Year round taro leaf production in northern New Zealand

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Abstract

Young leaves have been harvested at weekly intervals from late spring to early winter from three taro cultivars of tropical origin grown in a group of unheated large tunnel houses for over a decade. There is a linear relationship between monthly yield from these houses and monthly growing degree-days (base 10°C). Yields were higher in the first planting removed in winter 2004 than in the second planting. In a separate study between early May 2007 and late May 2008, Japanese cultivars of temperate origin produced leaves throughout but the tropical cultivar did not produce leaves between mid-winter and early spring. How best to optimise year round production of young taro leaves in northern New Zealand requires further study.

Additional keywords: temperature, degree-days, *Colocasia esculenta*

Introduction

Young taro leaves (*Colocasia esculenta* (L.) Schott) are widely used for the preparation of the gourmet dish *ngou'a* in Tonga, *palusami* in Samoa, *rakau* in Cook Islands or the equivalent in many other tropical countries (Purseglove, 1972). They are cut from maturing crops in the last few weeks before corms are dug. In wet South Pacific tropical islands, a supply of young leaves is generally available year-round because crops can mature year-round.

Many Pacific Islanders in northern New Zealand have continuously harvested young leaves between late spring and autumn as they develop to the desired stage on plants grown in their home gardens. Since 1998, members of a Pacific Island trust have been growing taro plants in unheated plastic tunnel houses and selling young leaves harvested between late spring and autumn at the Otara market in Manukau City (Bussell *et al*., 2004; Bussell, 2006). N this paper leaf production and its relationship to both temperature and year of harvesting, in the trust's unheated plastic tunnel houses, is described and discussed. Initial small scale studies on year-round leaf production and improving mid-winter to early spring yields are also described and discussed. In these initial studies several cultivars were compared; namely one of the main cultivars, grown since 1998, and four cool tolerant Japanese cultivars that have a high corm growth rate through to early winter in New Zealand (Scheffer *et al*., 1999; Scheffer and Douglas, 2000).

Materials and Methods

Cormels (suckers) of the New Zealand cultivar termed variant RR by Matthews (1985) and the South Pacific cultivars Niue and Ni Tonga were planted during the winter and spring of 1997 in unheated tunnel houses at the Kahoa Tauleva Trust property near Pukekohe. They were planted in flat beds with 6 rows approximately 15 cm apart and with plants approximately 15 cm apart in the row. The total area planted was 2730 m^2, with each cultivar occupying about one third. Most of the original plants were removed in winter 2004 because yield in the 12 months to June 2004 was about one third lower than in the previous three years (Figure 2). New cormels of the same cultivars were planted in the same areas. Composted sawdust and 40 g m^{-2} of Nitrophoska were applied and worked in before each planting. Nitrophoska, at the same rate, was also applied annually in mid-spring. The crop was irrigated as required and never appeared to suffer water stress.

Young leaves were cut at weekly intervals during the growing season and to maintain leaf tenderness were cut when one to two weeks old. At least two leaves were left on a plant so growth was maintained. The total weight of young leaves harvested each month was recorded from January 1998. Monthly yields to May 2008 were plotted against degree-days in each month that were above 10°C, calculated from NIWA data from Pukekohe. This is the base temperature used in recent Hawaiian taro growth studies (Miyasaka *et al*., 2003). Growing degree-days were calculated from daily maximum and minimum temperatures

$$\frac{\text{Maximum} + \text{Minimum}}{2} - 10$$

To better understand the crop and its environment within the tunnel houses, yields were analysed fitting a smooth curve (Grosse and Shyu, 1992), either over time, or as a function of degree-days $month^{-1}$ in time order. Annual cyclical effects were subtracted from the time series of degree-days $month^{-1}$ and the residuals were examined to see whether the months with lower or higher production than expected occurred consistently in each year.

For the initial small-scale study of year-round production and improving mid-winter to early spring yields, two plots with 6 rows approximately 15 cm apart and with cormels approximately 15 cm apart in the row were planted either in one of the single-skinned production tunnel houses or in a small night heated, double-skinned tunnel house. The night heating achieved a higher minimum temperature than in the production houses but not a target minimum temperature. One plot in each house contained the cultivar ‘variant RR’ and the other, because of limited planting material, equal numbers of four Japanese cultivars mixed randomly in the plot. These were the late maturing Akame, and the early maturing Yamato-wase, Ishikawa-wase, and an unnamed cultivar - here identified as J1. These four cultivars are collectively referred to as ‘Japanese’ in the rest of this paper. Sixty m^2 flat beds were planted in the production tunnel house and 9 m^2 beds, raised 15 cm above floor level, were planted in the double-skinned tunnel house. Composted sawdust and 40 g m^{-2} of Nitrophoska were applied and worked in before planting. Leaf production was recorded weekly from early May 2007 to late May 2008. The leaf nutrient status of plants was determined once in the study in mid-May 2008 from random samples of 20 harvested young leaves. The determination was undertaken by R J Hill Laboratories Ltd., Hamilton.

