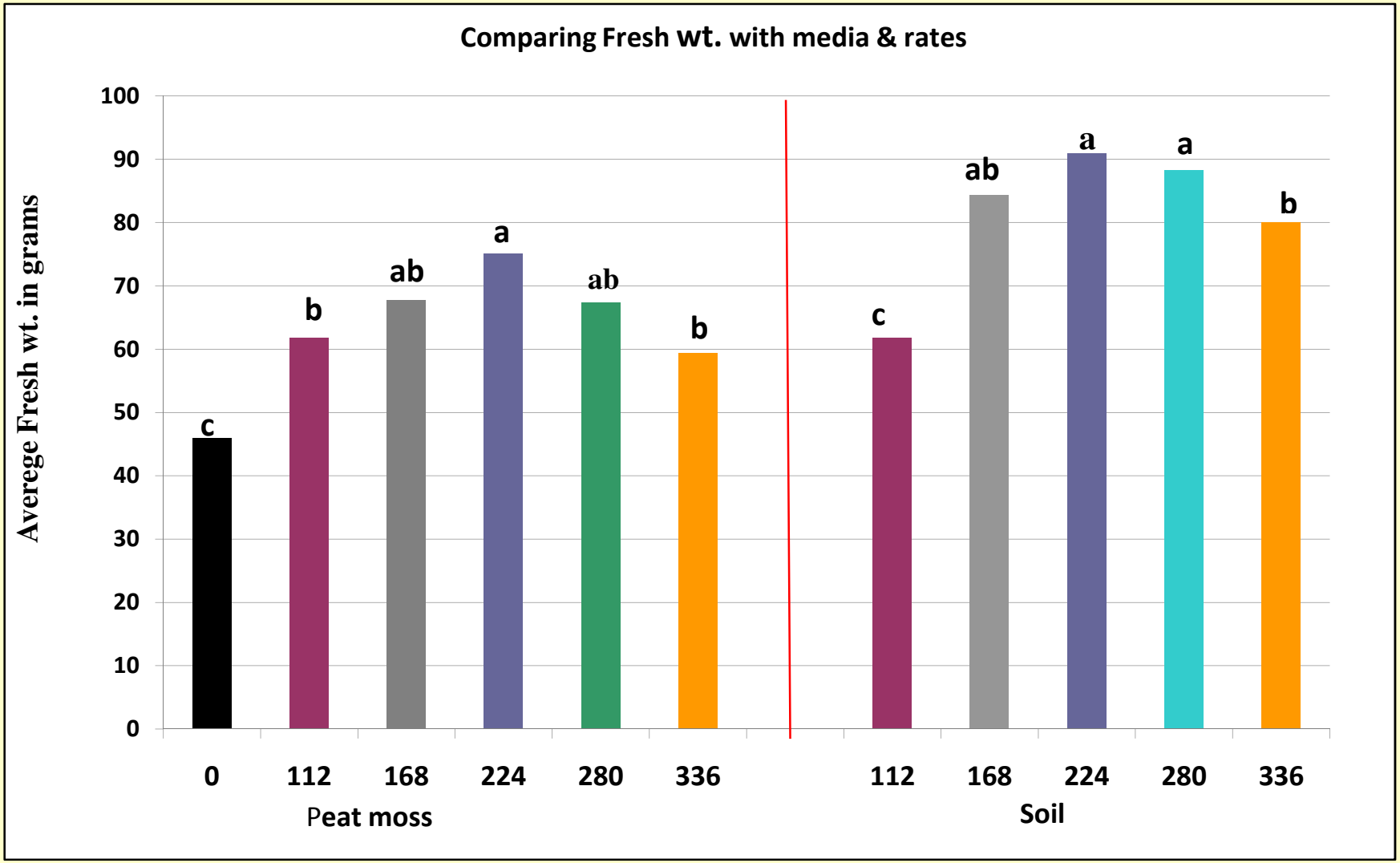


Figure 8: The bar diagram displaying the average **Fresh wt.**(gms) of Pak choi plants grown in 2 types of media, peat moss & soil at 5 different rates from the 2nd GH trial. Means followed by the same letter are not significantly different ($P < 0.05$) among each media types using Duncan's multiple range test.

Greenhouse 2nd – findings

- Based on statistical analysis of the data (ANOVA), the media (peat moss & soil) & rates were highly significant to leaf K content, fresh & dry weights.
- The two fertilizers were significant for fresh and dry wt., but not for K content.
- Synthetic was significantly higher than Eucheuma for yields, but only in soil media & not in peat moss based media.
- The interaction of fertilizer type & rates were not significant to yield or K content.
- The results of highest yields & Sap K content from 1st & 2nd GH trials were much consistent as they were observed in the range of between 224 -284 kgs of K /ha.

Conclusions from 1st & 2nd GH results:

* The 1st & 2nd GH results were much consistent with increased amount of algae significantly increasing the yield & K content of Pak choi compared to control treatments.

*Further field studies needed to validate the yield response curve developed from GH trials will hold good for field conditions.

* Testing needed with different crops & soil types.

* Additional benefits/mechanisms such as changes in free-living nematode communities with application of algae needs to be investigated.

