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Influence of time of spear harvest on the annual growth cycle of asparagus

A report prepared for the
New Zealand Asparagus Council

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CONTENTS

Page

1 EXECUTIVE SUMMARY 1

2 INTRODUCTION 3

3 METHODS 4

4 RESULTS 5

4.1 Crop growth in 1994/95 5
4.2 Spear yield in spring 1995 6
4.3 Number of buds per crown 6
4.4 Number of roots per crown 7
4.5 Fern dry weight 7
4.6 Root dry weight 7
4.7 Total dry matter balance 9

5 CONCLUSIONS AND RECOMMENDATIONS 11

6 ACKNOWLEDGEMENTS 12

1 EXECUTIVE SUMMARY

Asparagus has a complicated annual growth cycle. The goal of our research is to provide a sound basis for making good decisions about crop management by improving our understanding of the cycle

This report presents results from the first year's measurements in a field experiment in which the annual growth cycle was changed deliberately by varying the time of fern growth and spear harvest during the season. Four treatments were applied to an established crop:

1. undisturbed annual cycle - no spear or fern harvest,

2. spring spear harvest, then fern growth,

3. summer spear harvest, spring and autumn fern growth, and

4. autumn spear harvest, spring and summer fern growth.

The treatments had large effects on both above and belowground growth of the crop, and on spear production in the following spring. In all cases, the crop's annual dry matter balance was dominated by fern and root growth - spear yield was a very small part of the balance. The 'spring harvest' treatment (2.) was considered the most appropiate management regime because it met all of the following desirable crop management objectives:

- it had the best balance between the amount of total dry matter produced and the proportion of it allocated to spears,

- at the start of winter it had a fully recharged root system (buds and dry matter) for the next season, and

- it appeared set to maintain long-term crop performance by ensuring a dynamic, growing root system in terms of producing and using buds and storage roots, and dry weight.

The 'no harvest' treatment (1.) produced much higher total dry matter than the 'spring harvest' one, but there was too much allocated to ferns and not enough to spears. The 'summer and autumn harvest' treatments (3. and 4.) failed to meet all the objectives.

Results suggest that the common management aim of stimulating vigorous fern growth is not desirable. Although fern growth and yield were relatively low in the 'spring harvest' treatment, this condition had no adverse effect on root system performance or on spear yield in the following season. More research is needed to define the duration and amount of fern growth needed for optimum short- and long-term crop performance.

2 INTRODUCTION

Asparagus has a complicated annual growth cycle. Spear production is the result of a complex sequence of physiological processes. Events during fern growth, when spear yield potential is established by the formation of new buds and accumulation of reserves in the storage root system, are related very indirectly to spear production during the following season. This makes it difficult to understand the effects of weather and crop management on spear yield.

The goal of our research is to provide a sound basis for making good decisions about crop management by improving our understanding of the growth cycle. To achieve this, we are using two complementary approaches: development of a model of the growth physiology of asparagus, and field experiments to provide information for developing and testing the model.

Our objective in a field experiment at Lincoln is to change the annual growth cycle of the crop deliberately by varying the time of fern growth and spear harvest during the season. In this report we present results from the first complete cycle of measurements in 1994/95 which show the effects of these treatments on the root system and spear yield in the following season. The results highlight some interesting features of the crop's growth and have important implications for crop management.

3 METHODS

Jersey Giant Syn 4 crowns were planted in October 1992, and managed for two years using standard practices for the establishment phase.

In 1994/95, four spear harvest and fern management treatments were applied:

1. undisturbed annual cycle - no spear or fern harvest,

2. spring spear harvest, then fern growth,

3. summer spear harvest, spring and autumn fern growth, and

4. autumn spear harvest, spring and summer fern growth.

There were four replicates of each treatment - a total of 16 plots.

We excavated four plants from each plot at regular intervals during the season and measured:

- numbers of buds and storage roots per crown (old ones from last season, and new ones produced in the current season),

- root dry weight, and

- fern dry weight during periods of fern growth.

We also measured spear yield every second day during the harvest period for each treatment.

In late 1995, the spears in all plots were harvested in a normal spring harvest to measure the effects of the management treatments during the previous season. Spears were harvested from an area in each plot where an end-of-season fern cut had been made on 1 June 1995.

