Effects of an agricultural extract of the brown alga, *Ascophyllum nodosum* (Phaeophyceae), on mango, *Mangifera indica* (Anacardiaceae), grown for transplants in the nursery[1]

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Abstract: Experiments were conducted in Mayagüez, Puerto Rico, to assess the effects of a commercially available extract of the brown alga *Ascophyllum nodosum* on 'Palmer' and 'Parvin' mangos grown for transplants. The extract was soil-applied biweekly at 0 to 5 ml/L, using 150 ml of aqueous solution per plant per application. Both varieties responded similarly to the alga extract. Increasing the extract rate resulted in increased leaf chlorophyll content (up to 25% higher) and accelerated scion shoot height gain (up to 22%). These results indicate that *Ascophyllum* alga extracts can be used to reduce the time necessary to grow mango transplants.

Key Words: *Ascophyllum nodosum*, brown alga, Phaeophyceae, *Mangifera indica*, mango, Anacardiaceae, algal extracts, bioregulators

Organized commercial mango orchards are generally established using grafted transplants. Usually, mango transplants are grown in the nursery for two to six months after grafting until they attain a size deemed sufficient for growth in commercial orchards (Leger 2008). In Puerto Rico, grafted mango transplants are generally considered ready to be planted in orchards when the stem of the scion (the living buds of a selected mango variety grafted onto the young rootstock plant), has grown approximately 30 cm long with two new clusters of leaves, which commonly takes three to four months after grafting. The longer a plant remains in the nursery, the more nursery growers need to spend on labor, pesticides, fertilizers, water, weeding, and general operations maintenance, and the higher the risk of loss in the nursery due to pest, disease, hurricanes, and other environmental hazards. Hence, it is important for transplant growers to identify practices and systems that result in reduced growing time in the nursery.

Bioregulators can be useful tools to accelerate plant growth. Marine alga extracts have been shown to be valuable bioregulators for several crops (Khan et al. 2009). Research using extracts of the brown alga (Phaeophyceae) *Ascophyllum nodosum* (L.) Le Jolis (Figures 1-2) to reduce time in the nursery has been conducted on several species of *Citrus* (Morales-Payan and Santiago 2008, Santana et al. 2006), Spanish lime (*Meliccocus bijugatus* Jacquin, Sapindaceae) (Morales-Payan 2009), Italian pine (*Pinus pinea* L., Pinaceae) (Atzmon and Van Staden, 1993), and papaya (*Carica papaya* L., Caricaceae) (Morales-Payan and Stall 2005). However, there are no published research

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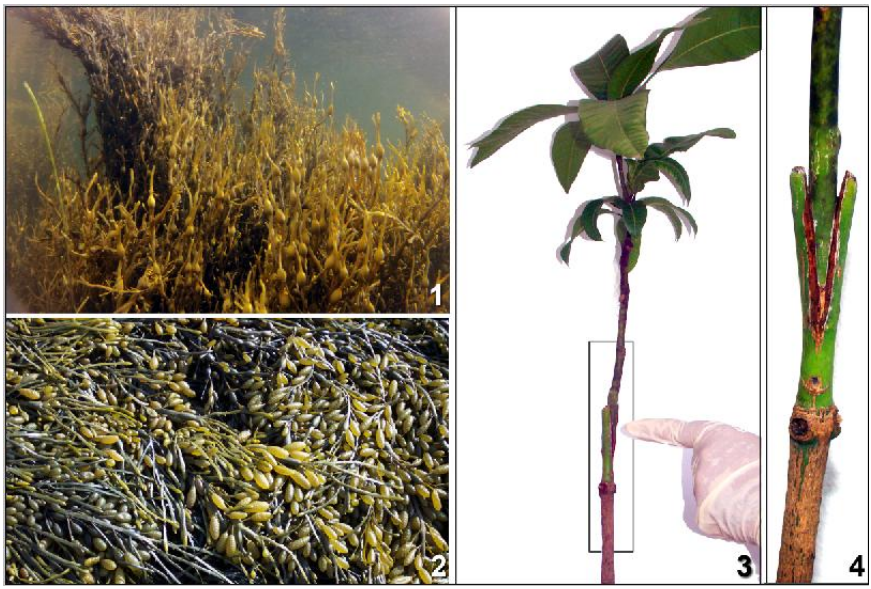
reports on the effects of alga extracts on grafted mango growing in the nursery. The objective of this research was to determine the effect of an extract of the brown alga *Ascopyllum nodosum* on grafted 'Parvin' and 'Palmer' mangos in nursery.



