Project Title:	***Alstroemeria*: Evaluation of irrigation/nutrition requirements relative to stage of growth for a range of commercially grown varieties of *Alstroemeria***
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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature .... Miss Margaret Scott
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PRACTICAL SECTION FOR GROWERS

Objectives and background

The production of flowering stems from commercially grown *Alstroemeria* is characterised by two main flushes in the spring and summer period. As temperatures increase in summer, rhizomes become dormant producing fewer stems over the autumn and winter. It would clearly be advantageous to have more control over this flushing pattern, and in particular to increase productivity in the potentially more rewarding times of the year (i.e. October to March).

Dutch growers use soil cooling to extend the season of flower production. However, this can be costly to install and may be successful with selected varieties only. UK growers were keen to establish if alternative cultural techniques could be identified which could be applied to soil grown crops to assist in making flushing patterns more even, or at least improve productivity when prices are higher.

Previous HDC funded work (PC 33a, ADAS 1993) indicated that by controlling irrigation applied using tensiometers, the number of marketable stems produced in the autumn increased. The benefit of these treatments was attributed to a soil cooling effect as a result of the increased level of irrigation on tensiometer controlled plots. PC 33b was set up to investigate this theory further by applying either standard or increased levels of irrigation during the summer period (March to October). These treatments were also combined with two nutritional regimes as detailed below:

Treatment code	Irrigation treatment	Nutrition treatment
A	Standard	High
B	Standard	Standard
C	High	Standard
D	High	High

Key

Irrigation treatments (March - October period only):

Standard = as required for standard commercial practice.

High = standard irrigation plus an extra 25% given with each application

Nutrition treatments:

Standard = 150 mg/l N : 200 mg/l K_2O (October - March)
= 200 mg/l N : 200 mg/l K_2O (March - October)

High = 200 mg/l N : 200 mg/l K_2O (October to March)
= 350 mg/l N : 200 mg/l K_2O (March to October)

Trials were planted in June of 1993, treatments commenced in October 1993 and records from January 1994. Flushing patterns were monitored over the following three years through weekly records of flowering stems produced and a record of thinnings removed from each treatment.

Summary of Results

Trends in production for each variety over a typical production cycle have been characterised to assist in the prediction of responses of other varieties with similar production patterns to the treatments investigated:

Annual Production/m² bed area*

	Total marketable Stems	Stems with up to 2 pedicels or less than 24" long	Semi aborted or aborted	Number of Thinnings	Returns (£/m²/annum)
Cavalier					
1994	321	21	11	146	92.67
1995	302	21	45	239	78.70
1996	240	29	41	197	63.57
Total	**863**	**71**	**97**	**582**	**234.94**
Libelle					
1994	415	56	10	190	118.22
1995	450	87	50	396	124.50
1996	366	70	30	367	101.23
Total	**1231**	**213**	**90**	**953**	**343.95**
Samora					
1994	553	17	5	500	151.75
1995	528	12	7	834	142.06
1996	533	12	4	662	146.34
Total	**1614**	**41**	**16**	**1996**	**440.15**
Wilhelmina					
1994	521	30	22	102	148.53
1995	470	40	114	424	130.61
1996	619	42	47	492	175.16
Total	**1610**	**112**	**183**	**1018**	**454.30**

* these figures do not take account of path spaces.

Samora and Wilhelmina produced the highest number of marketable stems, but Wilhelmina required less labour inputs for thinning plots. Although it is generally accepted that the crop should be replanted after three years there was no decline in yield with time for either of these varieties although productivity of both Cavalier and Libelle did appear to decline in the third year of the trial.

The influence of the four treatments was examined by comparing the patterns in production from the three treatments with the standard production regime, and by calculating annual returns for each treatment based on prices recorded in 1995/96. The results from these analyses indicate that response to treatment was variety dependent:

Comparison of the financial returns (£/m² bed space*) from each treatment.

		1994	1995	1996	Total
Cavalier					
	A	86.46	75.44	53.54	215.44
	B	94.67	79.25	73.86	247.78
	C	85.85	86.07	76.39	248.31
	D	103.70	74.04	50.50	228.24
Libelle					
	A	119.37	137.97	109.31	366.65
	B	120.33	114.89	102.01	337.23
	C	112.08	112.48	94.68	319.24
	D	121.10	132.65	98.91	352.66
Samora					
	A	161.03	146.55	160.88	468.46
	B	148.70	133.79	128.99	411.48
	C	150.01	146.31	153.76	450.08
	D	151.25	141.58	141.72	434.55
Wilhelmina					
	A	140.54	156.45	177.93	474.92
	B	149.70	108.17	167.15	425.02
	C	160.98	137.51	187.03	485.52
	D	142.91	120.30	168.53	431.74

* these figures do not take account of path spaces.

Key

A: Standard irrigation, High nutrition
B: Standard irrigation, Standard nutrition
C: High irrigation, Standard nutrition
D: High irrigation, High nutrition

Looking at common factors, which favoured growth over each of the three years of the trial, it was possible to identify the most favourable regime for each variety:

CAVALIER

1994 - High irrigation and high nutrition
1995 & 1996 - High irrigation and standard nutrition
Increase in irrigation recommended.

LIBELLE

1994 – No clear improvement above standard production
1995 & 1996 - Standard irrigation and high nutrition
Increase in nutrition recommended.

SAMORA

1994 - Standard irrigation and high nutrition
1995 - Standard irrigation and high nutrition, high irrigation and standard nutrition
1996 - Standard irrigation and high nutrition
Increase in nutrition recommended.

Wilhelmina

1994 - High irrigation and standard nutrition
1995 - Standard irrigation and high nutrition
1996 - High irrigation and standard nutrition
Increase in irrigation recommended.

This trial has examined a limited number of treatments so far and there is clearly scope to look at both irrigation and nutrition in more detail. For example it was only possible to compare one level of nutrition and irrigation and whilst the results have indicated where improvements may be possible through manipulating one or both of these factors, further data would be required to give more precise recommendations of irrigation or nutrition levels. Data collected from monitoring soil moisture and nutrition, as presented in the main report, can be used as a guideline to the levels achieved with the treatments investigated. Records of soil temperature indicated that the high irrigation treatments did not result in a soil cooling effect as was suggested in earlier work.

Action points for growers

Experimenting with existing irrigation and nutrition regimes may yield benefits. Growers would need to compare their own varieties against those examined in the current trial to determine whether manipulating nutrition or irrigation would provide the greatest improvements. Investment in equipment to monitor soil moisture levels would assist in understanding better the needs of the crop. Records provided in this report indicate the soil tensions that might be expected from high and standard irrigation treatments.

Practical and financial benefits

It is not possible to provide firm recommendations for irrigation or nutrition regimes based on the current trial. This is partly due to the wide variation recorded between varieties and also because it was only possible to examine a limited number of treatments. The work has however demonstrated the potential benefits that may result from further investigation of nutrition and irrigation for *Alstroemeria* and furthermore has identified which of these factors may have the greatest influence on four commercial cultivars.

INTRODUCTION

Alstroemeria species, along with their improved cultivars and hybrids, have become important cut flowers in recent years. It has been suggested that the currently available commercial hybrids have different physiological responses owing to the hybridisation of species from different climatic regions. For example one parent *Alstroemeria aurantiaca*, is found in moist, cool, semi-woodland habitats, whereas other parents such as *A. pelegrina* and *A. violacea* are found in dry, warm, desert-like areas. It is not surprising, therefore, that different types of *Alstroemeria* demand specific cultivation techniques, since parentage can play an important role in determining the plants response to environmental stimuli. The effect of temperature and photoperiod have been the main targets of research programmes in attempts to control flowering relative to time of year and market demands. Problems remain, however, with patterns in flowering of many cultivars produced in the UK. As identified in the HDC funded project PC 33 (Wilson, 1994), the production of flowering stems typically peaks in the spring and early summer period in the UK. High temperatures experienced during the summer, however, induce dormancy in the rhizomes, reducing the number of stems produced over the autumn period. These peaks and troughs in production have a significant impact on market prices. It is therefore desirable to determine a method of controlling the production of flowering stems to give a more even year round supply, or at least to increase productivity during the periods of the year when market prices improve.

Varietal response to irrigation and nutrition and how these factors can be manipulated at certain stages of crop development in order to stimulate growth and optimise flower production is one area of Alstroemeria production on which little information is available. All HDC funded project (PC 33a) was carried out by ADAS to examine the response of flushing patterns to controlling the application of irrigation water using soil tensiometers. Increasing the amount of water applied to tensiometer controlled plots with the aim of stimulating the end of the dormancy period, successfully increased the number of flowering stems produced by the variety Eleanor in the following September and October period. This shift in production of flowering stems was thought to be a result of the cooling effect that the increase in irrigation water supply had in preventing rhizome dormancy. It was therefore considered appropriate to examine in more detail the influence that high irrigation regimes may have on the flushing patterns on a range of commercially grown varieties and combine with this some preliminary observations of the effects of different nutritional regimes.

Finally, since a wide range of varieties are grown commercially and more will be introduced in the future, it is appropriate to classify the responses of the varieties assessed to season. This may enable prediction about the responses of other varieties with similar trends in seasonal production to one of the varieties included in the current trial (and hence make the data more widely applicable).

OBJECTIVE

To evaluate the effect of irrigation/nutrition regimes on crop development and flower production for a range of commercially grown varieties of *Alstroemeria*.

MATERIALS AND METHODS

Treatments

Main Trial

Treatments commenced in October 1993 (once the crop had become established) and comprised the following for irrigation/nutrition regimes:

1. Standard irrigation, high nutrition.
2. Standard irrigation, standard nutrition.
3. High irrigation, high nutrition.
4. High irrigation, standard nutrition.

Where:

Standard irrigation	=	normal commercial practise, delivering water according to incident solar radiation.
High irrigation	=	Delivering irrigation at the same intervals as the standard regime but increasing the volume delivered by 25% during the period March to October only (as per standard treatment from October until March).