4 RESULTS

4.1 Crop growth in 1994/95

The treatments caused large differences in fern and spear yield differences(Table 1). Fern growth was vigorous in all except the 'spring harvest' treatment until the ferns were cut either on 6 December for the 'summer harvest' (3290 kg/ha), on 6 March for the 'autumn harvest' (5400 kg/ha), or at the end of autumn (9200 kg/ha) in the 'no harvest' treatment. Fern yield was only 1860 kg/ha in the 'spring harvest' treatment.

Spear dry matter yield varied from 0 to 375 kg/ha (or 4140 kg/ha fresh weight). Spear yield was highest in the 'spring harvest' treatment, even though harvest started late because of low temperatures, and it was lowest in the 'autumn harvest' treatment, which, in retrospect, should have started earlier.

Total aboveground dry matter yield for the season, and its separation between fern and spear growth, was very variable among the treatments, ranging from about 2200 to 9200 kg/ha.

Table 1: Spear and fern yields in the four treatments in 1994/95.

	No harvest	Spring harvest	Summer harvest	Autumn harvest
Spear harvests				
Dates	--	19 Oct - 21 Dec	14 Dec - 6 Feb	13 Mar - 28 April
Days	--	63	54	46
Spear yield (kg/ha)				
Total	--	4140 (375 DM)	1570 (142 DM)	490 (44 DM)
% Export grade	--	15	1	4
Fern yield DM (kg/ha)				
6 Dec 1994	--	--	3290	--
6 Mar 1995	--	--	--	5400
29 Mar 1995	9200	1860	150	--
Total DM (kg/ha)	9200	2235	3582	5444

4.2 Spear yield in spring 1995

Treatments in the previous season caused very large spear yield differences in spring 1995. Dry matter yield varied from 110 to 980 kg/ha (or 1200 to 10 880 kg/ha fresh weight) (Table 2). Spear yield was highest following the 'no harvest' and 'spring harvest' treatments, reduced somewhat by the 'autumn harvest', and reduced severely by the 'summer harvest' in the previous season. The 'spring harvest' and 'no harvest' spear yields were similar, even though their fern growth was greatly different (1860 and 9200 kg/ha, respectively). The 'spring harvest' treatment was easily the most efficient producer in terms of the proportion of total dry matter produced that was harvested as spears.

Table 2: Spear yields in the four treatments in spring 1995 and total dry matter yields in both seasons.

	No harvest	Spring harvest	Summer harvest	Autumn harvest
1994/95 Total DM (kg/ha)				
	9 200	2 235	3 582	5 444
1995/96 Spear yield (kg/ha), 79 day harvest from 25 Sep to 13 Dec				
Total	10 200 (920 DM)	10 880 (980 DM)	1200 (110 DM)	7 230 (650 DM)
% Export Grade	24	23	10	23
1994/95 and 1995/96 Total DM (kg/ha)				
	10 120	3 215	3 692	6 094
% of total DM harvested as spears				
Export	2	7	<1	3
Total	9	30	3	11

4.3 Number of buds per crown

The number of old buds per crown (i.e. those produced in the previous season) declined as buds were used for spear and fern production (Fig. 1). The only obvious treatment effect was an accelerated decrease in bud numbers in the 'spring harvest' as buds were used to produce spears.

Production of new buds started in late December, and the treatments caused large differences in the pattern of production. The 'no harvest' and 'autumn harvest' treatments had a similar effect. New bud production did, however, stop in the 'autumn harvest' treatment during spear harvest. In the 'spring harvest', the start of new bud production was delayed by about three weeks. It then proceeded at the same rate as in the first two treatments. These three treatments all had about 50 new buds per crown by the end of the season. New bud production was severely reduced by the 'summer harvest'. There was a net gain of buds per crown during the season in all treatments except the 'summer harvest' one.

4.4 Number of roots per crown

The patterns of root loss and gain were similar to those for the buds (Fig. 2). The main difference was that losses of old *roots were negligible* in the 'no harvest' and 'autumn harvest' treatments while about 50 old roots per crown were lost in the 'spring harvest' one. However, the total number of roots had increased by the end of the season due to the production of new roots. There was severe loss of old roots and negligible production of new roots in the 'summer harvest' treatment.

