GROWTH AND PARTITIONING IN SWEET POTATOES

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ABSTRACT

In 4 sweet potato cultivars studied, harvest indices and dry weight accumulations of sweet potato storage roots and total plant dry weight increased throughout the growing season, but declined during the later part of the season. Vine dry weight slowly increased reaching a maximum at 14-16 weeks after transplanting, then slowly decreased throughout the season except in 1 cultivar where vine weight continued to increase. It is suggested that a balance between vines and roots is a factor in obtaining maximum yield, and that the crop may be either sink or source limited if a suitable balance is not maintained.

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KEY WORDS: Nemagold. Redmar. Jewel. Centennial. Vines. Storage roots. Sink strength. Source potential. Balance.

INTRODUCTION

Although there is conflicting evidence (such as that presented by Haynes et al., 1967), it is generally believed that the rate of translocation in sweet potato (*Ipomoea batatas* (L.) Lam.) is more important than the net photosynthetic rate and that yield is affected more by sink strength than source potential (Hahn, 1977; Wilson, 1977). Sweet potato vines, usually thought of only as a source, can also act as a sink and thereby compete with storage root production. An experiment was conducted to elucidate the relationships between sweet potato vines and the developing storage roots. As these relationships become better understood, production and breeding of sweet potato may become more efficient.

MATERIALS AND METHODS

Four replications of 4 sweet potato cultivars, 'Nemagold', 'Redmar', 'Jewel' and 'Centennial', were grown in a Norfolk sandy loam soil (fine-loamy, siliceous, thermic typic paleudults) near Salisbury, Maryland, USA (38° 22'N latitude). Spacing was 0.3 m between plants and 0.9 m between rows, resulting in a population of **ca** 36,000 plants per hectare. All plots received a total of 80-160-320 kg/ha of N, P_2O_5 and K_2O (1.6 mt of 5-10-20/ha) in 3 equal applications. The time and method of application were as follows: prior to planting, broadcast and incorporated; 2 weeks after transplanting, sidedressed in a band 15 cm from the row and 5 cm deep; 7 weeks after transplanting, top dressed over the row and cultivated in.

Five plant samples of each cultivar in each replicate were harvested at bi-weekly intervals beginning at 8 weeks after transplanting until the 20th week. Care was taken to obtain samples that had not been disturbed by previous sampling. Vines and storage roots were weighed and a sample was oven-dried (60°C) to determine the percentage of dry matter. The fibrous root system was not sampled since Enyi (1977) reported that the fibrous root system comprised only 2% of the entire root system. Therefore all references to root weight refer to storage root weight only. Dry weights were calculated as fresh weight x % dry matter.

RESULTS

The harvest index (dry weight basis) of all cultivars increased steadily throughout the growing season (Fig. 1) but decreased as the growing season progressed. The equations of the regression lines and their associated R^2 values are presented in Table 1. Al-