Details of actual water applied to each treatment are presented in Appendix I.p.45

Standard nutrition	=	150 ppm N : 200 ppm K_2O - October to March
		250 ppm N : 200 ppm K_2O - March to October
High nutrition	=	200 ppm N : 200 ppm K_2O - October to March
		350 ppm N : 200 ppm K_2O - March to October

These treatments were evaluated on the following four varieties in unreplicated plots:

Cavalier
Libelle
Samora
Wilhelmina

Observation Trial

Since treatments were having little apparent impact on the progress of the crop as periodically reviewed in 1994, two additional treatments were included in the guard beds to examine the impact of wider extremes of irrigation treatments on crop production. These commenced from March 1995 and were as follows:

'Dry' irrigation	=	Delivering irrigation at the same intervals as the standard regime above, but decreasing the volume applied on each occasion by 50% during the period March to October only (as per standard treatment from October to March).
'Wet' irrigation	=	Delivering irrigation at the same intervals as the standard regime above, but increasing the volume applied on each occasion by 50% during the period March to October only (as per standard treatment from October to March).

The standard feed as used in the main trial was applied to both observation treatments.

The trial layout is illustrated in Appendix II, p.52.

Cultural Details

Experimental plots were steam sterilised and base fertiliser applied according to MAFF RB 209 recommendations (MAFF 1988). Plots were then planted with potted plants of Wilhelmina and Cavalier on 8 July 1993 and of Libelle and Samora on 21 July 1993 (supplied by the commercial propagators Van Staaveran Ltd, Kunst, and Parigo Ltd) and covered over with a 5cm-depth peat mulch. A drench of furalaxyl (as Fongarid at 1g/l and 5 litres per m^2) was applied one week after all plots had been planted (30 July 1997).

All plots were given standard irrigation and nutrition to aid initial establishment before commencing treatments on 1 October 1993. A set point temperature of 12°C during the day and 8°C at night with venting 2°C above set point was maintained throughout the trial. Daylength and light intensity was maintained as ambient throughout the trial.

Pest and disease levels were regularly monitored and treated as necessary using standard commercially available pesticides as follows:

Caterpillars:	*Bacillus thurigiensis* (as Bactospeine at 1 g/l) or cypermethrin (as Ambush C at 1 ml/l)
Aphids:	Pirimicarb (as Piramor at 0.5 g/l)
Slugs:	Methiocarb (as Draza pellets)

Assessments

The following crop records were taken:

i. Number of harvested stems graded according to stem length and number of pedicels as follows:

   Stem length
   Over 32 inches
   32 - 24 inches
   Under 24 inches

   Pedicel number
   5 or more pedicels
   4 pedicels
   3 pedicels
   2 or less pedicels

ii. Number of aborted and semi-aborted stems.

iii. Number of stems removed by thinning.

All records are expressed per m² of bed area (i.e. pathways not accounted for).

In addition, soil temperature and moisture status of treatment were monitored using temperature probes attached to datalogging equipment and soil tensiometers at 10 and 20cm depths.

Results

Given the large data set collected over this three-year trial the production of stems from each treatment has been categorised into three main groups for clearer presentation. These are as follows:

i.	Total Marketable Stems	=	Stems over 24" in length with 3 or more pedicels
ii.	Short/Low Quality Stems	=	Stems less than 24" in length or with 2 or less pedicels
iii.	Aborted and Semi Aborted Stems		
iv.	Vegetative stems removed for thinning the plot		

The trial was conducted on unreplicated plots and hence data will be examined according to relative trends rather than statistical analysis. The figures representing the data in the following summary have been presented in two ways. One set of figures simply represents the number of stems within each category harvested each month. The others represent differences between the number of stems harvested from each treatment each month relative to the number of stems harvested from the standard treatment (i.e. by subtracting the number collected from the standard plot from that of each treatment plot). These latter figures therefore demonstrate how trends in production were affected by treatment in comparison with standard commercial practise.

1 Seasonal effects on crop production

All figures of seasonal trends are presented in Appendix III, p.54.

1.1 Seasonal effects on production of marketable stems

Cavalier

In all three years of the trial, production of total marketable stems peaked in May with a second peak later in the summer (figure 1 Appendix III, p. 55). The second peak occurred in August in 1994 and 1996 but occurred in July in 1995, when the weather during the summer period was hotter and brighter than average (see Appendix IV, p.87).

Production of marketable stems was more uniform in 1994 and from February onwards, was generally in excess of 20 stems/m^2 peaking in May at 74 stems/m^2. In 1995 there were greater fluctuations in the pattern of production which peaked at 112 stems/m^2 in May for high irrigation treatments and fell to a low of 1-10 stems/m^2 in January to March and in October to December for majority of treatments. A similar pattern was noted in 1996 where the peak of production was on average lower at 56-81 stems/m^2 dropping to 1-13 stems/m^2 during the winter months.

The total annual production of marketable stems declined with time dropping to 240 stems/m^2 in 1996 from 321 stems/m^2 in 1994 (table 1).

Libelle

As with Cavalier, there were two main production peaks occurring in May and August in all three years (figure 2, Appendix III, p.56). Production of marketable stems was also more uniform in 1994 than in the following two years (i.e. with smaller production peaks but also higher numbers of stems produced between the peak periods).

Total annual production of marketable stems also decreased with time (table 1) but overall was higher than that of Cavalier.

Samora

This variety was more productive in terms of total marketable stems than both Cavalier and Libelle as indicated by monthly figures (figure 3, Appendix III, p.57) as well as total annual production (table 1). Two peaks in production occurred in 1994, the first in June (at 95-105 stems/m^2) and the second in August (at 105-140 stems/m^2). As time progressed however these peaks became less pronounced to the point in 1996 where production was consistently high between the months of April and August (with around 56-120 stems/m^2 per month depending on treatment). Productivity was, however, particularly poor in the November and December period of both 1995 and 1996 for this variety (when prices are much more favourable).

Total annual production remained fairly stable throughout the three years of the trial and showed no indication of decline in the third year of production.

Wilhelmina

This was the only variety not to have two peaks in production in 1994, and was also unusual in having very different production patterns in each year of the trial (figure 4, Appendix III, p.58).

In 1994, production of marketable stems steadily increased from 12-17 stems/m^2, in February to between 40 and 90 stems/m^2 per month from May to October before declining again towards the end of the year. In 1995, two distinct peaks in production occurred in May (up to 107 stems/m^2) and in July (up to 125 stems/m^2). Production was however much lower during January to April (at 7-22 stems/m^2 per month) and also September to December (17-42 stems/m^2 per month). In 1996 production was similar to 1994 in having an increased number of marketable stems through the period April to September but this resulted from a sharp increase in productivity following the low numbers produced from January to March (3-23 stems/m^2 per month).

Wilhelmina was also a productive variety with a similar total annual production to Samora and higher production than Cavalier and Libelle (table 1). There was again no indication of declining productivity towards the end of the 3 year trial.

Table 1. Average annual production per m² bed area of total marketable stems

Variety	1994	1995	1996
Cavalier	321	314	267
Libelle	415	426	357
Samora	553	511	531
Wilhelmina	521	452	621

1.2 Seasonal effects on production of short and low quality stems

Cavalier

For majority of treatments, no short or low quality stems were produced during the January to May and September to December periods (figure 5, Appendix III, p.59). A peak in production of this category of stems occurred in July in all three years of the trial, which coincided with the period following the main production peak of marketable stems in May each year. The size of this peak in numbers of stems/m² also increased as the years, and hence the age of the plant material increased from 11-15 stems/m² in 1994 to 11-25 stems/m² in 1995 and 18-36 stems/m² in 1996.

There was little change with time in the total annual production of short and low quality stems (table 2).

Libelle

Similar trends were observed to those described above for Cavalier (figure 6, Appendix III, p.60). That is the peak in production occurred in July in each year, although the size of the peak and its duration was greater than for that of Cavalier. The size of the peak in production also varied with time. The largest peak (at 60 stems/m²) occurred in 1995 with up to 33 stems/m² in 1994 and 42 stems/m² in 1996. This is reflected in the annual production figures (table 2) which were greatest in 1995.

Libelle produced the largest number of short and low quality stems of the four varieties assessed.

Samora

Despite being one of the two most productive varieties assessed as described above, Samora produced the lowest number of short and low quality stems overall (figure 7, Appendix III, p. 61). The peak in production occurred during the summer as with Cavalier and Libelle described above, with the size and shape of the peak changing each year. In the first year of production a small peak occurred in July with a maximum of 11 stems/m² recorded. In 1995 a low level 'peak' occurred from May to July with between 2 and 9 stems/m² produced per month. In 1996 production of short and low quality stems peaked in June with a maximum of 10 stems/m² with production continuing at between 2 and 7 stems/m² in July before dropping again in August and September.

Wilhelmina

The number of short and low quality stems produced remained below 20 stems/m² per month throughout the trial (figure 8, Appendix III, p.62). During the winter periods this number reduced to less than 5 stems/m² per month. Numbers increased during the summer period each year with greater numbers produced in the summers of 1995 and 1996 (2-23 stems/m² per month and 5-18 stems/m² per month respectively) than in the summer of 1994 (1-11 stems/m² per month).

Overall Wilhelmina produced similar numbers of short and low quality stems to Cavalier (table 2), with a slight increase in 1995 and 1996 compared with 1994.

Table 2. Average annual production per m² bed area of short/low quality stems

Variety	1994	1995	1996
Cavalier	21	23	37
Libelle	56	88	79
Samora	17	12	14
Wilhelmina	30	40	44

1.3 Seasonal effects on production of aborted or semi aborted stems

Cavalier

Problems with bud abortion occurred during the winter period with either no problems or only very low levels during the rest of the year (figure 9, Appendix III, p.63). This corresponds with the decline in light levels experienced during the winter. There was a greater number of aborted and semi aborted stems recorded over the winter 1995/96 period (peaking at 14-34 stems/m² in February) than the winter 1994/95 period (peaking at 9-14 stems/m² in January). Surprisingly, there were only very low levels of aborted or semi aborted stems produced at the end of 1996. Total annual production was lowest during the first year of the trial with similar levels in 1995 and 1996 (table 3).

Libelle

Again trends in production were very similar to those noted for Cavalier (figure 10, Appendix III, p.64) with peaks in production occurring during the winter period. The size of the peak in production was however comparable over both the winter 94/95 period (peaking at 18-23 stems/m² in January) and the winter 95/96 period (peaking at 11-23 stems/m² in January). Overall total annual production was comparable with that for Cavalier with the largest total number of stems recorded in 1995 (table 3).

Samora

Samora produced the lowest numbers of aborted and semi aborted stems of the four varieties assessed (table 3). As with Cavalier and Libelle, production of aborted and semi aborted stems occurred predominantly in the winter when light levels declined (figure 11, Appendix III, p.65). The highest numbers of stems recorded within this category was 5/m² in January 1995. Numbers of stems within this category remained low throughout the three years of the trial.