4.5 Fern dry weight

The effects of the treatments on patterns of fern dry matter yield were predictable (Fig. 3). Main features of the results were:

- the large amount of biomass produced compared with the spear yields,
- the relatively low fern dry weight production following the 'spring harvest, and
- the large loss of fern dry weight from about the end of March, presumably caused by both senescence losses and translocation of resources to the storage roots. (Note that fern yield results in Table 1 were taken from the harvest on 29 March, which was closest to when fern growth peaked.)

4.6 Root dry weight

Root dry weight declined until about mid-December in all treatments due to use of resources for spear and/or fern growth (Fig. 4). In the 'no harvest' and 'autumn harvest' treatments the decline was followed by a sustained increase in root dry weight during summer and autumn that coincided with the production of new buds and roots (Figs 1 and 2). Fern and spear harvests in the 'autumn harvest' treatment caused only a small

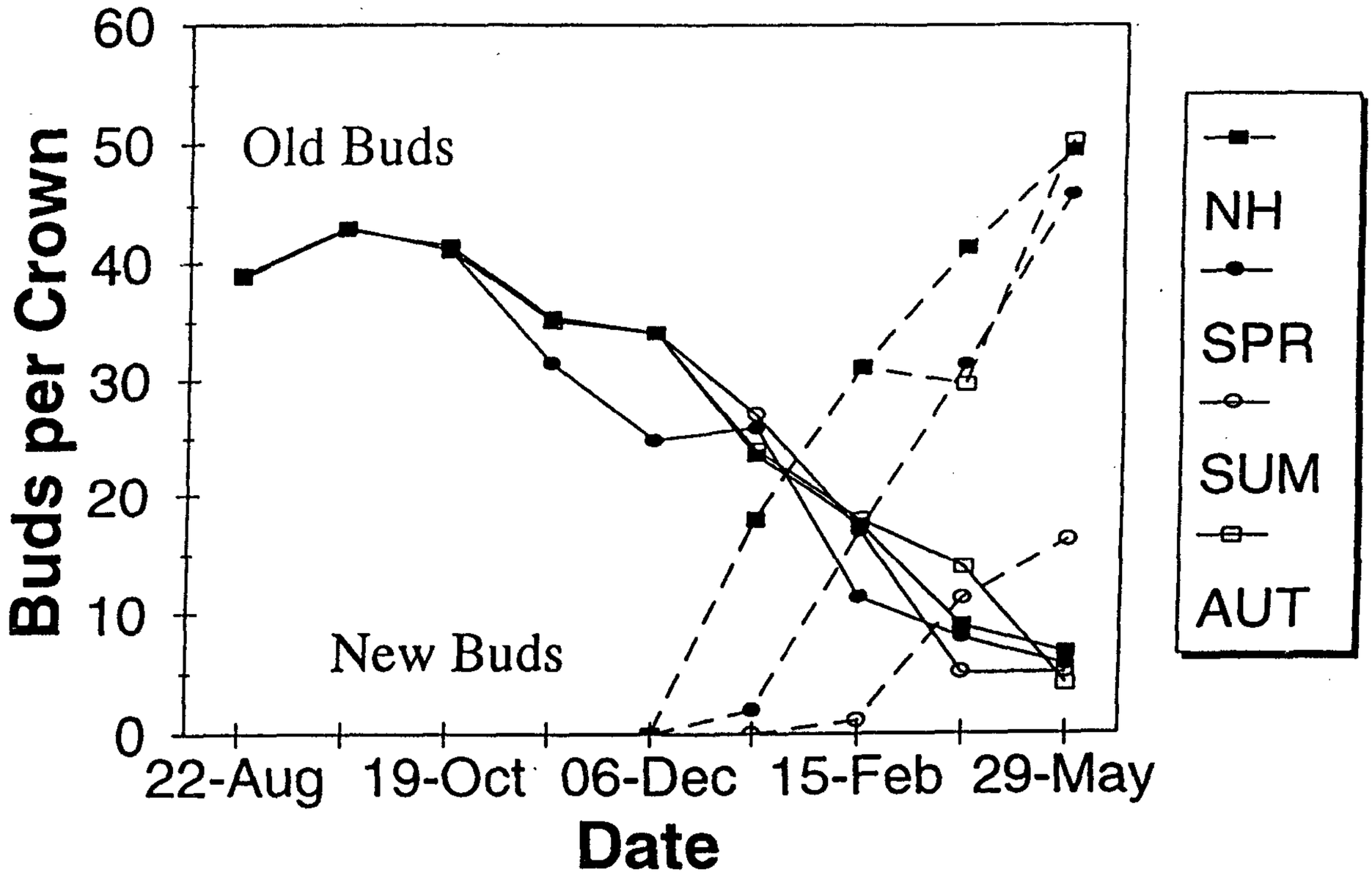

Figure 1: Numbers of old and new buds in four asparagus spear harvest and fern management treatments.
NH - no harvest, SPR - spring spear harvest, SUM - summer spear harvest, AUT - autumn spear harvest.