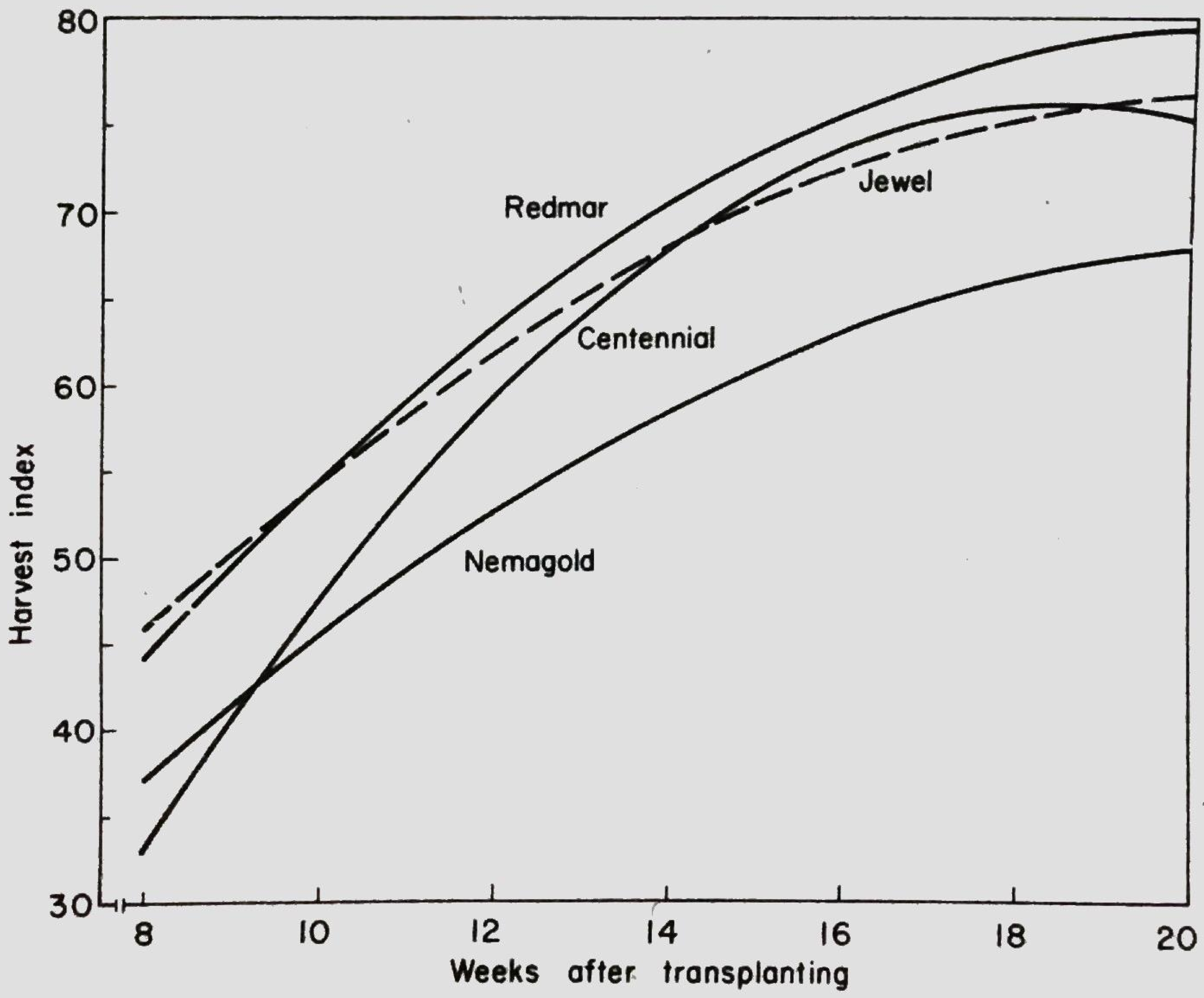

Fig. 1 Harvest indices of 4 sweet potato cultivars at successive sampling dates.

Table 1. Quadratic regression equations, with R^2 values, relating the predicted harvest index to sampling date for 4 sweet potato cultivars.

Cultivar	Equation[1]	R^2
Centennial	$y=15.1 + 19.5x - 1.56x^2$	0.987**
Nemagold	$y=26.9 + 10.7x - 0.70x^2$	0.961**
Redmar	$y=31.1 + 13.7x - 0.95x^2$	0.975**
Jewel	$y=36.0 + 10.6x - 0.68x^2$	0.986**

[1] Where y = predicted harvest index and x = sample no. (1 to 7).
** Significant at .01 level of probability.

though there were variations among the cultivars relative to one another in the early part of the growing season, differences among cultivars were more nearly constant during the later part of the season. Harvest of these plots would normally have occurred 14-16 weeks after transplanting since optimum root size (rather than maximum yield) determines harvest date in the USA.

Dry matter accumulation patterns of the vines and storage roots are presented in Figure 2 and the regression equations in Table 2. Total dry weight and root dry weight increased throughout the growing season, but decreased with each succeeding sample. Vine dry weight increased at a much slower rate and reached a maximum by the 16th week and then slowly decreased except in the case of 'Nemagold' where vine dry weight continued to slowly increase until the 20th week.