Wilhelmina

As with the production of total marketable stems, the pattern of production of aborted and semi aborted stems varied each year for this variety.

Wilhelmina followed a similar trend to the other varieties in 1994 with very low numbers of aborted or semi aborted stems during majority of the year but with numbers starting to increase in November and December (figure 12, Appendix III, p.66). In 1995 a rather erratic production pattern occurred with sharp peaks for specific treatments at different times of the year. Along with the peaks in production over the winter periods as observed for the other varieties assessed, a higher level of production was also noted throughout the rest of the year. Not surprisingly then the highest annual production of aborted and semi aborted stems was recorded for Wilhelmina over the 1995 period (table 3). Other than the peak at the beginning of 1996, production followed a similar trend to the rest of the varieties during this year resulting in a more typical annual production figure.

Table 3. Average annual production per m² bed area of aborted and semi aborted stems

Variety	1994	1995	1996
Cavalier	11	40	44
Libelle	10	41	32
Samora	5	6	5
Wilhelmina	22	97	49

1.4 Seasonal effects on the production of vegetative shoots

Cavalier

In all three years, the number of vegetative shoots removed for thinning was very low until September (figure 13, Appendix III, p.67). During the September to December period around 50 stems/m² were removed each month (with variations according to both treatment and month).

Overall there were fewer vegetative shoots removed from plots in 1994 (at 88-105 stems/m² for the three months September to November) than in 1995 (125-226 stems/m² for the same three month period) and 1996 (121-216 stems/m²).

Libelle

At least a low level of thinning was required throughout the year for majority of the trial, although no thinnings were removed during the period May to August in the first year following planting i.e. 1994 (figure 14, Appendix III, p.68). This period also coincided with the lowest levels of thinning in the two subsequent years.

The main peak in thinning occurred during September to December and this peak, as may be expected was larger in the two later years of the trial (i.e. 1995 and 1996 with around 100 stems/m² removed per month in comparison with 1994 at around 50-75 stems/m² per month). Consequently annual production was higher in 1995 and 1996 than in 1994 (table 4).

Samora

Samora required more thinning than the other varieties assessed, as illustrated by the highest annual figures for all three years of the trial (table 4). Level of thinning was generally low in the first year of the trial until September when vegetative growth increased and thinning was required to maintain adequate light transmission into the plot as light levels began to decline (figure 15, Appendix III, p.69). The peak in plot thinning also coincided with the winter period in the subsequent years of the trial with the most thinning work carried out in 1995. The period May to July generally required the least thinning when plots became naturally thinner due to a decline in stem production from high temperatures.

Wilhelmina

After Samora, Wilhelmina was the next most demanding variety in terms of requirement for thinning as indicated by the annual figures (table 4). Although a slight increase in thinning occurred during the winter period as noted for the other varieties assessed (figure 16, Appendix III, p.70), Wilhelmina required a more consistent low level of thinning throughout the year (for example around 50 stems/m² per month for majority of the 1996 period). Less thinning was required in 1994 than the two subsequent years of the trial.

Table 4. Average annual production per m² bed area of vegetative stems removed for thinning

Variety	1994	1995	1996
Cavalier	146	239	197
Libelle	190	396	367
Samora	500	834	662
Wilhelmina	102	424	492

2. Effects of irrigation and nutrition on crop production

The figures that have been used to demonstrate trends due to treatment differences have been produced, as described above, by plotting the difference between the treatment in question and 'standard' production (i.e. standard feed and standard irrigation). No difference will therefore be represented by zero. Where the treatment in question produces more stems than the standard treatment, a positive figure will result (i.e. represented by a point above the x axis). Where the treatment in question produces fewer stems than the standard treatment, a negative figure will result (i.e. represented by a point below the x axis).

All figures of treatment trends are presented in Appendix III, p.54.

2.1 Effects of irrigation and nutrition on production of total marketable stems

Cavalier

Trends in treatment effects varied over the three years of the trial (figure 17, Appendix III, p.71). In 1994, the treatment most frequently producing more marketable stems than the standard was high irrigation and high nutrition. The remaining treatments generally produced either equivalent numbers or fewer stems than the standard treatment.

In 1995 high irrigation and high nutrition produced more stems than the standard treatment early and late in the year (which coincided with the periods of higher returns - see section 3). High irrigation and high nutrition was however not as effective during the summer months when the benefits of soil cooling may be expected to be shown, if it were taking place. The guard treatment receiving the highest level of irrigation, (i.e. the 'wet' treatment where irrigation was applied at 150% of the standard treatment), was the only treatment to consistently produce more marketable stems than the standard treatment over the summer months of 1995. However, the guard treatment receiving the lowest level of irrigation (i.e. the 'dry' treatment where irrigation was applied at 50% of the standard treatment) produced the highest number of marketable stems during August September and October (when plots may be expected to be low yielding due to heat induced dormancy). All treatments produced higher numbers of marketable stems than the standard at the end of the year with standard feed and high irrigation and the 'wet' guard observation plot being the most favourable treatments at this time.

In 1996 none of the main trial treatments produced particularly favourable results in comparison with the standard treatment. In fact, the standard irrigation and high nutrition and the high irrigation and high nutrition treatments were particularly poor in comparison with the standard treatment during the summer months. The 'dry' guard observation treatment, however, produced more marketable stems than the standard treatment from January to June and also from September to December. The 'wet' guard also produced more stems than the standard treatment from June to August.

Libelle

No treatment consistently increased production in 1994 in comparison with the standard treatment (figure 18, Appendix III, p.72). Both the high irrigation and high nutrition and the standard irrigation and high nutrition treatments increased production in April, May, July, October and December.

In 1995, the high irrigation and high nutrition and the standard irrigation and high nutrition treatments increased production for majority of the year. The extremes of treatments applied to the guard beds had less of an impact on Libelle in 1995 than they did on Cavalier in this year as described above. High irrigation and standard nutrition and both guard treatments reduced production early in the year.

In 1996 treatments were much closer together and generally remained close to the standard treatment in terms of numbers of stems produced. Greater treatment differences were apparent later in the year when for example high irrigation and high nutrition produced 26 stems/m^2 more than the standard treatment in July, whilst the extreme 'dry' treatment produced 41 stems/m^2 fewer than the standard treatment. Standard irrigation and high nutrition also produced more stems than the standard treatment and the remaining treatments during July and August and was equivalent to if not slightly better than the standard treatment for most of the rest of 1996.

Samora

All treatments increased production compared with the standard during the summer period of 1994 (figure 19, Appendix III, p.73). Standard irrigation and high nutrition produced the greatest advantage with increased production commencing in May and continuing through to September. The other two treatments (high irrigation and high nutrition, and high irrigation and standard nutrition) increased production between June and August. No treatment was unfavourable in comparison with standard production in this year.

Again none of the main treatments performed unfavourably in comparison with standard production in 1995. A decrease in production was, however, recorded for the 'wet' observation treatment, particularly early in the year. All main trial treatments increased production in comparison with the standard, particularly during March to September.

Trends in treatment effects in 1996 were similar to those recorded in 1994. That is all treatments had a large impact on production during the summer period in comparison with the standard. The treatment producing the largest number of stems and also increasing production over the greatest time period was standard irrigation and high nutrition. However, the 'dry' observation treatment also gave comparable yield increases in July and September, so it would be difficult to attribute this benefit to the potential cooling effect of high irrigation alone. Following the increases in production in the earlier part of the year, all treatments except for the 'dry' observation treatment produced fewer stems than the standard treatment during October - September (i.e. when prices were generally more favourable).

Wilhelmina

Treatments were generally comparable with standard production for the early part of 1994 (figure 20, Appendix III, p.74). Differences became apparent from August in 1994 when high irrigation and standard nutrition produced the highest number of stems (9 stems/m^2 more than the standard treatment in August and 13 stems/m^2 more in September). The remaining two treatments generally produced fewer stems than the standard from August through to December.

In general all treatments produced more stems than the standard treatment throughout 1995, the main exceptions being high irrigation and high nutrition which produced fewer stems than the standard treatment in the early part of the year, particularly in April and May; and the 'dry' observation treatment in May. Standard irrigation and high nutrition consistently produced more stems/m^2 than the standard treatment. High irrigation and standard nutrition treatment produced the highest numbers of stems/m^2 during May-July but was less effective early and late in the year when prices are higher. The 'wet' observation treatment produced a similar result to the standard irrigation and high nutrition treatment in this year, with a consistent improvement over standard production throughout the year. It is difficult therefore to identify the main benefit since these two treatments involved different nutrition and irrigation regimes.

All treatments were comparable to standard production early in 1996, but then all increased the number of stems produced compared with standard production by 14-45 stems/m^2 in April, before returning to a more comparable level in May. This would indicate a potential problem with the standard production for this variety in May of 1996. Greater differences between treatments became apparent during the summer period. High irrigation and high nutrition produced fewer stems/m² than standard production from June to October. The 'dry' observation treatment also performed unfavourably compared with the standard treatment during this period. The 'wet' observation treatment and high irrigation and standard nutrition produced more stems/m² than the standard treatment for selected months during the summer period, but neither produced a consistent advantage over standard production.

2.2 Effects of irrigation and nutrition on production of short and low quality stems

Cavalier

All treatments were comparable with standard production during 1994 and majority of 1995 and 1996 (figure 21, Appendix III, p.75). In the summer of 1995 and 1996 however, some treatments produced more short and low quality stems than the standard. In 1995 the high irrigation and high nutrition and the high irrigation and standard nutrition treatments produced higher numbers of short and low quality stems than the standard in July. The two observation treatments also produced higher numbers of short and low quality stems than the standard from May to July. A similar trend occurred in 1996 with the two observation treatments producing the highest numbers of short and low quality stems in July and August, but with fewer stems produced within this category from any of the main trial treatments.

Libelle

Libelle was comparable with Cavalier in that for majority of each year all treatments produced similar numbers of short and low quality stems with differences only appearing during the summer (figure 22, Appendix III, p.76). In the summer of 1994 few differences were recorded other than a slight fluctuation around the figure for standard production in June and July and no real treatment trends. In 1995 greater fluctuations were recorded in May, June and July. High irrigation and high nutrition and standard irrigation and high nutrition both produced more short and low quality stems in May and June but then produced fewer in July in comparison with the standard treatment. Both observation treatments also increased the production of short and low quality stems at this time.

