Evaluating Three Invasive Algae sp. (*Eucheuma denticulatum*, *Gracilaria salicornia,* and *Kappaphycus alvarezii*) as Local Organic Sources of Potassium (K) for Pak Choi (*Brassica rapa*, Chinensis Group)

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INTRODUCTION

♦ Hawaii imports roughly 85% of its food. There is a need to increase food security and self-sufficiency.

♦ Strategies needed to increase the production of locally grown foods & their demand to move the state towards greater self-sufficiency. One such strategy is identifying the low cost, locally available resources & increasing their use in crop production.

♦ Algae biomass has been used as a soil improver and natural fertilizer owing to their high potassium content for centuries in coastal areas around the world.

♦ The 3 species of invasive algae (*Eucheuma denticulatum*, *Gracilaria salicornia* and *Kappaphycus alvarezii*) that are found in Hawaiian reefs show potential for use as local inputs for crop production with significant levels of potassium content (14-21%).

Hypothesis: Invasive algae species could be used as a local source of potassium in vegetable crop production.

The spread of invasive marine algae is one of the greatest threats to Hawai'i's coral reefs marine ecosystems. A sustained effort to remove the algae has produced millions of pounds of biomass that must be disposed.

OBJECTIVES

The main objective was to evaluate the effect of these invasive algae species, applied at different application rates, on yield & K mineral nutrition of pak choi plants.

MATERIALS & METHODS

Three trials were conducted at the university of Hawaii, Manoa greenhouse facilities; & plants were grown in 1 gal size pots with peatmoss as the growing media.
The required amounts of K from each fertilizer type & rate were calculated based on the K% in each. N & P at 168 kgs/ha were provided through urea and superphosphate.

♦GH trial # 1 April-May 2013: Pak choi cultivar Bonsai. CRD with 5 reps. 5 rates of 0, 84, 168,252 & 336 kgs of K/ha from 3 algae species.

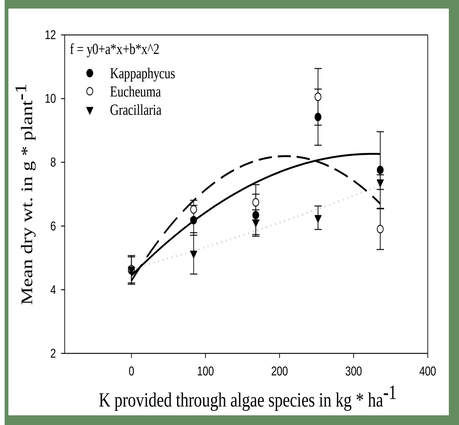
♦ GH trial # 2 Jan-Feb 2014: Pak choi cultivar Bonsai. CRD with 3 reps. 6 rates of 0,112,168,224,280 & 336 kgs of K/ha from algae *(Eucheuma denticulatum*) and potassium nitrate (KNO_3).

♦ GH trial # 3 Mar- April 2015: Pak choi cultivar Mei Qing. CRD with 4 reps. 6 rates of 0, 112, 168,224, 280 & 336 kgs of K/ha from algae (*Kappaphycus alvarezii*), potassium nitrate (KNO_3) & potassium chloride (KCl).

Plants were harvested 6 weeks after emergence for all the 3 trials, fresh weights were immediately measured after harvest and data were recorded. The plants were then dried in an oven at 70 °C for 72 h & the dry weights were recorded. The dried tissue samples were analyzed for K and other macro-micro nutrients at the ADSC laboratory, university of Hawaii at Manoa.
Analysis of Variance (ANOVA) & regression was conducted for plant growth parameters & mineral K using SAS (V 9.2).