DISCUSSION

The pattern of change in harvest indices is similar to that reported by Lowe and Wilson (1974), showing greater changes among cultivars relative to one another early in the growing season than later. It is also apparent that early development of a high root/vine ratio does not necessarily result in higher yield, nor does a low root/vine ratio result in a poor yield. The final harvest index is also not closely related to root yield although Enyi (1977) reported a significant correlation in a year when vine growth was generally excessive.

Total and root dry weight accumulation patterns generally agree with those reported by Enyi (1977), Lowe and Wilson (1974) and Austin and Aung (1973) although the yields in the present study are generally higher. A decrease in the rates of accumulation near the end of the growing season was observed in 4 of 6 cultivars investigated by Lowe and Wilson (1974) and 6 of 7 and 6 of 8 cultivars studied by Enyi (1977) over 2 years. Since the plant is perennial and not subject to ripening or maturity, this phenomenon may be attributed to one or more of the several changes occurring near the end of the growing season. These include a reduction in both

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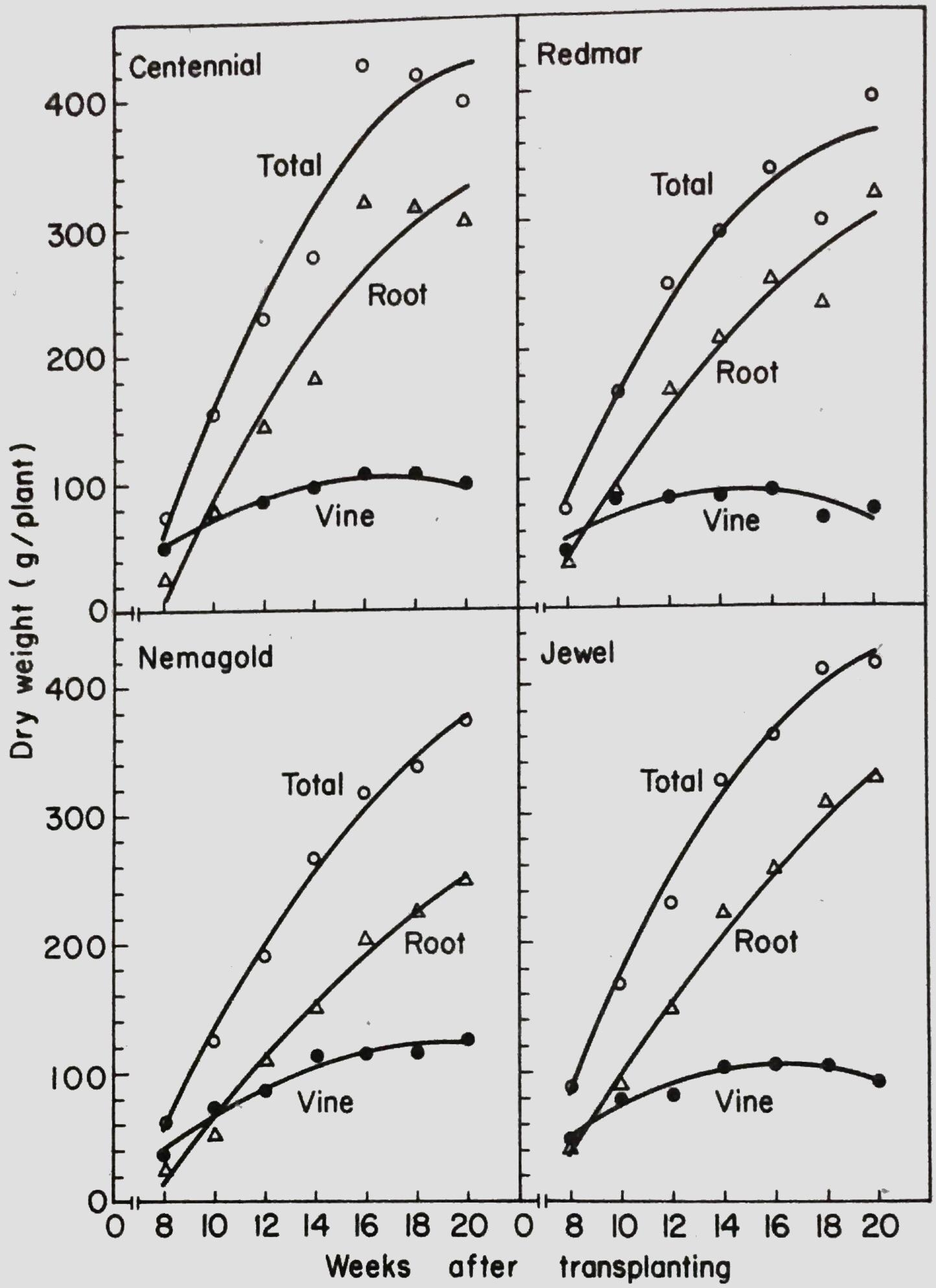