In 1996, treatment differences from standard production were mainly apparent from June through to September. The wet observation treatment had the greatest effect at this time producing the highest number of stems within this category in June and September. Other notable treatment trends included a decrease in short and low quality stems for both the high irrigation and high nutrition and the standard irrigation and high nutrition treatments in July and August.

Samora

As noted for Cavalier and Libelle above, all treatments were comparable with standard production for majority of the trial (figure 23, Appendix III, p.77). Where differences occurred they were again found during the summer which coincides with the general peak in production of this category of stems as described in section 1 above. The greatest increase in short and low quality stems resulted from the 'dry' observation treatment in 1995 and in 1996 during the May to September and the July and August periods respectively.

Wilhelmina

In accordance with trends described for the varieties above, all treatments were again comparable with standard production in terms of the numbers of short and low quality stems produced during majority of the trial with treatment differences only really apparent during the summer period (figure 24, Appendix III, p.78). In 1995 the main treatment effects were recorded during the July to August and the October periods. All main treatments increased production of short and low quality stems during these periods but the greatest difference resulted from the 'dry' observation treatment, which increased production by 14 stems/m² in July.

All treatments gave comparable increases in production over the standard treatment in 1996.

2.3 Effects of irrigation and nutrition on production of aborted and semi aborted stems

Cavalier

Treatment effects were restricted to the winter period of each year of the trial when the largest number of aborted and semi aborted stems were being produced (figure 25, Appendix III, p.79). All treatments increased the number of aborted and semi aborted stems produced at the end of 1995 in comparison with the standard treatment. At the beginning of 1996 however all treatments decreased the number of stems produced in this category. In general however these fluctuations were not sufficiently consistent to enable any firm conclusions on treatments which may have had a particular influence on flower abortion.

Libelle

All treatments were comparable with standard production for majority of the year (figure 26, Appendix III, p.80). High feed and standard irrigation produced marked increases in production in February of 1995 and January and July of 1996. The 'dry' observation treatment also produced notable increases in production in December of 1995 and February, March and July of 1996.

Samora

All treatments produced comparable numbers of aborted and semi aborted stems to standard production throughout the three years of the trial (figure 27, Appendix III, p.81).

Wilhelmina

In 1994, all treatments were comparable with standard production (figure 28, Appendix III, p.82). In contrast, in 1995 wide fluctuations in numbers of aborted and semi aborted stems were recorded. In the early part of 1995 standard irrigation and high nutrition produced consistently more stems in this category than the standard treatment. From May to September the standard treatment produced the highest number of stems in this category with little difference between the remaining treatments. Towards the end of the year (October to December), the 'wet' observation treatment consistently produced more stems than the standard. During the same period, high irrigation and high nutrition generally produced fewer stems than the standard. Some fluctuation in numbers of stems was recorded in January of 1996 with the 'dry' observation treatment increasing the number of stems produced and high irrigation and standard nutrition decreasing the number. For the rest of the year however all treatments were comparable with the standard with no consistent trends relating to any single treatment or factor.

2.4 Effects of irrigation and nutrition on production of vegetative stems

Cavalier

Treatment effects on number of thinnings produced was generally restricted to the September to December period in each year when the greatest number of thinnings were being removed from plots (figure 29, Appendix III, p.83). In all three years, high irrigation and high nutrition increased the number of thinnings produced for most of this period. The 'wet' observation treatment also appeared to increase the number of thinnings over this period indicating overall that high irrigation may increase the number of thinnings produced by this variety.

Libelle

All treatments were comparable with standard production from January to September in 1994 (figure 30, Appendix III, p.84). Later in 1994 some fluctuation in number of thinnings was recorded but no consistent trends were noted. In 1995 the high irrigation and high nutrition treatment increased the production of thinnings in May, August, September and November. The 'wet' observation treatment decreased the number of thinnings produced early and late in the year. Trends in 1996 were inconsistent but again with some increase towards the end of the year associated with the high feed and high irrigation treatment.

Samora

From September 1994 onwards, standard irrigation and high feed consistently produced an increase in thinnings in comparison with standard production (figure 31, Appendix III, p.85). All other treatments, however, tended to increase rather than decrease number of thinnings indicating that perhaps none of the treatments were an improvement over standard production in terms of the requirement for thinning.

Wilhelmina

For majority of 1994 there were no differences between treatments and standard production in terms of the amount of thinning work required and only small and inconsistent differences at the end of the year (figure 32, Appendix III, p.86). Differences between standard production and each treatment were greater in 1995 and 1996 but again no consistent trends were observed throughout these periods. The 'wet' observation treatment apparently increased the number of thinnings during May, June and November in 1995 and also in July to September in 1996, however in other parts of these years (e.g. March and April in 1995) this treatment decreased the number of thinnings produced.

3. Effects of irrigation and nutrition on financial returns

To assist in interpreting the influence of treatments on trends in production discussed in section 2, the expected financial returns from each plot have been calculated. In order to make these calculations, the returns achieved by a commercial grower over the period 1994 to 1995 using the simple grading structure described above (page ?) have been taken to represent average market prices. Figure 1 illustrates what these returns are and how they vary during one calendar year.

By applying these prices to the grade data collected from each plot, the annual returns per treatment have been calculated and presented in table 5.

Figure 1

Figure 1. Seasonal fluctuation in prices for Alstroemeria stems (based 1995/96 figures)

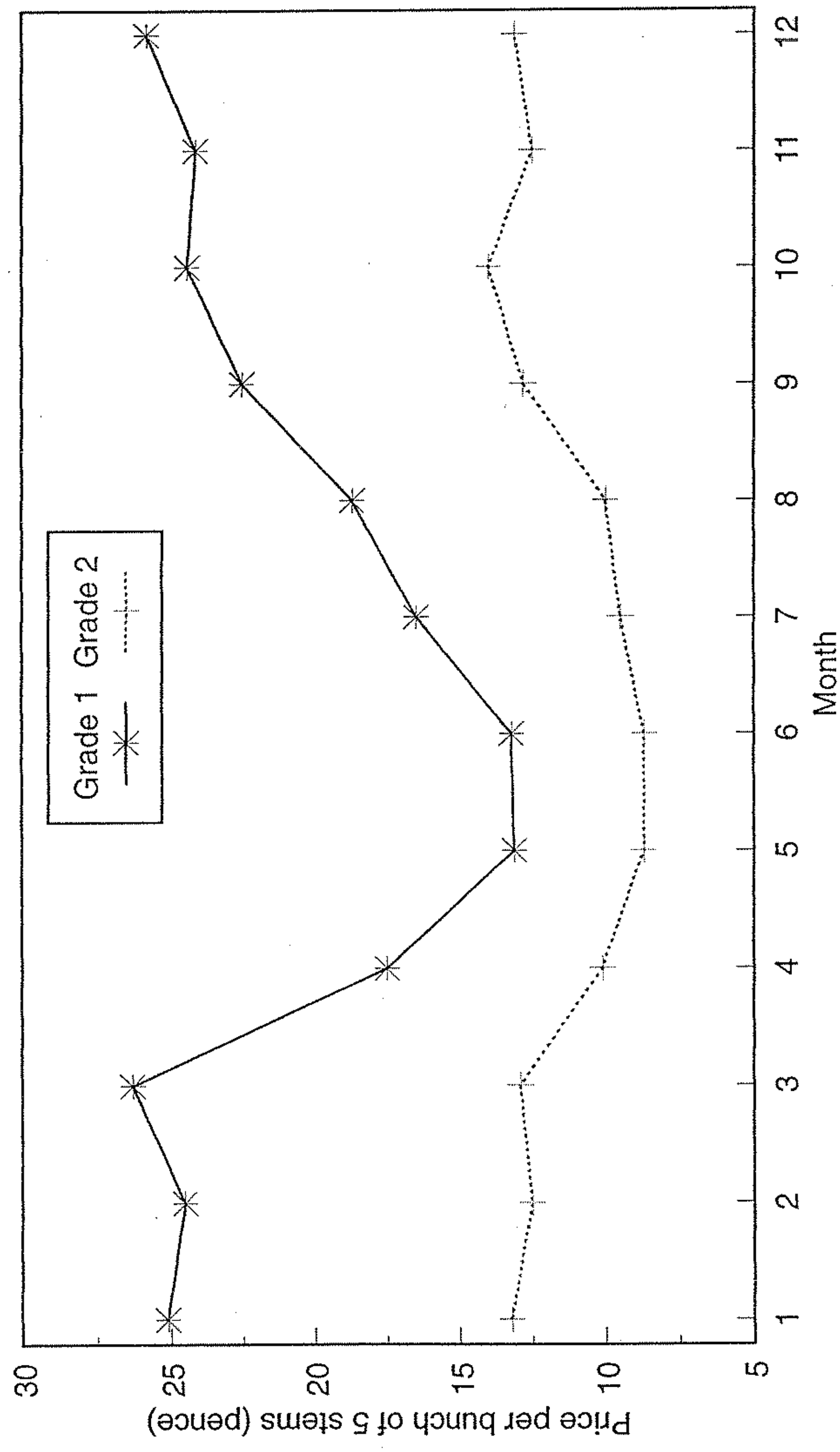


Table 5. Comparison of the financial returns (£/m² bed space*) from each treatment.

	1994	1995	1996	Total
Cavalier				
A	91.24	82.85	63.76	237.85
B	99.12	89.37	83.79	272.28
C	89.40	96.32	84.60	270.32
D	109.01	82.12	63.47	254.60
WG	-	92.11	105.24	-
DG	-	104.09	85.15	-
Libelle				
A	129.23	157.70	126.29	413.22
B	130.22	130.15	117.45	377.82
C	121.52	130.67	108.54	360.73
D	130.06	152.92	116.32	399.30
WG	-	112.46	115.93	-
DG	-	123.29	105.35	-
Samora				
A	164.50	150.00	163.57	478.07
B	151.32	135.97	131.50	418.79
C	154.18	148.67	155.08	457.93
D	154.44	143.74	144.06	442.24
WG	-	138.77	166.92	-
DG	-	119.93	132.10	-
Wilhelmina				
A	147.48	175.85	189.38	512.71
B	156.91	128.31	181.76	466.98
C	168.57	157.74	197.82	524.13
D	152.24	139.71	183.13	475.08
WG	-	116.61	174.01	-
DG	-	141.79	203.95	-

*no path space included.

