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Differences in biomass production and carrageenan yields among four strains of farmed carrageenophytes in Northern Bohol, Philippines

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Abstract

Comparative studies on the biomass and carrageenan production of two strains of *Eucheuma denticulatum* and two strains of *Kappaphycus alvarezii* were made to assess the seasonality in their production capacities.

The high and similar refined carrageenan (RC) yields (43–53% of dry wt.) of the four strains in the first cropping season (June–October) coincided with their high biomass production with plants averaging from 1.1 to 1.8 kg each at harvest. The poor RC yields (21–33%) recorded in the second cropping (October–February) coincided with their season of low biomass (av. wt: 0.34 to 1.0 kg). The four strains, however, recorded contrasting performance in the third cropping season (February–July) with the two *E. denticulatum* strains recording high RC yields (43 and 42.5%) together with high biomass (av. wt: 1.5 and 1.6 kg) in contrast to the low RC yields (30 and 39%) and low biomass (av. wt. 0.21 and 0.28 kg) of the two *K. alvarezii* strains. Records for semi-refined carrageenan (SRC) yields in the second and third cropping seasons were quite consistent and similar for the four strains (42–55%), except in the second cropping where the two *K. alvarezii* strains recorded low SRC. These differences in production potentials highlight the need for cropping management of the four strains to improve their cropping performance.

Introduction

The great demand for carrageenans on the world market has encouraged the commercial production of carrageenophytes through mariculture which is presently one of the few important livelihoods among the coastal populations in the Philippines. The industry, however, is faced with problems like the apparent decrease in vigor of farmed stocks resulting in low farm production outputs, poor quality of the produce caused by poor post harvest handling practices, e.g., high moisture content, presence of extraneous materials such as other seaweeds, sand, and plastic materials, and low yields of refined carrageenans from farm grown crops.

The different strains of carrageenophytes presently farmed in Danajon Reef, Northern Bohol show distinct differences in their growth rates and production (biomass) during the different seasons of the year (Trono & Ohno, 1989). The current cropping practice of farmers is to mix-plant the different strains and select seedstocks for the next cropping season from the present harvest. Because the different strains differ in their production capacities during the different parts of the

year, the seedstocks selected for the succeeding cropping season are not at all acclimated to this season resulting in low production yields of pure carrageenan of crops.

The green (GSP1) and the brown (BSP1) strains of *Eucheuma denticulatum* (Burman) Collins et Hervey and the green (GST1) and the brown (BST1) strains of *Kappaphycus alvarezii* (Doty) Doty are commonly farmed throughout the year. *E. denticulatum* produces *iota* carrageenan and is called the 'spinosum' of commerce while *K. alvarezii* produces *kappa* carrageenan and is the 'cottonii' of commerce. We report here the seasonal differences in biomass production and carrageenan yields (semi-refined and refined) of the four strains from three different cropping seasons with the view to illucidating the seasonality in their production potentials as basis for their cropping management.

Materials and methods

This research was conducted at the Antonio-Agro Seaweed Farm on Danajon Reef, Northern Bohol, Philippines (10° 16′ N. Lat; 124° 3′ E. Long.) from March 1983 to September 1984.

The fixed bottom monoline method (Trono & Fortes, 1988) was used in the culture of the four strains. The experimental plots for each strain consisted of 20 monolines, each monoline planted to 20 plants/cuttings, the individual cuttings weighing 100 g.

Four croppings were made, the first was from 13 June to 5 October 1983; the second from 12 October 1983 to February 1984; the third from 7 April to 20 July 1984. The fourth cropping from 5 August to September 1984 was destroyed by a typhoon. The growing period lasted from 12 to 18 weeks.

The sampling for biomass was done one week after planting and weekly thereafter. Sampling was done by randomly harvesting the whole monoline from experimental plots of each strain. The average biomass (fresh) of the plants in the monoline was recorded. The harvests (biomass) were sun dried. The dried materials starting with the fourth week harvest were analyzed for semi-refined (SRC) and refined carrageenan (RC) yields. The extraction of SRC was done by Marine Colloids Philippines, Inc. in Cebu City. RC was processed by the alcohol precipitation method (Towle, 1973).

The data on standing crop and carrageenan yields of the four strains from the different cropping periods were analyzed and compared.

Results

No significant differences in the amount of RC between strains were observed in the first cropping (June–October) (Table 1a). The RC yields of the four strains were within the narrow range of 43–53% of dry weight and were the highest among values recorded in the three cropping seasons. The biomass of the plants was also the highest recorded as all strains showed good growth.

The second cropping (Oct–Feb) was a period of poor growth for all strains as the strains suffered the 'ice-ice' disease, with the exception of the brown strain of *K. alvarezii* (BST1) which recorded relatively good growth (attaining more than 1000 g maximum average biomass). The maximum average biomass attained by the other strains was barely 500 g.

Differences between strains in amount of carrageenan yields in the second cropping were observed. The *E. denticulatum* strains (BSP1 and GSP1) yielded significantly higher amount of SRC than did the *K. alvarezii* strains (Table 1b). The amount of RC appeared to be significantly different among the four strains although the green strains (GSP1 and GST1) seemed to yield more RC than did the brown strains (BSP1 and BST1) (Table 1a). The yields of RC relative to SRC from the four strains during this cropping season differed, i.e., the RC yields of the *K. alvarezii* strains were almost as much as the SRC in contrast to those of *E. denticulatum* strains which were considerably less than that of the SRC.