Results and Discussion

The simple linear regressions (Figure 1) between yield of leaves harvested month^{-1} and degree-days above 10°C in each month is fitted subject to a constraint. In months with zero production, degree-days in those months (the lowest observed was July 2001, 13.1 GDD and July 2003, 14.0 GDD) are set to zero. The estimated slope of the regression line is 2.0 (standard error = 0.11, P~2 x 10^{-16}). With an increase of 10 GDD month^{-1} above 10°C yield from the total production area increases by 20 kg (standard error = 1.1, P<0.001). The spread around the fitted line is not symmetric. For most months leaf production, in kg, is approximately twice the GDD in the month. A few months, usually in the cool months of July, August or September, in each year (those points below the lower dashed line in Figure 1) have production which is less than or equal to the GDD and a few other usually warmer months (those points above the higher dashed line in Figure 1) have production over four times the GDD.

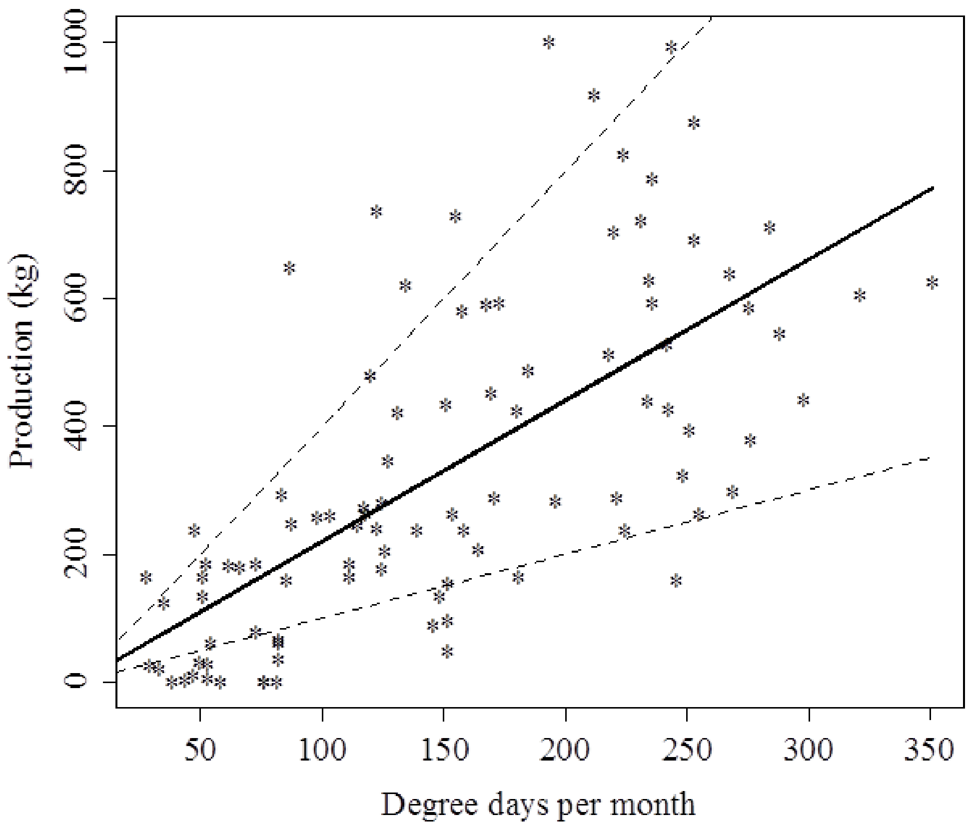

Figure 1: Monthly yield (kg) of taro leaves (fresh weight) in response to monthly growing degree-days (base 10°C).

When monthly leaf yields are plotted in time order (Figure 2) it can be seen that all the high yielding months occurred before 2004 during the first planting in the production houses. The median value of the fitted trend from January 1998 to when the crop was replanted in June 2004 is approximately 375 kg month^{-1}, but after replanting it was only 200 kg month^{-1}. The fitted trend increased to a peak of 425 kg month^{-1} and then decreased during the life of the first planting of the crop. However, the fitted trend did not change in the three years of the second planting (Figure 2). The change in the fitted trend may be due to some unidentified detrimental effects on yield of replanting.