Fig. 2 Dry weight accumulation of 4 sweet potato cultivars at successive harvest dates (0 = total dry weight, Δ = root dry weight, ● = vine dry (weight).

daylength and average temperature, a reduction in leaf area and an increase in total respiration due to increased plant mass. Since daylength and temperature reductions are likely to be small in the tropics, it seems probable that reduced photosynthesis and/or increased respiration may be implicated as factors in this phenomenon.

The data on vine dry weight accumulation are in general agreement with those reported by Enyi (1977), and Lowe and Wilson (1974), but with some notable differences. In 3 culti-

Table 2. Quadratic regression equations, with R^2 values, relating dry matter accumulation of plant parts to sampling dates in 4 sweet potato cultivars.

Cultivar	Plant Part	Equation[1]	R^2
Jewel	Root	$y = -40.3 + 75.2x - 3.19x^2$	0.993**
	Vine	$y = 17.9 + 34.0x - 3.33x^2$	0.952**
	Total	$y = -22.4 + 109.3x - 6.52x^2$	0.992**
Nemagold	Root	$y = -40.0 + 56.1x - 2.01x^2$	0.990**
	Vine	$y = 6.3 + 37.0x - 2.95x^2$	0.977**
	Total	$y = -33.7 + 93.1x - 4.96x^2$	0.995**
Redmar	Root	$y = -34.1 + 73.1x - 3.65x^2$	0.955**
	Vine	$y = 27.2 + 27.2x - 3.10x^2$	0.650[ns]
	Total	$y = -6.9 + 100.3x - 6.75x^2$	0.938**
Centennial	Root	$y = -86.4 + 98.2x - 5.67x^2$	0.933**
	Vine	$y = 26.1 + 29.2x - 2.70x^2$	0.973**
	Total	$y = -60.3 + 127.4x - 8.37x^2$	0.944**

[1] Where y = predicted dry matter accumulation in grams and x = sample no. (1 to 7).
** Significant at .01 level of probability.
[ns] Not significant.

vars of the present study and in one year of Enyi's investigation, the maximum accumulation usually occurred after 14-16 weeks (14.2-16.3) while Lowe and Wilson (1974) reported maxima at about 12 weeks. The pattern of relatively small decline in vine dry weight was also reported by Agata (1981) and Enyi (1977) in one year, while Wilson and Lowe (1974) reported substantial declines in dry weight. Austin and Aung (1973) and Enyi (1977) in the other year reported increasing vine size throughout the season as with 'Nemagold' in the present study. The variety of vine growth patterns previously reported suggests that vine growth is more sensitive to growing conditions than root growth. It may be noted, however, that when vine weight decreases slowly during the later part of the growing season, root yield are usually higher than when vine weight continues to increase or decrease substantially.

It also seems likely that the patterns of leaf area index increase and decline as reported by Wilson (1977) and Milthorpe (1967) may not be appropriate for all environments.