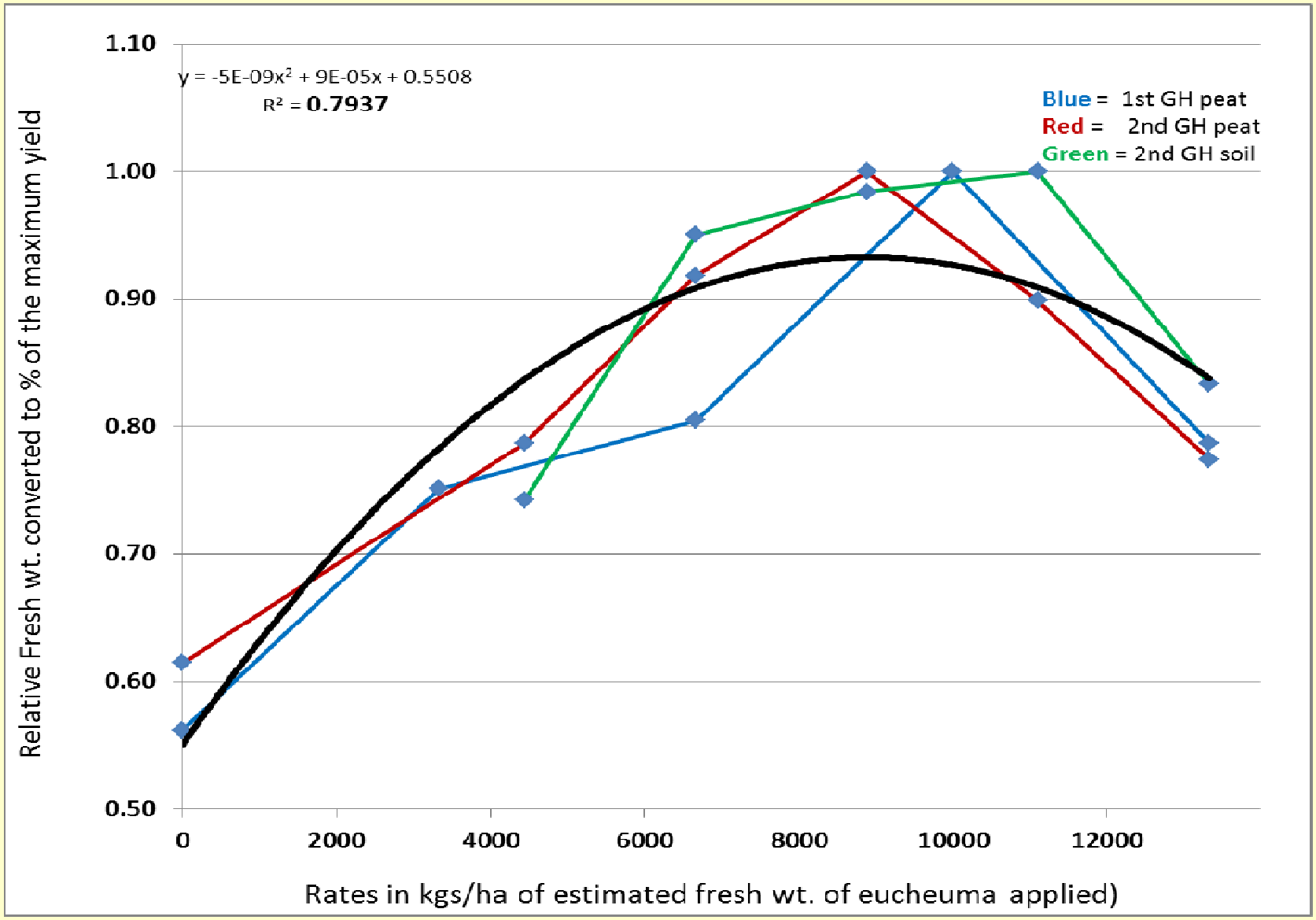


Figure 9: The scattered line diagram displaying the relative response of Fresh wt. to algae application from 1st and 2nd greenhouse trials

Proposed studies: 2nd objective

1. Validate yield response curve developed from GH trials in two different fields with different soil types by growing Pak choi & Eggplant using Eucheuma algae for growth, yield & K content

Waimanalo Research Station- Mollisols

Poamoho Research Station- Oxisols

Proposed studies- Field trials:

Design: (similar for both the fields)

- 2 crops: Pak choi, Var: Bonsai & Eggplant, Var: Nitta

- Randomized complete block design with rates as main plots & crops in split plots,4 reps & 5 rates(0, 84, 168,252,& 336 kgs)K /ha.

- 20 rows(beds) of 40 ft. length & 100 ft. width with a spacing of 3 ft. apart from row to row.& each row/bed with 2 ft. surface area.

- Pak choi will be planted at a spacing of 25 cms from plant to plant, where as eggplant will be planted at 2 ft. spacing.

Proposed studies: 3rd Objective

♦ Eggplant- 2 locations (diff. soil).
Design same as 2nd objective.

♦ The impact of algae on soil free-living nematode communities.

♦ Nematodes as soil health bioindicator,
Are well classified into functional groups & important role in soil nutrient cycling.
(Wang and McSorley, 2005).

"Influence of organic Crotalaria juncea hay and ammonium nitrate fertilizers on soil nematode communities"
(K.H. Wang, , , R. McSorley, A. Marshall, R.N. Gallaher, 2006)

Dissertation Format

Number of chapters - 6

Main Chapters

1. GH trial 1 and 2 – Manuscript 1

2. Field trial at 2 locations (pak choi) – Manuscript 2

3. Algae in improving soil health – Manuscript 3

- Chapters will represent peer reviewed publications

Timeline

Year: 2014 **December 16th** ------Official proposal defense.

December end ---- ---------- preparations for field trials, sowing, beds prep

Year: 2015

January----------Manuscript submission to ASHS -1st & 2nd GH trials, starting field trials, Nematode counting (pre-planting)

February -----------Prepare for oral examination.

March-April-May----------Harvest Pak choi & eggplant, manage data, nematode counting with soil samples (post-harvest)

June –August ----------Data analysis, thesis chapters, Manuscript submission from field trials

September – October ----------Thesis additional chapters (Results, discussion & summary

November----------Final defense seminar

December 2015-----------Expected Graduation.

MAHALO & THANK YOU