In the third cropping (Feb–Jul), the RC yields of the *E. denticulatum* strains were significantly

Table 1. Comparison of the RC (Table 1a) and SRC (Table 1b) yields (± std. deviation), in per cent of dry weight, of the two strains of *Eucheuma* (BSP1 and GSP1) and *Kappaphycus* (BST1 and GST1). Results of the ANOVA-Duncan's Multiple Range Test are shown on the left (for comparisons between cropping seasons within a strain) and on the right (for comparisons between strains within a cropping season) of the values; means with the same letter are not significantly different from each other ($p < 0.05$). For Table 1b, the t-Test was used to compare the yields of a strain from the two cropping seasons; s = significant, ns = not significant ($p < 0.05$).

Table 1a

Strain	Cropping season		
	Jun–Oct	Oct–Feb	Feb–Jul
GST1	a 51.30 (± 4.65) a	b 33.18 (± 5.27) a	b 37.05 (± 3.88) a
BST1	a 49.74 (± 2.22) a	b 26.51 (± 7.55) b	b 29.98 (± 2.82) b
GSP1	a 49.68 (± 3.66) a	b 30.82 (± 6.16) ab	c 42.47 (± 3.87) c
BSP1	a 49.88 (± 3.65) a	b 20.86 (± 6.18) c	c 43.00 (± 5.46) c

Table 1b

Strain	Cropping season	
	Oct–Feb	Feb–Jul
GST1	s 33.68 (± 6.04) a	54.86 (± 4.71) a
BST1	s 31.40 (± 7.55) a	41.48 (± 5.00) b
GSP1	ns 52.84 (± 3.35) b	49.16 (± 6.40) c
BSP1	ns 52.28 (± 7.25) b	47.63 (± 9.41) c

higher than those of the *K. alvarezii* strains (Table 1a). All strains, however, yielded fairly the same amount of SRC but the amount of RC from the *K. alvarezii* strains was significantly less than that of the SRC while the amount of RC from the *E. denticulatum* strains was almost as much as their SRC.

The four strains appeared to follow a common pattern of intercropping differences in the yields of RC, i.e., highest in the first cropping, lowest in the second, and intermediate in the third (Table 1a). These differences appeared significant among the *E. denticulatum* strains while they did not appear substantial in the *K. alvarezii* strains in the third cropping.

Differences in biomass production of the different strains during the three cropping seasons were also observed. The *E. denticulatum* strains showed a trend similar to that of their RC yields: high in the first and third croppings but low in the second cropping although a longer period (16 weeks) was required to attain maximum biomass in the third cropping compared to the first cropping (7 weeks). In contrast, high biomass production among the *K. alvarezii* strains was observed only in the first cropping periods. Their RC yields appeared to follow the trend in their biomass production, e.g., high during the first and low during the second and the third croppings.

Discussion

The low quality of farm produce (low RC yields) has always been attributed to poor post-harvest processes. Despite efforts to induce farmers to improve the quality of their produce such as through graded pricing based on the physical quality, processors still receive batches of seaweeds with low RC yields. The results of this study show that the state of the crop at the time of harvest, i.e., whether healthy or not, appeared

to be an important factor affecting the SRC and RC yields. The amount of yields appeared to vary with the growth performance of the strains, as indicated by biomass production. High RC yields of the four strains were recorded in the June–October cropping period when growth was good (high standing crop) and significantly low yields in the October–February cropping period when growth was poor. Thus, the observed intercropping differences in the yields of RC appear to take exception to the general observation that rapid growth of carrageenophytes, as a result of elevated nutrient levels is accompanied by less carrageenan production (Dawes *et al.*, 1974a, b; McCandless & Craigie, 1979; Chopin *et al.*, 1990). The lack of agreement between the results of the present studies and those of the other workers might have been caused by differences in ambient environmental conditions. Dawes *et al.* (1974a, b) reported that maximum growth and minimum carrageenan yields occurred in period of low temperature. Trono & Ohno (1989) reported high growth and biomass during periods of relatively high temperature regimes.

Differences in the RC yields and biomass production observed among the four strains appeared to be species-specific. The two *E. denticulatum* strains showed similarly seasonality in biomass and RC yields as did the two strains of *K. alvarezii*. Trono & Ohno (*loc. cit.*) reported the same species-specificity in the seasonality of biomass production of the different strains. But differences in RC yields between the brown and green strains of the two species were also noted during the second cropping periods with the green strains of the two species recording higher RC yields than their brown counterparts.

The distinctly higher ratio of SRC to RC yields of crops during cropping seasons of low biomass production and lower ratio during cropping seasons of high biomass production are very apparent. The incidence of what is known as the 'ice-ice' disease is preceded by the paling of the color, the loss of the glossy surface and thinning of the branches, and occurrence of epiphytes and other weeds. The SRC yields during this period remain approximately similar to that recorded in crops from good cropping period but the RC yields were significantly lower. A large portion of the carrageenan in diseased or sickly crops apparently is degraded to other products and cannot be recovered by alcohol precipitation during processing of RC. But during SRC processing, this portion is apparently retained. The presence of these degraded products may reduce the gel strength and viscosity of the carrageenan. This important problem needs clarification.

The results of this study show that the production potentials of the different farmed strains varied with species and with cropping seasons. The production in the first cropping period was not at all affected by choice of species or strains as all showed good performance (high biomass and carrageenan yields). In the second cropping period, however, the green strains of both species appeared to record better crop performance than did the brown strains. In the last cropping, both strains of *E. denticulatum* recorded good growth compared to those of *K. alvarezii*. This information can be used as basis for cropping management of different strains to improve the productivity of the farms.

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