RESULTS

Results from the 1st greenhouse trial are presented below:



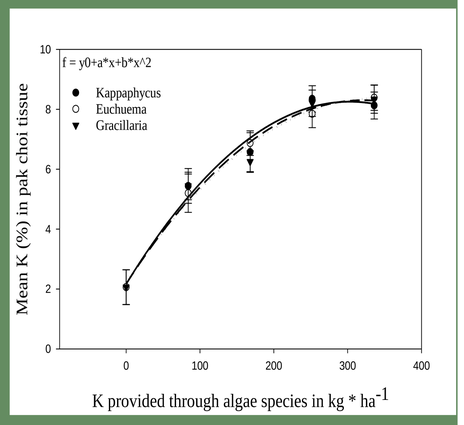
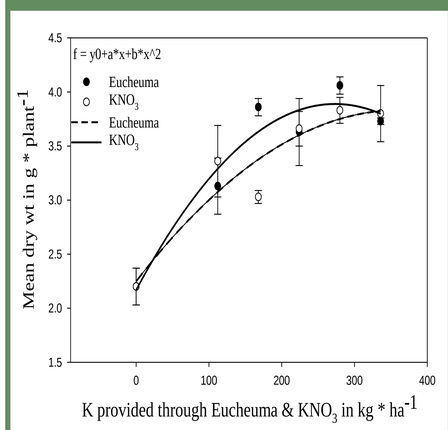


Figure 1 & 2: The effect of 3 algae species on dry weight(gms) & tissue K (%) of pak choi grown with 5 different rates of K (kg/ha) from the 1st GH (n = 65).
Solid line = *Kappaphycus alvarezii*, Long dash line = *Eucheuma denticulatum* & Dotted line = *Gracilaria salicornia*.

Results from the 2nd GH are presented below:



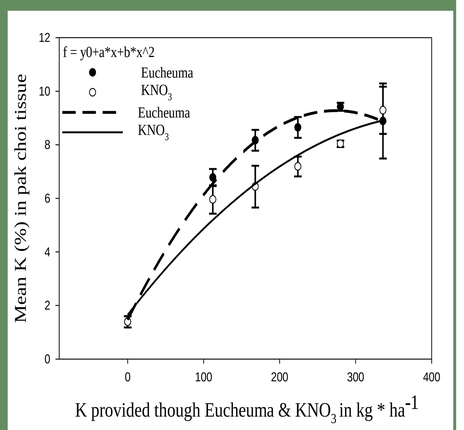
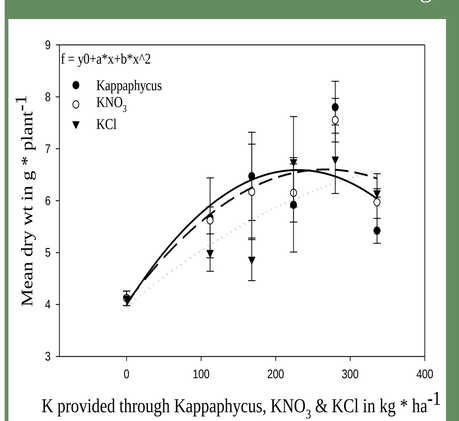


Figure 3 & 4: The effect of *Eucheuma denticulatum* & KNO_3 on dry weight(gms) & tissue K (%) of pak choi grown with 6 different rates of K (kg/ha) from 2nd GH (n = 33).

Results from the 3rd greenhouse trial are presented below:



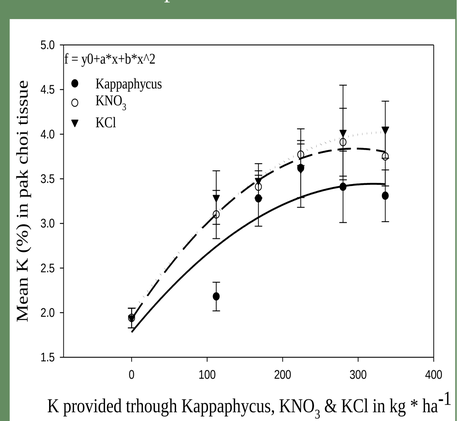


Figure 5 & 6: The effect of *Kappaphycus alvarezii*, KNO_3 & KCl on fresh weight(gms) & tissue K (%) of pak choi grown with 6 different rates of K (kg/ha) from 3rd GH (n = 70).
Solid line = *Kappaphycus alvarezii*, Long dash line = KNO_3 & Dotted line = KCl