Figures 1-4. 1.-2. *Ascophyllum nodosum* (Phaeophyceae). 1. Overall view. 2. Close-up. Photos courtesy of Dr. Raul Ugarte, Acadian Seaplants Limited (Dartmouth, Nova Scotia, Canada). 3. Mango cleft graft, showing rootstock, below finger, and canopy or scion, above finger. 'Palmer' and 'Parvin' scions were cleft-grafted onto the 'Colombo Kidney' rootstock. 4. Enlargement of boxed area in Figure 3.

Methods

Nursery research was conducted in October 2009-January 2010 and October 2010-January 2011 in Mayagüez, Puerto Rico. Seeds from open-pollinated 'Colombo Kidney' mango trees were grown in black polyethylene perforated bags 9 cm in diameter and 25 cm tall, containing seven kg of a mixture 3:1 of loamy soil and compost. The 'Colombo Kidney' seedlings used as rootstock onto which 'Palmer' or 'Parvin' scions were cleft-grafted (Figures 3-4, 6-8). Two weeks after grafting, a commercially available extract of the brown alga *Ascophyllum nodosum* (Stimplex™, Acadian Seaplants Limited, Darmouth, Nova Scotia, Canada) was applied to the plants. The extract of *A. nodosum* contains small concentrations of plant growth-promoting substances such as cytokinins, gibberellins, auxins, betaines, carbohydrates, vitamins, organic acids, amino acids, peptides, polyamines, polyphenols, and mineral nutrients (Norrie and Keathley 2006), and may promote the synthesis and activity of

phytohormones such as cytokinins and abscisic acid in treated plants (Wally et al. 2012). The extract was applied as aqueous solution in soil drench, at rates of 0 (control), 1, 2, 3, 4 and 5 ml of the extract per liter of water. Each plant received 150 ml of aqueous solution (Figure 5). Applications were repeated every two weeks until the plants reached the recommended transplanting size (30 cm of new growth in the scion).

Figures 5-8. 5. Drench application of the *A. nodosum* algal extract onto the grafted mango tree. 6. Mango fruits of variety 'Parvin' (left). 7. Mango fruit of variety 'Palmer'. 8. A 'Parvin' mango (left) typically weighs circa 570 grams (approximately 20 ounces), whereas a 'Palmer' mango (right) averages 710 grams (approximately 25 ounces).

The treatments (extract rates and mango varieties) were established in a randomized complete blocks design, using 10 replications. Except for the application of the algal extract, the plants were managed according to local mango nursery recommendations (Toro 1988). Scion length and chlorophyll concentration were determined in each mango variety every two weeks after the algal extract application. Chlorophyll concentration was determined in the most recent fully expanded leaf of each plant using a Minolta SPAD 502 meter. Regression analysis (95% confidence level) was conducted on the scion length and leaf chlorophyll concentration data.

Results

In both years of research, the two mango varieties did not differ in their response to the algal extract, and therefore results will be presented and discussed using pooled average values for the two varieties across two

experiments. As the concentration of the alga extract in the drench solution increased, there was a concurrent increase in the concentration of chlorophyll in the mango leaves, reaching a maximum of 25% over the value of control plants (Figure 9). Similarly, increasing the concentration of the alga extract resulted in greater shoot length of the scion, attaining a maximum value 22% greater than in control plants by 98 days after grafting (Figure 10).