Key

Main Treatments:

A:	Standard irrigation	High nutrition
B:	Standard irrigation	Standard nutrition
C:	High irrigation	Standard nutrition
D:	High irrigation	High nutrition

Observation Treatments

WG:	'Wet' Guard
DG:	'Dry' Guard

Cavalier

In the first year of treatments, the highest returns resulted from the high irrigation and high nutrition treatment producing between £9.89 and £19.61 /m^2 above the remaining main treatments. In the second and third year of treatments the highest returns resulted from the high irrigation and standard nutrition treatments. The common factor for these two 'best' main treatments was therefore high irrigation. In conflict with these results, the wet guard observation treatment produced lower returns than the dry guard observation treatment in 1995, although in 1996 the wet guard produced the highest returns of all treatments assessed.

Libelle

Standard irrigation and standard nutrition produced the highest returns in 1994 but returns from the standard irrigation and high nutrition as well as the high irrigation and high nutrition were also very close. In 1995 and 1996, however, the standard irrigation and high nutrition treatment produced higher returns than the remaining main treatments and observation treatments. Over the three years of the trial, standard irrigation and high nutrition also produced the highest level of returns. Low financial returns resulted from both observation guard treatments in 1995 and 1996.

Samora

Standard irrigation and high nutrition produced the highest returns in 1994 and 1995. This treatment also produced the second highest returns in 1996. Overall then standard irrigation and high nutrition produced the most favourable result totalled across the three years of the trial. Returns from the guard treatments in 1995 were generally poor and returns from the dry treatment were much lower than for any of the other treatments in that year. Similarly in 1996, the dry guard treatment produced lower returns than the wet guard treatment and the standard irrigation and standard nutrition treatment produced the poorest returns overall in this year.

Wilhelmina

In 1994, high irrigation and standard nutrition produced the highest returns. In 1995 this treatment also produced a high level of returns in relation to the rest of the treatments except for standard irrigation and high nutrition which produced the highest returns in this year. In 1996 high irrigation and standard nutrition also produced favourable returns in relation to majority of the rest of the treatments assessed, however in this year the dry guard produced the most favourable returns overall. Of the four main treatments, high irrigation and standard nutrition was therefore the most favourable over the three years of the trial.

4. Effects of irrigation and nutrition on environmental data

4.1 Soil temperature

Soil temperature fluctuated on a daily basis, as influenced by solar gain. Hence temperature gradually increased during the day and decreased again overnight resulting in a cyclic pattern. Temperature also varied between the four main treatments monitored. In some cases, for example, data collected in April 1996 (figure 2), the standard feed and high irrigation treatment bed temperature was approximately 1°C lower than the other beds. It is difficult however to attribute this to the effects of cooling since the temperatures of the high feed and high irrigation treatment bed were not affected in the same way. Even during the summer of 1995, when high temperatures were experienced daily, soil temperatures did not appear to be lowered by the high irrigation treatments (e.g. June 1995, figure 3).

None of the data collected indicates a consistent lowering of soil temperature associated with both high irrigation treatments. In fact any differences detected can probably be explained by background variation in soil temperature from bed to bed. This is best demonstrated by data collected over the winter period (October to March) when all beds were receiving a common irrigation treatment and therefore would not be expected to be influenced by cooling as a side effect of irrigation regime. Examples of such data are given in figure 4 (December 1995) and figure 5 (March 1996). In both cases all beds were receiving a common irrigation regime and yet the temperatures of treatment bed C (standard nutrition and high irrigation) were consistently 0.5-1.0°C lower than those of the remaining three beds.

Irrigation treatments, therefore, did not have a measurable influence on the temperature of the soil beds at a depth of 10 cm.

Figure 2

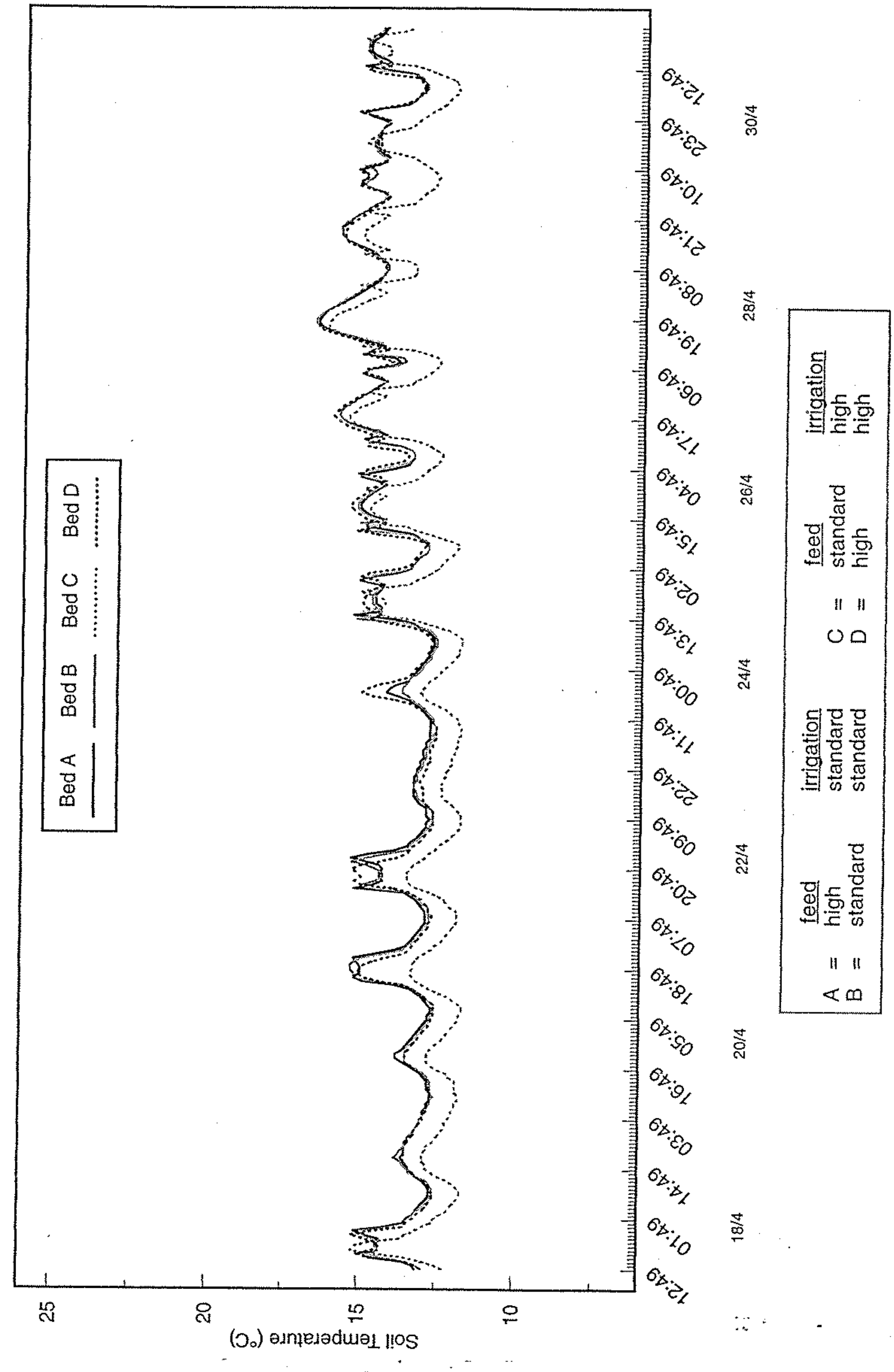


Figure 2. Effects of irrigation and nutrition on soil temperatures 17/4/96 to 30/4/96

Figure 3

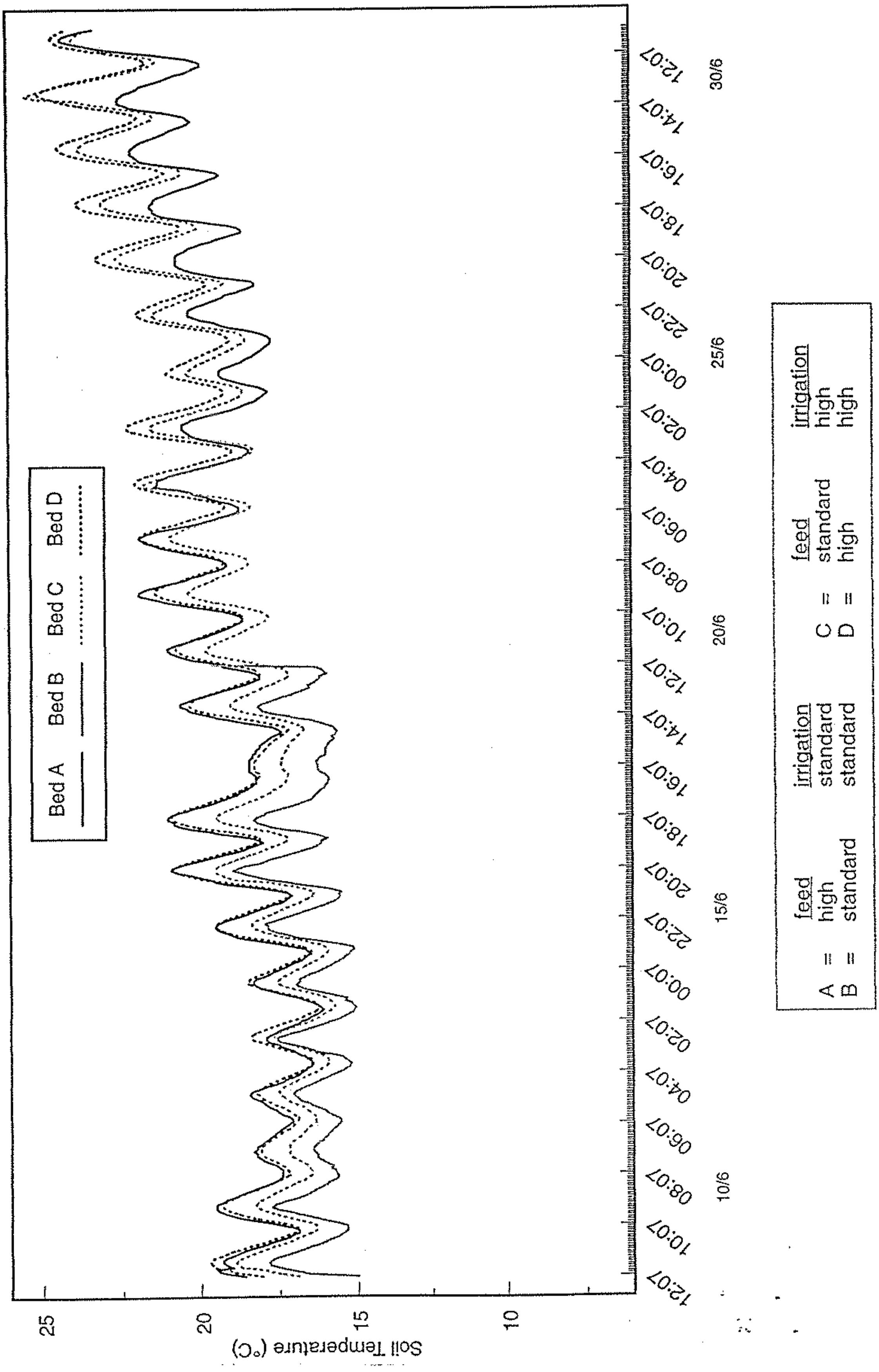


Figure 3. Effects of irrigation and nutrition on soil temperatures 8/6/95 to 30/6/95