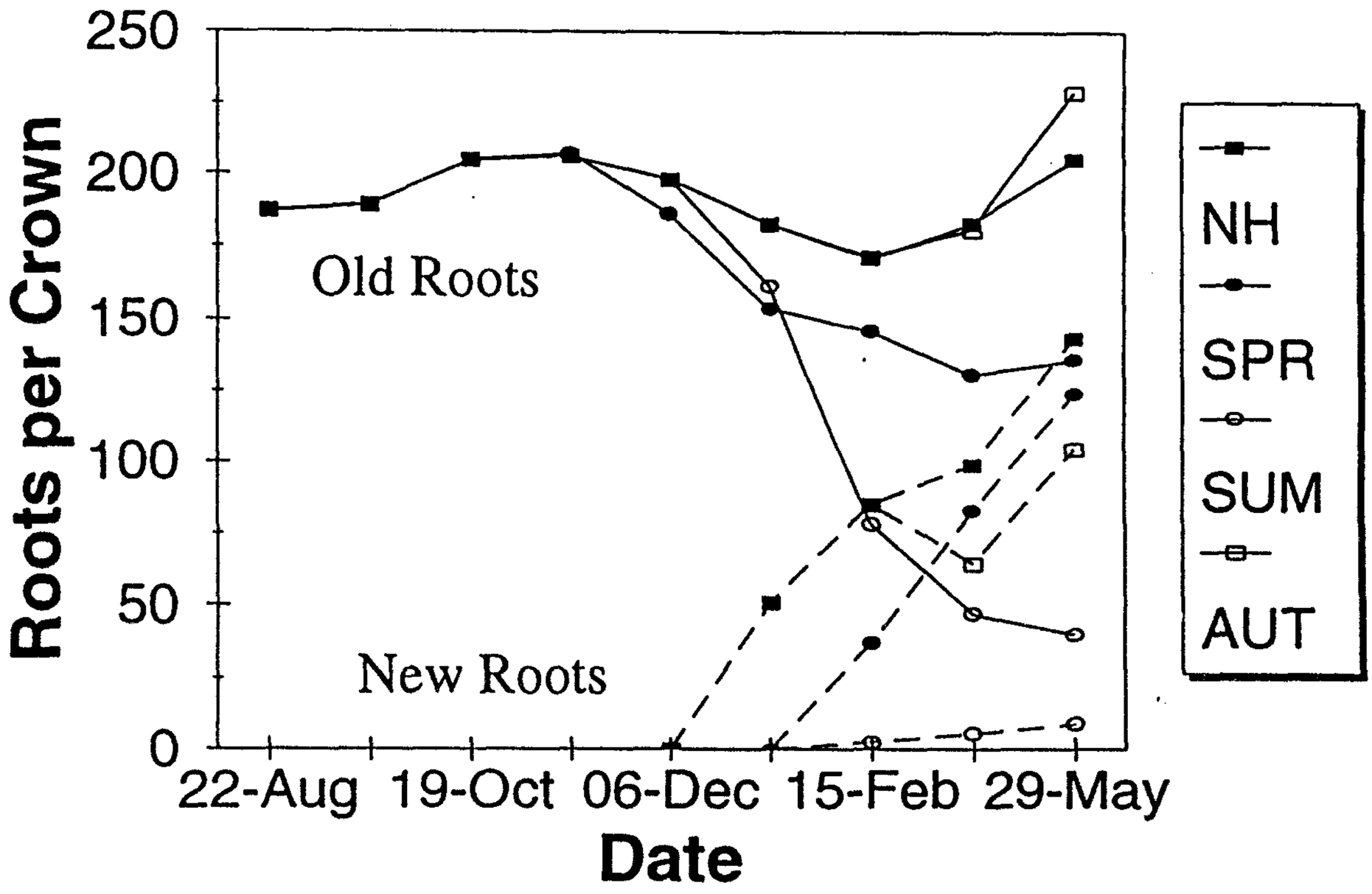

Figure 2: Numbers of old and new roots in four asparagus spear harvest and fern management treatments.
NH - no harvest, SPR - spring spear harvest, SUM - summer spear harvest, AUT - autumn spear harvest.

reduction in root weight. In the 'spring harvest' treatment, the start of root dry weight accumulation was delayed by about three weeks and then proceeded at the same rate as in the first two treatments. These three treatments all had about 7-8 t/ha of root dry weight at the end of the season. In the 'summer harvest' treatment, root dry weight declined progressively throughout the season, ending with a depleted root system at about 2 t/ha.

Table 3: Total dry matter balance (kg/ha) in the four treatments in 1994 and 1995.

	No harvest	Spring harvest	Summer harvest	Autumn harvest
1994/95				
Spears	--	375	142	144
Fern	9 200	1 860	3 440	5 400
Roots	8 100	7 340	1 780	7 090
1995				
Spears	920	980	110	650
Total	18 220	10 555	5 472	13 284
Spears				
Total	920	1 355	252	794
% of Total	5	13	5	6

4.7 Total dry matter balance

At the start of the experiment, in August 1994, all treatments had a total root dry weight of about 5 t/ha (Fig. 4). In all treatments except the 'summer harvest' one, in which the root system was depleted to only 1.78 t/ha, the sizes of the root systems increased during the experiment (Table 3). Total dry matter production by the end of the 1995 spear harvest ranged from 5.47 t/ha in the 'summer harvest' treatment to 18.22 t/ha in the 'no harvest' treatment. The 'autumn harvest' treatment produced more dry matter than the conventional 'spring harvest' one.

Spear yields depended on the partitioning of the total among roots, ferns and spears, and this differed greatly among the treatments. Both spear yield and the proportion of total yield that went into the spears were highest in the 'spring harvest' treatment, even though it only had the third highest total yield. The proportion of total yield that went into spears was similar for the other three treatments.