It was noted in the present study that vine weight began to decrease in each cultivar at about the time when the harvest index reached 72-74 (except 'Nemagold'). Thus, the sink effect of the roots predominated over the sink effects of the vines when root dry weight reached slightly more than 2 times the vine dry weight. In one year of Enyi's (1977) study, the vine dry weight began to decrease at a harvest index of 54% ± 2%, indicating a similar relationship of vine and root sinks while in the other year, vine dry weight continued to increase throughout the season. A similar pattern was not observed in the data of Lowe and Wilson (1974) as it appears that vine dry weight reductions were controlled by external rather than internal factors.

'Nemagold' would seem to be an example of a variety where the vine sinks remain strong throughout the growing season, and where yield may have been reduced by the partitioning of greater amounts of assimilates to the vines ("sink limited"). 'Redmar', on the other hand, produced a high root/vine ratio early in the growing season and yield may have been limited by leaf area ("source limited").

This suggests that maintaining an optimum canopy (optimum being defined as the balance of source and sink effects of the canopy) might result in higher yield. In the present study, highest root yields were obtained in the 2 cultivars with intermediate vine dry matter accumulation while lower yields were noted when vine weight was smaller ('Redmar') or larger ('Nemagold') in proportion to root weight. Similar findings were reported by Haynes et al. (1967) in variety '049' which produced good yields without additional supplies of nitrogen. This variety had a LAI which increased rapidly to 3 then decreased to 1. When additional nitrogen was supplied, the LAI increased to nearly 4 and root growth was depressed. As the LAI dropped below 3, growth rate began to increase but root dry weight never equalled that of the treatment without additional nitrogen. A second cultivar, 'C9', had a lower yield and LAI without additional nitrogen, but demonstrated a considerable increase in both LAI and root yield when nitrogen was applied.

Control of vine size relative to root size may be accomplished in several ways depending on climate and soil conditions. Nitrogen applications may be expected to increase the canopy (Haynes et al., 1967). Tsuno and Fujise (1964), however, found that potassium applications suppressed excessive vine growth even under high nitrogen conditions. Application or withholding water may also be practical, either separately or in combination with adjusting K ratios. Although the optimum balance between vine weight and root weight will probably be different for different cultivars, and in different locations and seasons, certain generalizations may be possible with further research.

Although discussions on whether sweet potato, in general, is source or sink limited are useful, such generalizations are not particularly helpful in solving the problem of identifying the yield limiting factors within a given management system. It seems likely that a given planting may be either source or sink limited (defined as storage roots) depending on cultivar, environment and canopy management. The present emphasis on canopy management arises from the fact that more is known about canopy management than storage root management. If a balance is to be maintained, however, greater attention needs to be given to studies on the development and growth of storage roots.

It is also important to note that optimum root/vine ratios vary according to cultivar and time, and that absolute vine weight at any point in the growing season is not as important as the dynamic balance between the roots and the vines.

The present study may also have implications for sweet potato breeders. Yield gains realized through selection under a given management system are likely to be the result of identifying clones which respond to that system with an optimum balance of root and vine sinks. 'Jewel' and 'Centennial' in the present study may be considered as representative of such a response. New cultivars, selected under that management system are likely to respond similarly to 'Jewel' and 'Centennial'. This may result in "yield plateaus". A change in management system is likely to result in lower yields for such cultivars.

Increasing or decreasing the level and kinds of inputs may be expected to produce a change in the balance of root and vine sinks. Yields of the best cultivars selected under the modified management system may exceed yields of the best cultivars under the previous system.

Before changing the management under which new clones are selected, a breeder should try to identify clones which respond sub-optimally to the existing system. Clones responding similarly to 'Redmar' in the present study may be considered likely to respond positively to inputs which are known to increase the canopy. Clones responding like 'Nemagold' may respond with increased yields to reduced inputs. Watanabe (1979) also concluded that various cultivars were better adapted to either high input or low input management systems. Greater yields in the modified system would prove that the present management system may be limiting genetic gains.

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