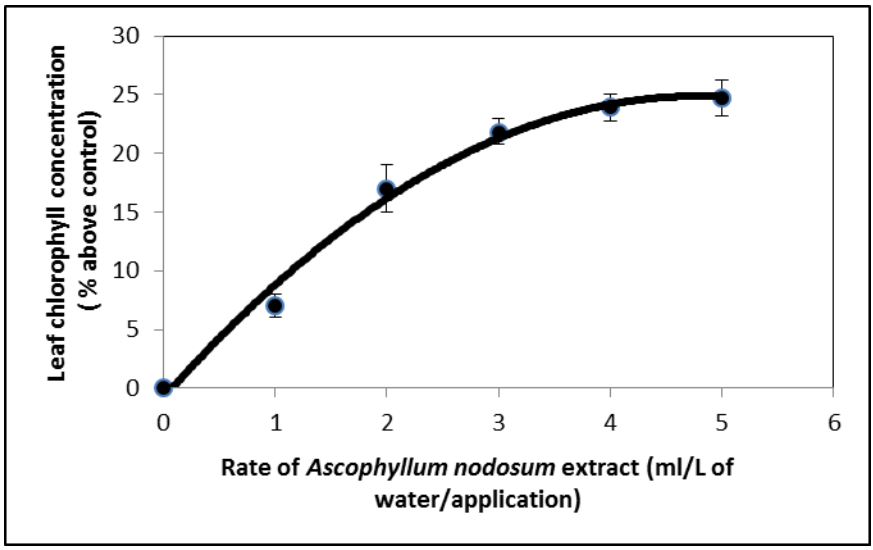


Figure 9. Chlorophyll concentration in the laves of grafted 'Palmer' and 'Parvin' mangos as affected by rates of an *Ascophyllum nodosum* extract applied to the soil every 14 days after grafting. The response of chlorophyll concentration (Y) to extract rate (X) is described by the equation, $Y = 12.8/[1 + (12.8x/44.2)]$; $r^2 = 0.97$. Points in the figure represent average values with standard error bars for both mango varieties in two experiments conducted in 2009-2010 and 2010-2011 in Mayagüez, Puerto Rico.

Discussion

Mango seedlings grafted with 'Palmer' and 'Parvin' scions responded to the alga extract in a similar fashion. Alga extract concentrations higher than 2 ml per liter of water elevated the concentration of chlorophyll in mango leaves, reaching as much as 25% above the chlorophyll concentration in control plants at 98 days after grafting (Figure 9). Other researchers have reported increased chlorophyll concentrations when plants were treated with *A. nodosum* extracts. Blunden et al. (1997) found that applying *A. nodosum* extracts increased chlorophyll concentration in tomato (*Lycopersicon esculentum* L., Solanaceae), barley (*Hordeum vulgare* L., Poaceae), wheat (*Triticum aestivum* L., Poaceae), and bean (*Phaseolus vulgaris* L., Fabaceae), and Eris et al. (1995) found similar

results working with alga extracts on peppers (*Capsicum annuum* L., Solanaceae).

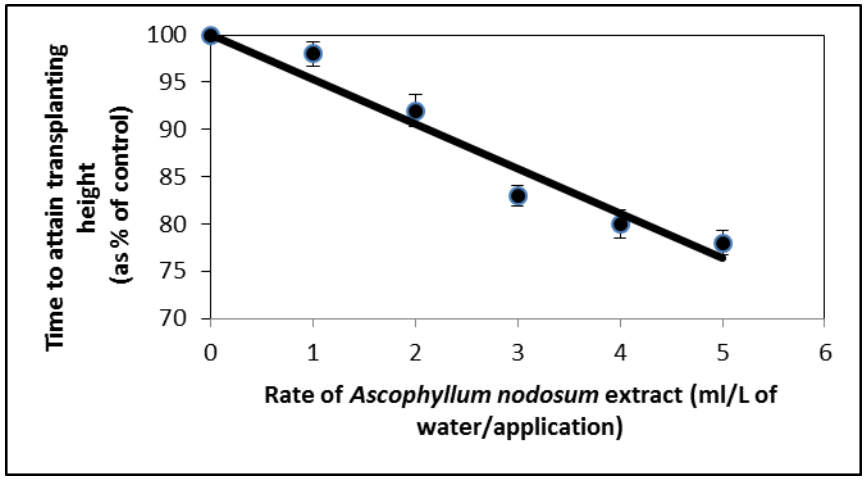


Figure 10. Reduction in time for grafted 'Palmer' and 'Parvin' mangos to attain recommended transplanting height as affected by rates of *Ascophyllum nodosum* extract applied to the soil every 14 days after grafting. The response of reduction in time (Y) to extract rate (X) is described by the equation, $Y = -5.2x + 101.3$; $r^2 = 0.92$. Points in the figure represent average values with standard error bars for both mango varieties in two experiments conducted in 2009-2010 and 2010-2011 in Mayagüez, Puerto Rico.