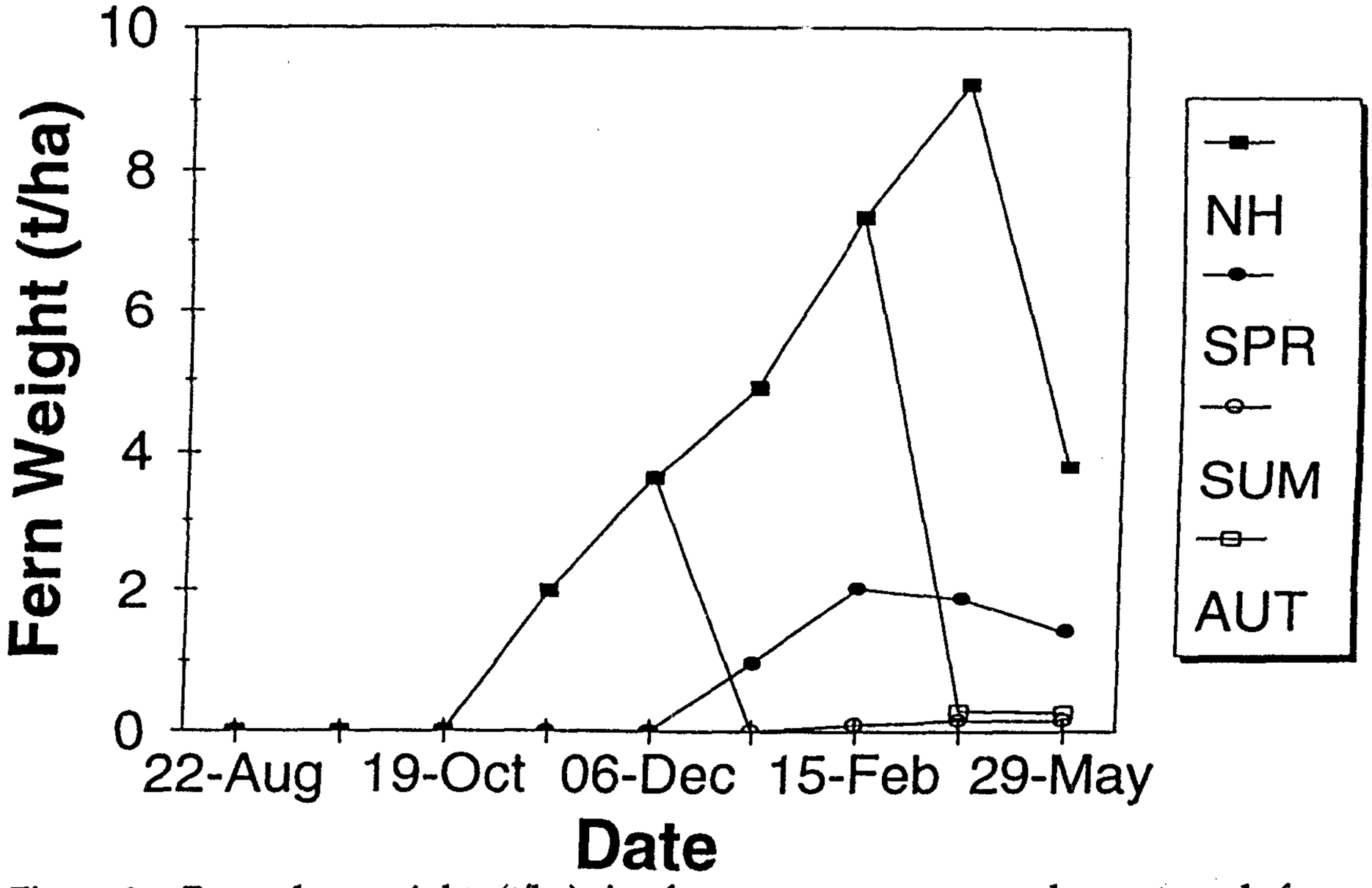

Figure 3: **Fern dry weight (t/ha) in four asparagus spear harvest and fern management treatments.**
NH - no harvest, SPR - spring spear harvest, SUM - summer spear harvest, AUT - autumn spear harvest.