DISCUSSION

In the 1st GH trial,
♦No significant differences in yield or tissue K concentrations among the 3 algae species but were significantly different from control.
♦The K fertilizer rates were significant ($P < 0.05$) to yield & highly significant ($P < 0.0001$) to tissue K content.The pak choi yield & tissue K increased significantly with increasing K rates
♦The highest yields (mean 8-.57 g/plant) & tissue K (mean 8.2%) were recorded when K was provided at 252 kg*ha^{-1}.

In the 2nd GH trial,
♦ *Eucheuma denticulatum* was evaluated with KNO_3.
♦The rates of K from both fertilizers were significant ($P < 0.05$) to yields & highly significant ($P < 0.01$) to tissue K. The results were consistent with 1st GH findings.
♦ The two fertilizer types had no significant difference in yields or tissue K between them, but were significantly different from control.
♦The *Eucheuma denticulatum* treated plants had numerically higher tissue K (mean 8.38%) than KNO_3 (mean 7.38%) and both were significantly different from control plants.
♦ The highest yields & tissue K were observed when K was applied at the rate of 284 kg*ha^{-1} and further increased rates did not increase the yield.
In the 3rd GH trial,
♦*Kappaphycus alvarezii* was evaluated for yield and K intake of pak choi with 2 synthetic K fertilizers, KNO_3 & KCl.
♦The analysis of the data shows that the rates were highly significant ($P < 0.001$) to yields and tissue K which was consistent with the 1st and 2nd GH findings.
♦ No significant differences in yield among the 3 fertilizer types were found but they were significant from control.
♦ The fertilizer types were significant for tissue K with KCl (mean 3.69 %) & KNO_3 (mean 3.59 %) significantly different from *Kappaphycus alvarezii* with a mean score of 3.16%.

The findings from these GH studies show that K application rates from using algae as a fertilizer appeared to affect the yield and K nutrition of pak choi plants but the plants that received 224 -284 kg*ha^{-1} of K fertilizer achieved the highest yields & tissue K. These results were consistent from all the three GH trials.

CONCLUSION

The invasive algae positively influenced the growth and K nutrition of pak choi. The response was greater when algae was applied at the rate of 224 - 284 kg*ha^{-1}. Several studies have reported brown, red & green algae species also contains plant growth promoting hormones & other micronutrients. Further studies on specific mechanisms attributed to plant growth are required to determine the potential of these algae species as commercially viable products. The consistent results from these studies show that the these invasive algae species of Hawaiian Islands have potential to be used as a replacement for synthetic potassium fertilizer in vegetable crop production and are particularly beneficial when used for crops with high potassium requirements.

REFERENCES

Crouch, J.J., Beckett, R.P., and J. Van Staden. 1990. Effect of seaweed concentrates on the growth & mineral nutrition of nutrient stress lettuce. J.Appl. Phycol.2:269-272.

Crouch, I.J., and J.Van Staden. 1992. Effect of seaweed concentrates on the establishment & yield of greenhouse tomato plants. J. Appl. Physiol 4:291-296.

Radovich, T.J.K., Pant, A., Hue, N.V., Sugano, J., Sipes, B., Arancon, N., Tamaru, C., Fox, B.K., Kobayashi, K.D. and R.Paull. 2012. Innovative use of locally produced inputs to improve plant growth, crop quality & grower profitability in Hawai'i, Hortech 22: 738-742.

Sasikumar, K., Govindan T., and C. Anuradha. 2011. Effect of seaweed liquid fertilizer of *Dictyota dichotoma* on growth and yield of *Abelmoschus esculantus* L. European J. of Experimental Biology 1:223-227.

Zodape, S.T., 2001. Seaweeds as a biofertilizer. J. of Sci. and Indust. Research, 60: 378-382.

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