The increased concentration of chlorophyll in plants exposed to extracts of *A. nodosum* has been associated with presence of betaines in the alga extracts (Blunden 2003, Blunden et al. 1997, MacKinnon et al. 2010, Whapman et al. 1993); betaines increase plant tolerance to stress (Blunden 2003) and have effects similar to those of cytokinins that may contribute to plant growth (Verineri et al. 2006). Higher concentrations of chlorophyll are potentially conducive to higher photosynthetic activity and increased output of photoassimilates leading to enhanced plant growth. Additionally, alga extracts applied to the soil have been shown to reduce nitrogen leaching and increase nitrogen availability for plants (Leach et al. 1999), which would help explain increased chlorophyll concentrations in the leaves of mango plants treated with the alga extract. It has also been reported that plants exposed to alga extracts had increased nutrient uptake (Mancuso et al. 2006), which may have contributed to increased chlorophyll concentration, photosynthetic activity, and overall faster growth in the mango plants.

The scions of mango transplants treated with the *A. nodosum* extract grew faster than control plants. The scion of transplants treated with the 5 ml per liter concentration had grown 40 cm when measured 98 days after the start of the alga treatments, whereas control transplants required 120 days to reach the same

height. That time difference represented a 22% reduction for mango plants to reach the recommended transplanting height. Mango plants receiving lower alga extract rates grew faster than control plants, but at heights lower than those recorded at the highest application rate. Similar effects on plant height and reduction of time in the nursery have been reported for several fruit crops such as papaya, Spanish lime for rootstock, budded tangelo (*Citrus reticulata* Blanco x *C.* x *paradisi* Macfadden), budded orange [*Citrus sinesis* (L.) Osbeck], and budded grapefruit (*Citrus* x *paradisi*) (Morales-Payan 2009, Morales-Payan 2008, Morales-Payan and Stall 2005, Morales-Payan and Santiago 2008, Santana et al. 2006), suggesting that the physiological processes stimulated by the marine alga extract may be similar in a number of crop species.

When using a naturally complex bioregulator such as an *A. nodosum* extract, it is very difficult to pinpoint the active ingredient that eventually causes a measurable increase in plant size; the final effect is most likely the result of the combination of physiological effects brought about by several growth promoting substances known to exist in *A. nodosum* and in its extracts, such as cytokinins, gibberelllins, auxins, betains, saccharides, and other organic and inorganic components (Khan et al. 2009, Whapman et al. 1993). Nevertheless, our results show that grafted seedlings of mango grown for transplants may be physiologically stimulated to increase their chlorophyll concentration and grow faster following treatment with extracts of *A. nodosum*, and such effect may be of value for mango transplant producers.

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Literature Cited

Atzmon, N. and J. van Staden. 1994. The effect of seaweed concentrate on the growth of *Pinus pinea* seedlings. *New Forests* 8:279-288. http://dx.doi.org/10.1007/BF00025373

Blunden, G., T. Jenkins, and Y. Liu. 1997. Enhanced leaf chlorophyll levels in plants treated with seaweed extracts. *Journal of Phycology* 8(6):535-543.

Blunden, G. 2003. Betaines in the plant kingdom and their use in ameliorating stress conditions in plants. *Acta Horticulturae* 597:23-29.

Eris, A., H. Sivritepe, and N. Sivritepe. 1995. The effect of seaweed (*Ascophyllum nodosum*) extract on yield and quality criteria in peppers. *Acta Horticulturae* 412:185-192.