Figure 4

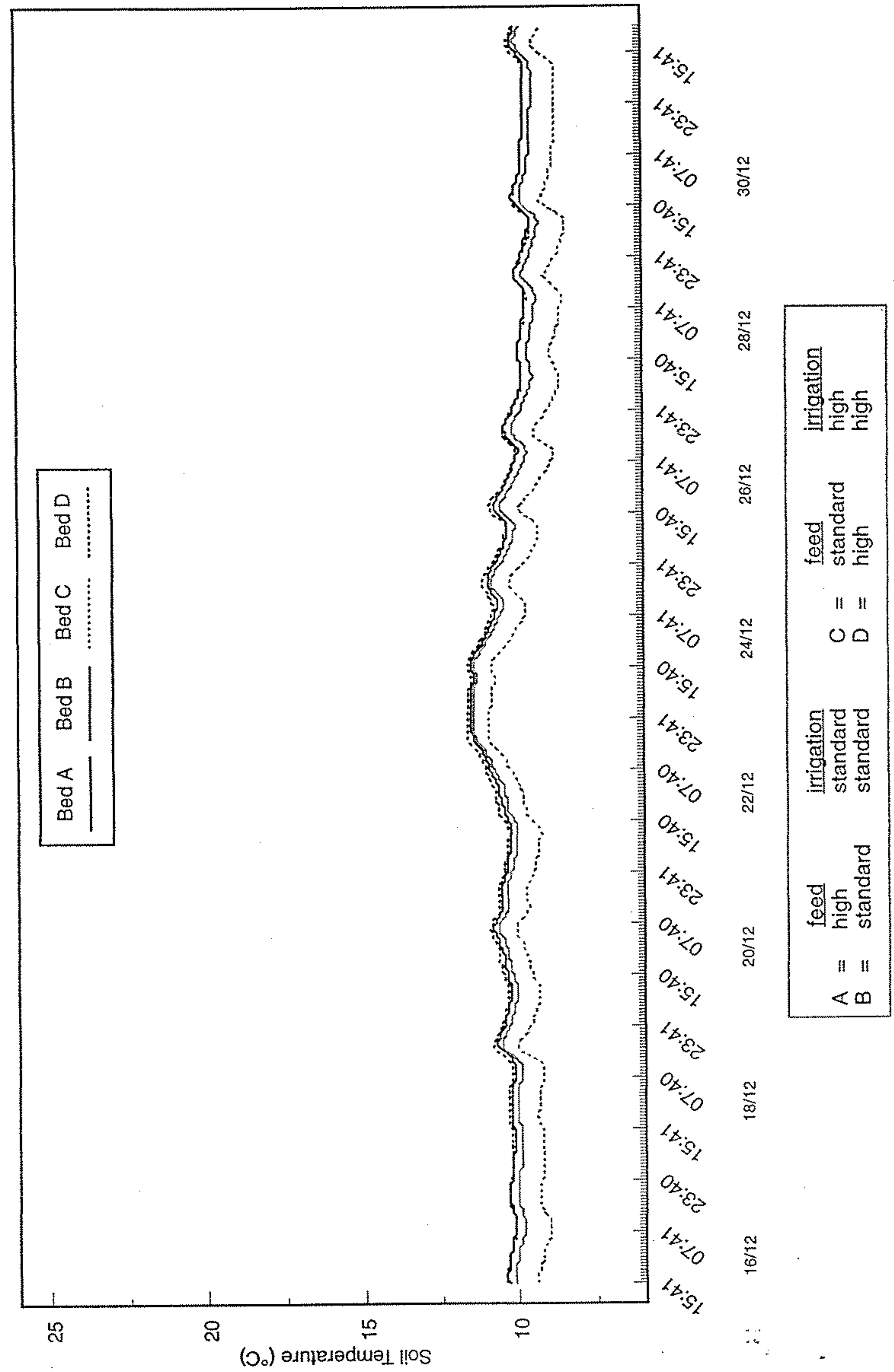


Figure 4. Effects of irrigation and nutrition on soil temperatures 15/12/95 to 31/12/95

Figure 5

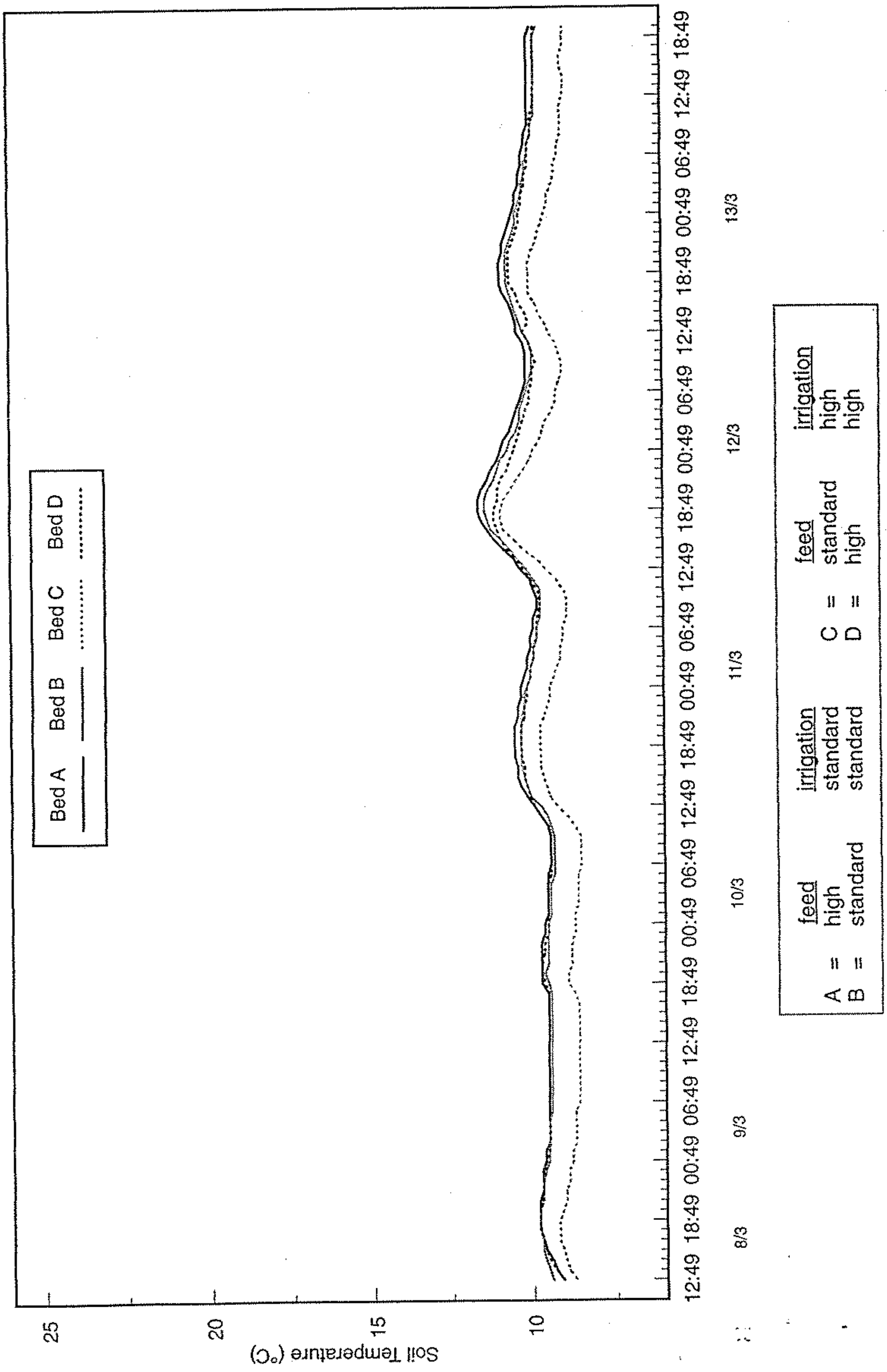


Figure 5. Effects of irrigation and nutrition on soil temperatures 8/3/96 to 13/3/96