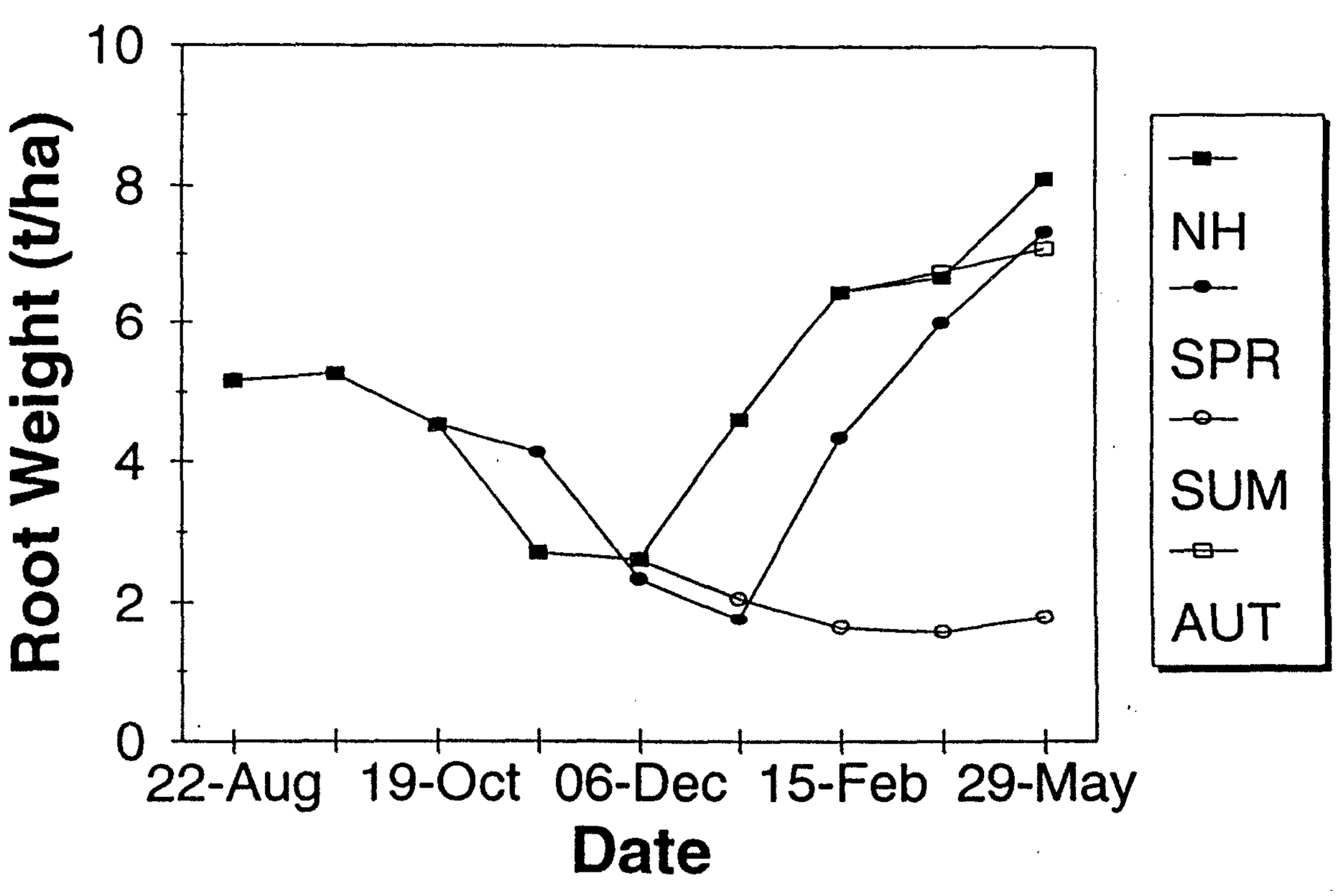

Figure 4: **Storage root weight (t/ha) in four asparagus spear harvest and fern management treatments.**
NH - no harvest, SPR - spring spear harvest, SUM - summer spear harvest, AUT - autumn spear harvest.

5 CONCLUSIONS AND RECOMMENDATIONS

The fern growth and spear harvest treatments had large effects on the annual cycle of asparagus. Aboveground measurements showed that fern growth was much greater than spear growth, and that spear yield was a very small part of the crop's dry matter balance. However, aboveground information only tells part of the story about the crop's growth. Cycles of depletion and storage in the root system are important indicators of crop performance in both the short and long term, and they were also strongly affected by the treatments.

Our results suggest that the objectives of fern management and timing of spear harvest should be to:

- achieve the best balance between the amount of total dry matter produced and the proportion of it going to spears,
- at the start of winter, ensure a fully recharged root system (buds and dry matter) for the next season, and
- maintain long-term performance of a crop by ensuring a dynamic, growing root system in terms of production and utilisation of buds and storage roots, and of dry weight. Results showed that there was close synchronisation between patterns of bud, root and dry weight depletion and renewal.

In our experiment, only the 'spring harvest' treatment achieved all of these objectives. Although its fern yield was very low, this condition had no adverse effect on root system performance or on spear yield in the following season. The 'no harvest' treatment produced high total dry matter, but there was too much allocated to ferns and not enough to spears. The 'summer and autumn harvest' treatments failed to meet all of the objectives.

Results suggest that the common management aim of stimulating vigorous fern growth is not desirable. More research is needed to define the duration and amount of fern growth needed for optimum short- and long-term crop performance.

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