Khan, W., U. Rayirath, S. Subramanian, M. N. Jithesh, P. Rayorath, D. M. Hodges, A. T. Critchley, J. S. Craigie, J. Norrie, and B. Prithiviraj. 2009. Seaweed Extracts as Biostimulants of Plant Growth and Development. *Journal of Plant Growth Regulation* 28:386-399. http://dx.doi.org/10.1007/s00344-009-9103-x

Leach, W. R., B. A. Plunkett, and G. Blunden. 1999. Reduction of nitrate leaching from soil treated with an *Ascophyllum nodosum* based soil conditioning agent. *Journal of Applied Phycology* 11:593-594. http://dx.doi.org/10.1023/A:1008163024879

Leger, R. 2008. Guía técnica del cultivo de mango (Technical guide for mango production). Centro de Desarrollo Agropecuario y Forestal. Santo Domingo, Dominican Republic. 148 pp. (in Spanish).

MacKinnon, S. L., D. Hiltz, R. Ugarte, and C. A. Craft. 2010. Improving methods of analysis for betaine in *Ascophyllum nodosum* and its commercial seaweed extracts. *Journal of Applied Phycology* 22:489-494. http://dx.doi.org/10.1007/s10811-009-9483-0

Mancuso, S., E. Azzarello, S. Mugnai, and X. Briand. 2006. Marine bioactive substances (IP extract) improve ion fluxes and water stress tolerance in potted *Vitis vinifera* plants. *Advances in Horticultural Science* 20:156-161.

Morales-Payan, J. P. and W. M. Stall. 2005. Papaya (*Carica papaya*) transplant growth and quality as affected by nitrogen and a soil-applied seaweed extract. *HortScience* 40:1107-1108.

Morales-Payan, J. P., and S. Santiago. 2008. Accelerating the growth of 'Orlando' tangelo (*Citrus reticulata* x *C. paradisi*) in nursery with a commercial amino acid formulation, a commercial extract of kelp (*Ascophyllum nodosum*), and a fertilizer. *Proceedings of the Plant Growth Regulation Society of America* 35:211-219.

Morales-Payan, J. P. 2008. Using a commercial mixture of amino acids and a commercial extract of *Ascophyllum* kelp to reduce the time in nursery of 'Duncan' and 'Marsh' grapefruits (*Citrus paradisi* Macf.) in Puerto Rico. *Proceedings of the Caribbean Food Crops Society* 44:355-356.

Morales-Payan, J. P. 2009. Growth acceleration of quenepa (*Melicoccus bijugatus*) rootstock with an extract of the brown alga *Ascophyllum nodosum* and a blend of amino acids, peptides and related compounds. *Proceedings of the Caribbean Food Crops Society* 45:211-214.

Norrie, J. and J. P. Keathley, 2006. Benefits of *Ascophyllum nodosum* marine-plant extract applications to 'Thompson Seedless' grape production. *Acta Horticulturae* 727:243-248.

Santana, L. M., R. Gabriel, J. P. Morales-Payan, C. H. Puello, J. Mancebo, and F. Rondon. 2006. Effects of biostimulants on nursery growth of orange budded on volkamer lemon (*Citrus volkameriana*) and 'Swingle' citrumelo (*C. paradisi x Poncirus trifoliata*). *Proceedings of the Plant Growth Regulation Society of America* 33:217-219.

Toro, E. 1988. Cultivo de mangos en Puerto Rico (Mango production in Puerto Rico). Agriculture Extension Service. University of Puerto Rico. Mayagüez, Puerto Rico. 95 pp. (in Spanish)

Vernieri, P., E. Borghesi, F., Tognoni, G., Serra, A. Ferrante, and A. Piagessi. 2006. Use of bio-stimulants for reducing nutrient solution concentration in floating system. *Acta Horticulturae* 718: 477–484.

Wally, O. S. D., A. T. Critchley, D. Hiltz, J. S. Craigie, X. Han, L. O. Zaharia, S. R. Abrams, and B. Prithiviraj. 2012. Regulation of phytohormone biosynthesis and accumulation in Arabidopsis following treatment with commercial extract from the marine macroalga *Ascophyllum nodosum. Journal of Plant Growth Regulation* 32:1-16.

Whapman, C. A, G. Blunden, T. Jenkins, and S. D Hankins. 1993. Significance of betains in the increased chlorophyll content of plants treated with seaweed extract. *Journal of Applied Phycology* 5:231–234. http://dx.doi.org/10.1007/BF00004023