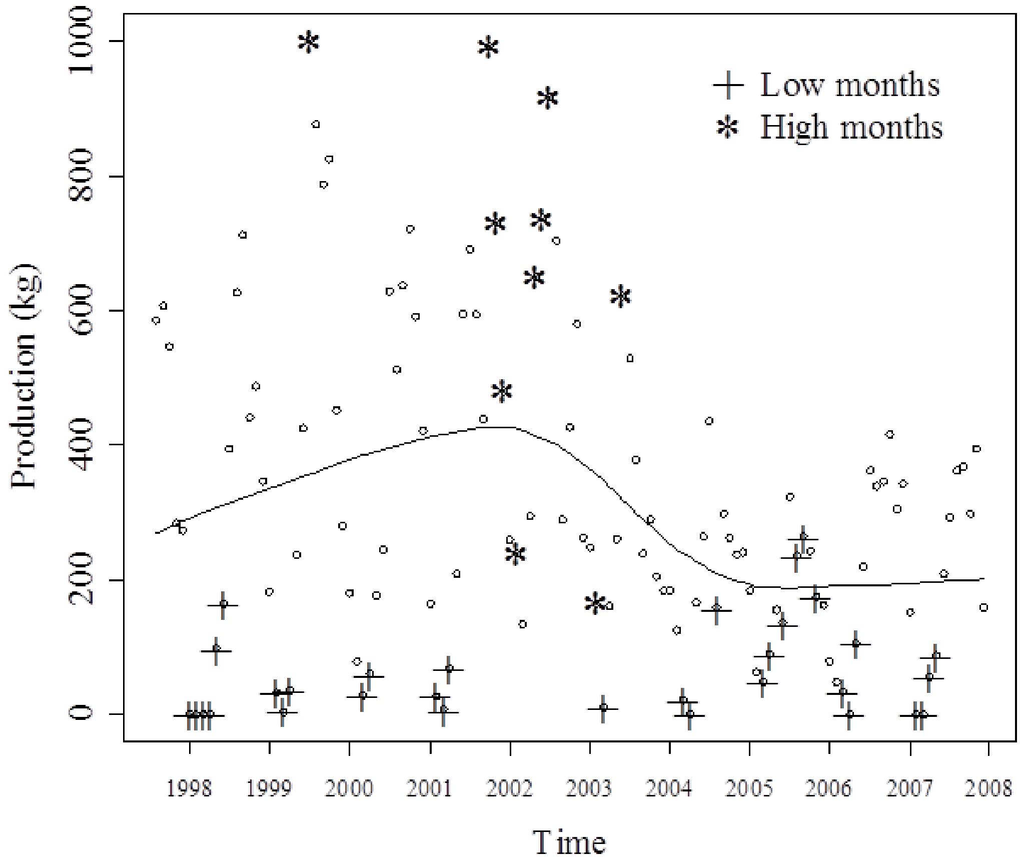

Figure 2: Production (kg) in each month for each year 1999 to 2008. Points denoted by * are the values above the top dotted line in Figure 1 those denoted by + are the values below the bottom dotted line in Figure 1. Points denoted * occur mostly before 2004 while those denoted + are mostly in August and September.

The time series of production each month was analysed to give a seasonal decomposition as the sum of three components; long term trend, monthly effect centred on the long term mean, and residual variation using the seasonal adjustment function, *stl*, in the statistical package R (Cleveland *et al*., 1990; R Development Core Team, 2010). The monthly effects are given in Table 1 and show the very rapid increase in production of approximately 475 kg month^{-1} from the very low production level in August to maximal production in December and January declining slightly in February and March.

The number of degree-days in each month is obviously dependent upon the annual solar cycle. Before trying to relate leaf yield each month to variation in the number of degree-days it is necessary to estimate the effect of this annual cycle again using the seasonal adjustment function. The time series of degree-days in each month was decomposed into three components; long term trend, monthly effect, and residual variation. The monthly effects are given in Table 2 and range from 26 GDD in July to 259 GDD in January. However, even when accounting for this month-to-month variation, there is considerable unexplained variation around the long-term and annual cycle

Table 1: Seasonal components from decomposition of time series of monthly production (kg) into trend + seasonal + irregular components. Seasonal components centred at zero.