4.2 Soil moisture status

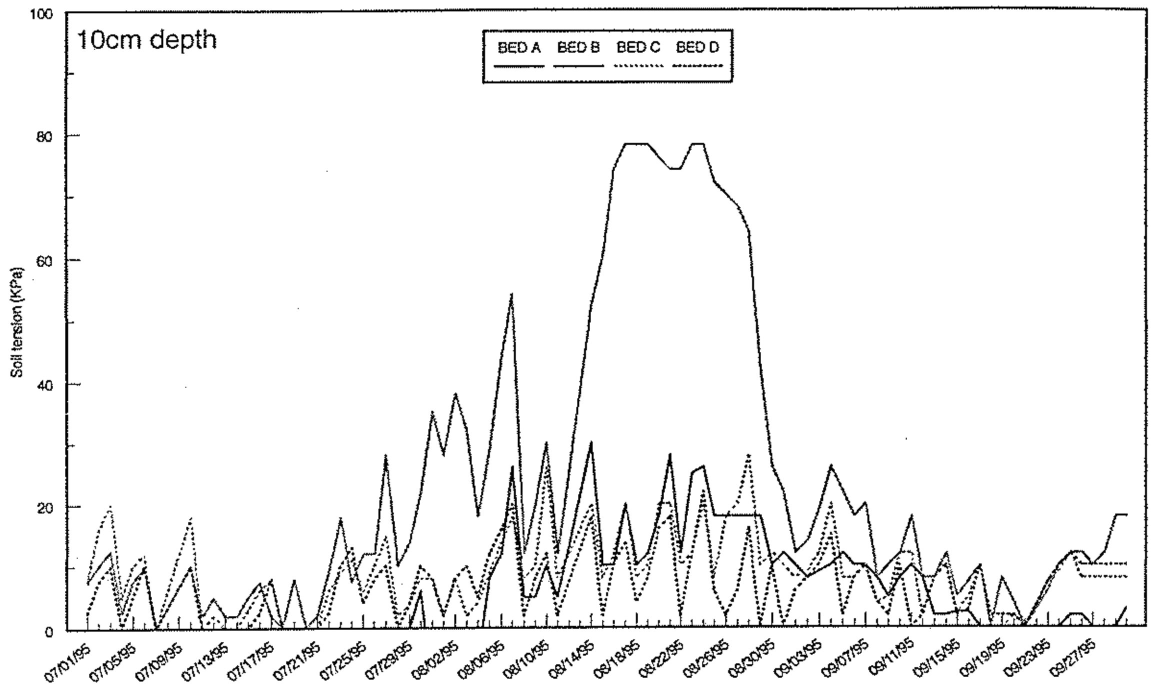
Soil moisture status, as monitored by tensiometers, showed greater variation than temperature discussed before. This fluctuation appears to be related to irrigation events, with soil tension falling following irrigation and then gradually rising again prior to the next irrigation. This monitoring was however susceptible to errors. In particular it is important not to allow air pockets to form between the soil and the porous cup of the tensiometer. With a crop such as *Alstroemeria*, however, where rhizomes are continuously developing and stems are pulled from plots up to three times a week for harvesting, the soil experiences considerable disturbance which were reflected from time to time in the tensiometer data until tensiometers were re-positioned.

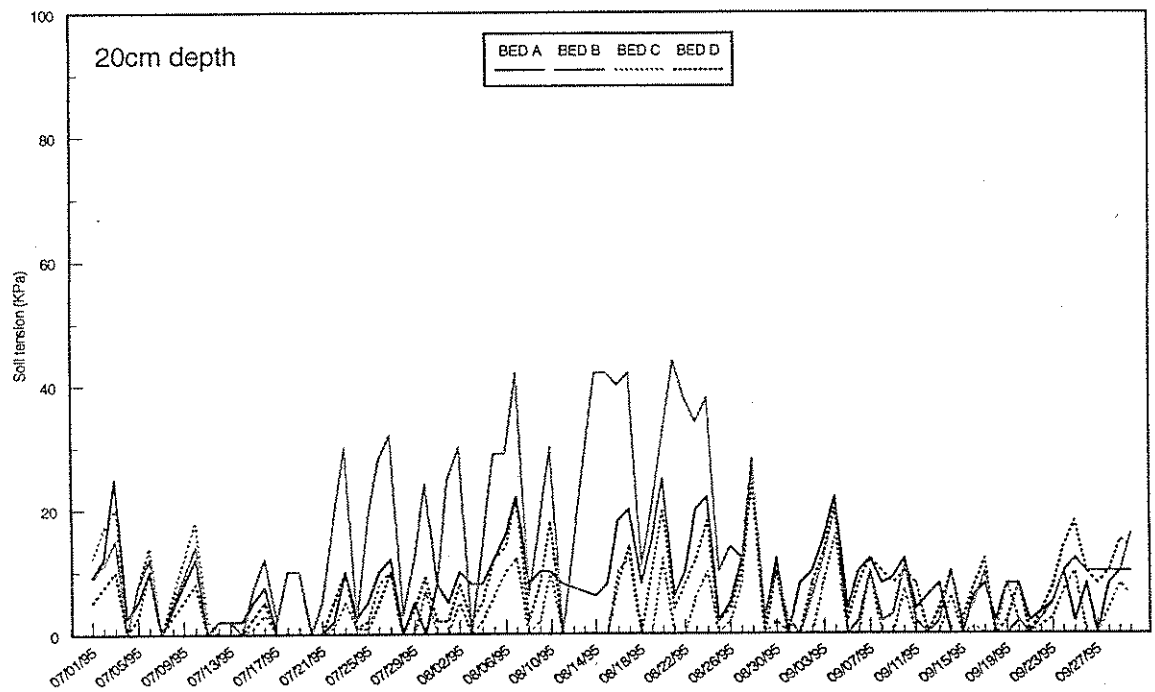
Despite these difficulties, monitoring soil tension indicated that the irrigation treatments influenced soil moisture levels. During the summer (i.e. when different irrigation treatments were applied), soil tension increased to greater levels (indicating lower soil moisture) between irrigation events on the plots receiving standard irrigation than on those receiving high irrigation treatments (figure 6). Thus high irrigation treatments did influence soil moisture levels although this trend was more noticeable in the 10cm layer of soil than the 20cm layer. During winter, when beds received a common irrigation regime, this separation of treatments is no longer apparent in the soil tensiometer data (figure 7).

The high irrigation treatments applied were therefore capable of influencing the availability of water in the root zone. These differences did not however appear to influence soil temperature as discussed above.

Figure 6

Figure 6. Effects of irrigation and nutrition on soil tension (July - September 1995)

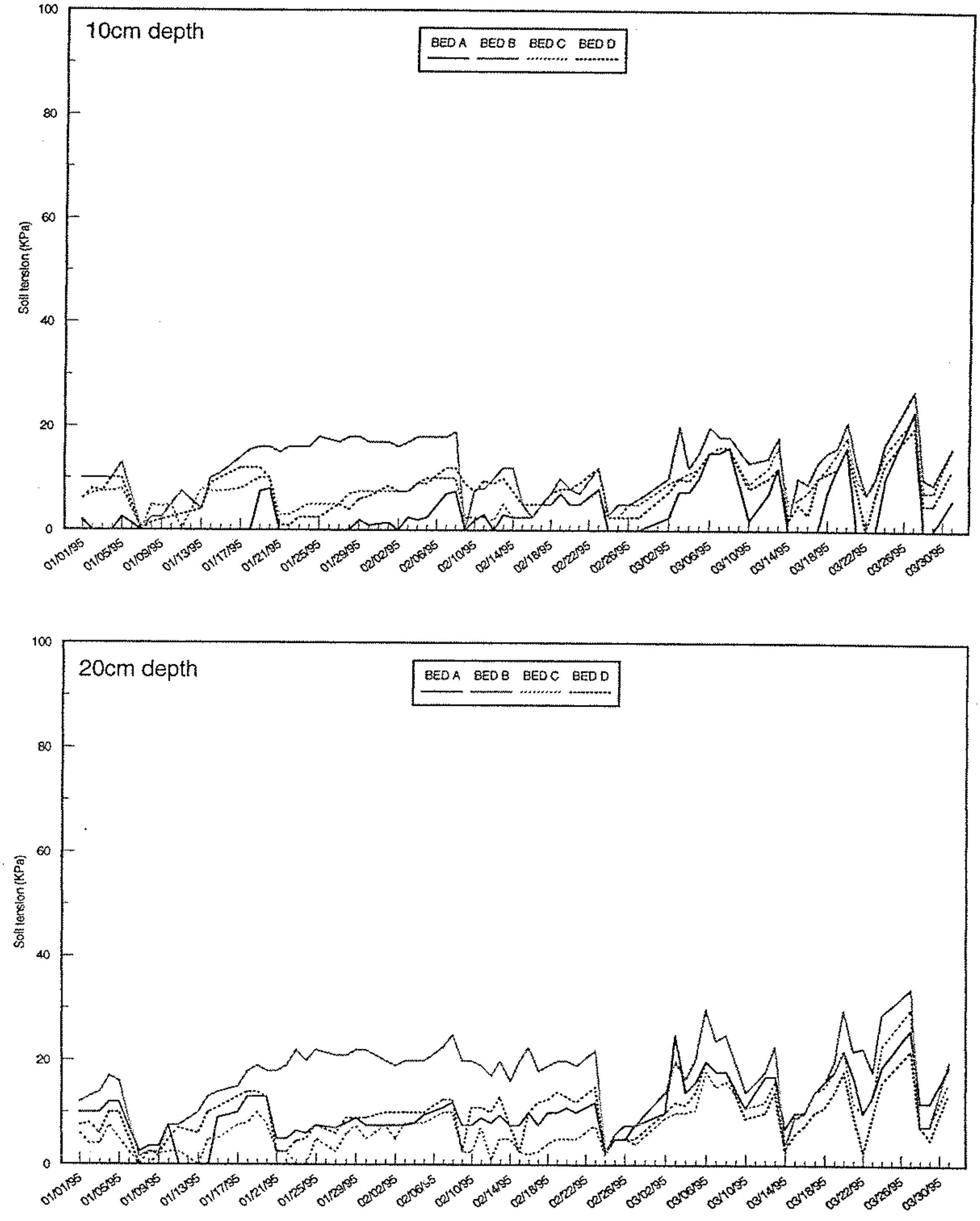




	feed	irrigation		feed	irrigation
A =	high	standard	C =	standard	high
B =	standard	standard	D =	high	high

Figure 7

Figure 7. Effects of irrigation and nutrition on soil tension (January - March 1995)



	feed	irrigation		feed	irrigation
A =	high	standard	C =	standard	high
B =	standard	standard	D =	high	high

4.3 Mineral nutrient levels

All beds were fertilised with mineral base dressings according to MAFF recommendations (MAFF 1988) prior to commencing the trial. Hence the results of soil analyses on samples taken during the early stages of the trial (prior to commencing feed treatments and one month after commencing feed treatments), indicated comparable concentrations of major nutrient ions on all plots (table 6). As the trial progressed, however, the effects of the two feed treatments were detected through differences in N:K ratios. The high feed treatment provided a higher level of N relative to K both in winter and summer (although the absolute amounts applied varied with season). Correspondingly higher N:K ratios were recorded on the high feed treatments plots from August 1994 onwards (i.e. eight months after commencing feed treatments). These differences were apparently due to higher concentrations of nitrate-nitrogen in the soil where the high nutrition treatments had been applied. These differences were also reflected in conductivity levels, which were also generally higher on beds receiving the high irrigation treatment.