Month	Monthly component	Month	Monthly component
January	198	July	-227
February	176	August	-276
March	165	September	-227
April	107	October	-88
May	-10	November	59
June	-142	December	190

Table 2: Seasonal components from decomposition of time series of growing degree-days (base 10°C) into trend + seasonal + irregular components. Seasonal components centred at long term mean.

Month	Monthly component	Month	Monthly component
January	258.8	July	25.7
February	242.1	August	28.4
March	225.5	September	67.4
April	155.5	October	107.1
May	104.8	November	146.6
June	53.1	December	209.7

Cumulative yield from weekly harvests of the small-scale trial on year-round production of cultivars ‘RR’ and ‘Japanese’ is given in Figure 3. ‘Japanese’ produced leaves all year round while ‘RR’ did not produce any from early winter to mid spring. The cultivar ‘RR’ produced leaves at a faster rate, particularly when growth resumed in spring, than ‘Japanese’ for most of the time when both cultivars produced leaves during the period May 2007 to May 2008 resulting in higher yields from ‘RR’ than from ‘Japanese’. The cultivar ‘RR’ had a 65% (7.6 kg m^{-2}) and ‘Japanese’ had a 100% (6.6 kg m^{-2}) higher yield in the small tunnel house where both soil and air temperatures were slightly higher.

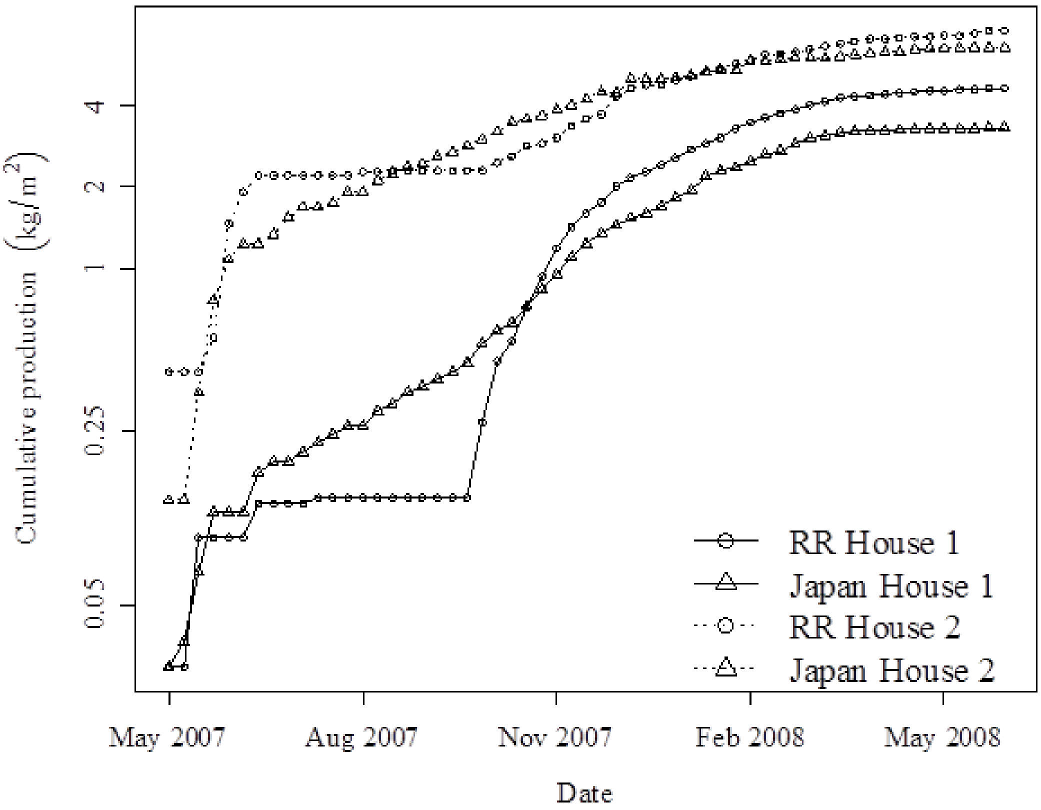

Figure 3: Cumulative production (kg m^{-2}) plotted on a logarithmic scale in cultivars 'RR' and 'Japanese' grown in a production house (House 1) and a small tunnel house (House 2) from early May 2007 to late May 2008.

Leaf test levels for all nutrients except boron in both small scale trials were in the adequate range established from University of Queensland studies of tropical Melanesian and Polynesian taro crops (O'Sullivan *et al*., 1996). However, based on experience of reduced yield in the second large planting in production, adequate levels for optimum yield of leaves may be higher for the unique system used in this study.

How best to optimise year round production of young taro leaves in northern New Zealand is likely to require further study.

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