Table 6. Soil analyses:

	Soil pH:						Conductivity (ìS/cm):					
Date	A	B	C	D	WG	DG	A	B	C	D	WG	DG
06/10/93	6.9	6.9	6.8	7.0	6.8	6.9	2700	2700	2630	2530	3030	2750
20/01/94	6.9	6.8	6.8	6.8	6.6	6.8	2710	2670	2510	2640	3020	2600
02/08/94	6.5	6.8	6.6	6.5	6.5	6.7	2765	2765	2523	2620	2838	2620
12/10/94	6.2	6.5	6.6	6.2	6.4	6.6	2670	2490	2501	2645	2568	2388
03/12/94	6.8	7.1	7.3	6.8	6.9	7.2	2400	2486	2284	2613	2451	2502
30/03/95	6.6	7.1	7.2	6.8	6.8	7.3	2510	2436	2280	2538	2604	2290
31/05/95	6.5	6.9	6.9	6.2	6.6	6.9	2719	2456	2383	2401	2474	2392
31/08/95	6.5	7.0	7.1	6.4	6.8	6.7	2961	2685	2519	3062	2510	2694
30/11/95	6.1	7.2	6.1	6.1	7.0	6.9	3117	2697	2520	3425	2678	2510
29/02/96	6.0	6.7	6.6	5.9	6.7	6.8	2991	2599	2452	3089	2599	2452

Key

Main Treatments:
A: Standard irrigation, High nutrition
B: Standard irrigation, Standard nutrition
C: High irrigation, Standard nutrition
D: High irrigation, High nutrition

Observation Treatments
WG: `Wet Guard'
DG: `Dry Guard'

Nitrate-N (mg/l):

Date	A	B	C	D	WG	DG
06/10/93	186	205	185	135	345	257
20/01/94	173	185	119	171	307	152
02/08/94	239	186	147	197	231	164
12/10/94	229	133	142	235	160	131
03/12/94	123	81	62	214	119	157
30/03/95	170	92	57	168	154	73
31/05/95	313	178	145	245	181	176
31/08/95	38	23	18	43	15	28
30/11/95	46	24	18	55	22	20
29/02/96	429	257	182	503	251	208

Pottassium(mg/l):

Date	A	B	C	D	WG	DG
06/10/93	452	427	485	453	572	532
20/01/94	356	378	264	412	390	266
02/08/94	565	685	605	365	650	515
12/10/94	225	207	225	156	291	181
03/12/94	204	217	207	201	255	234
30/03/95	246	188	192	198	356	198
31/05/95	217	229	300	196	274	234
31/08/95	218	230	188	206	230	256
30/11/95	218	193	193	251	239	208
29/02/96	259	206	160	214	220	187

Magnesium (mg/l):

Date	A	B	C	D	WG	DG
06/10/93	267	287	280	219	328	231
20/01/94	310	328	300	254	350	202
02/08/94	193	252	189	176	208	169
12/10/94	170	172	155	134	175	134
03/12/94	131	172	146	134	145	121
30/03/95	404	394	296	339	430	257
31/05/95	239	239	203	182	213	126
31/08/95	195	197	170	162	158	122
30/11/95	189	227	197	209	211	116
29/02/96	54	41	26	46	35	40

Phosphorus (mg/l)

Date	A	B	C	D	WG	DG
06/10/93	111	99	119	106	129	91
20/01/94	89	96	82	97	118	92
02/08/94	95	109	133	100	120	83
12/10/94	76	59	59	69	76	70
03/12/94	70	59	55	67	69	65
30/03/95	78	56	36	65	81	40
31/05/95	84	69	67	73	84	66
31/08/95	98	72	71	83	89	62
30/11/95	123	107	104	116	120	94
29/02/96	112	101	79	124	119	88

N:K ratio:

Date	A	B	C	D	WG	DG
06/10/93	0.41	0.48	0.38	0.30	0.60	0.48
20/01/94	0.49	0.50	0.45	0.42	1.20	0.57
02/08/94	0.42	0.27	0.24	0.54	0.36	0.32
12/10/94	1.02	0.64	0.63	1.51	0.55	0.72
03/12/94	0.60	0.37	0.30	1.10	0.47	0.67
30/03/95	0.69	0.49	0.30	0.85	0.43	0.37
31/05/95	1.44	0.78	0.48	1.25	0.66	0.75
31/08/95	0.17	0.10	0.10	0.21	0.10	0.11
30/11/95	0.21	0.12	0.10	0.22	0.10	0.10
29/02/96	1.66	1.25	1.14	2.35	1.14	0.11

Key

Main Treatments:
A: Standard irrigation High nutrition
B: Standard irrigation Standard nutrition
C: High irrigation Standard nutrition
D: High irrigation High nutrition

Observation Treatments
WG: 'Wet' Guard
DG: 'Dry' Guard

As discussed previously, combined nutrition and irrigation treatments appeared to have some effect on the yield of stems in the categories recorded. A spot check on foliage nutrient status indicated that the feed treatments had a small impact on leaf N:K ratios of the varieties Samora and Cavalier but had little influence over the other two varieties in the trial or on the individual concentrations of major nutrients analysed (Table 7).

Table 7. Leaf analysis (from samples taken 6/3/95):

	A	B	C	D	WG	DG
% Nitrogen						
Samora	5.97	4.79	5.54	5.66	5.63	5.03
Cavalier	5.55	4.23	4.72	5.11	5.12	5.23
Libelle	4.51	4.55	5.51	5.02	5.16	4.6
Wilhelmina	4.51	4.57	4.98	5.02	4.73	5.05
% Phosphorus						
Samora	0.544	0.473	0.489	0.446	0.504	0.628
Cavalier	0.466	0.449	0.438	0.504	0.562	0.437
Libelle	0.464	0.545	0.541	0.523	0.497	0.467
Wilhelmina	0.575	0.451	0.503	0.548	0.569	0.537
% Potassium						
Samora	4.61	4.62	4.75	4.23	4.85	5.24
Cavalier	4.68	4.55	5.31	5.20	4.97	4.75
Libelle	5.36	5.04	5.12	5.16	5.12	4.71
Wilhelmina	4.71	5.14	5.19	5.07	5.72	4.41
% Calcium						
Samora	1.686	1.875	1.803	2.335	1.750	1.620
Cavalier	2.052	1.897	1.695	1.833	1.379	1.788
Libelle	1.557	1.647	1.392	1.405	1.393	1.751
Wilhelmina	1.712	1.669	1.606	1.406	1.406	1.118
%						
Magnesium	0.356	0.338	0.326	0.358	0.331	0.266
Samora	0.352	0.350	0.267	0.252	0.306	0.269
Cavalier	0.293	0.277	0.276	0.277	0.290	0.296
Libelle	0.320	0.285	0.286	0.289	0.247	0.260
Wilhelmina						
% Manganese						
Samora	136.6	123.4	133.7	180.1	114.3	155.0
Cavalier	146.2	124.7	102.7	308.5	113.6	116.7
Libelle	189.3	124.8	136.2	152.5	134.5	195.8
Wilhelmina	149.4	155.8	150.8	122.1	86.1	200.6
N:K ratio						
Samora	1.30	1.04	1.17	1.34	1.16	0.96
Cavalier	1.19	0.93	0.89	0.98	1.03	1.10
Libelle	0.84	0.90	1.08	0.97	1.01	0.98
Wilhelmina	0.96	0.89	0.96	0.99	0.83	1.15

Key

Main Treatments:
A: Standard irrigation High nutrition
B: Standard irrigation Standard nutrition
C: High irrigationStandard nutrition
D: High irrigationHigh nutrition

Observation Treatments
WG: 'Wet' Guard
DG: 'Dry' Guard

Discussion

Seasonal fluctuations as well as differences in treatment trends throughout the trial make interpretation of these results difficult, particularly in the absence of statistical analyses. It is clearly not possible to identify one specific regime of the two factors assessed, which will favour the growth of a wide range of varieties in the future. The data can therefore only be used to make suggestions about the likely responses of the specific varieties assessed (possibly along with other varieties known from previous experience to behave in a similar way to one of the varieties assessed in this trial).

Trends in total marketable stems relating to treatment differences correlate well with the financial returns calculated (since stems within this category generated a majority of the returns). Hence in 1994, high irrigation and high nutrition produced the highest returns for the variety **Cavalier**, whilst in 1995 and 1996 high irrigation and standard nutrition was the most favourable treatment. These benefits have to be balanced against the amount of labour inputs required both for thinning the beds and for harvesting and marketing flowering stems. In all three years of the trial high irrigation and high nutrition increased the amount of thinning work on Cavalier in comparison with the standard treatment. On balance therefore, high irrigation would be recommended for this variety but with a standard nutrition regime. Indications from the observation treatments suggest that unless weather conditions are extreme (as during the summer of 1995), there is no benefit from further increasing the irrigation applied (and of course care must be taken to avoid waterlogging particularly as the winter period approaches and transpiration and evaporation decreases). Given that the 'dry' observation treatment was comparable with the 'wet' observation treatment in terms of stem production, it is difficult to attribute any benefits observed to cooling effects of the higher irrigation regimes.

There was no clear improvement over standard production for **Libelle** in the first year of the trial and high irrigation and standard nutrition produced low returns in relation to the other treatments assessed. For the remainder of the trial however standard irrigation and high nutrition appeared to be the most favourable treatment for this variety in terms of total marketable stems and total returns. Extremes of irrigation (i.e. as provided on the guard observation beds) apparently reduced production resulting in lower financial returns than the standard treatment in 1995 and 1996. There is therefore little evidence to support changing the irrigation of Libelle from current standard practice, but improvements do appear possible through manipulation of nutrition.

With the higher productivity achieved for Libelle with the standard irrigation and high feed treatment, an increase in short and low quality stems as well as aborted and semi-aborted stems also resulted, although there was no resultant increase in the number of stems removed for thinning from this treatment. These factors would detract from the financial data presented in table 5 (page 27) since these figures represent returns from harvested stems alone and do not account differences in labour requirements for removing unmarketable stems from the bed.

In contrast with Libelle all treatments appeared to have a positive effect on the production of **Samora** throughout the trial. This is reflected both by trends in numbers of stems produced and the calculated financial returns for each treatment. It appears therefore that out of the four varieties assessed Samora would produce the greatest benefits from changing irrigation and feed management from the current standard. There was, however, no evidence from the responses of Samora to either the main or observation treatments that high irrigation was benefiting production through a cooling effect, since both high and standard irrigation treatments increased production during the summer periods. Overall, Samora was the most productive variety in terms of marketable stems but this variety also produced the highest number of thinnings, which would have to be accounted for in terms of labour costs.

Of the four main treatments assessed, high irrigation and standard nutrition produced the highest annual financial returns in 1994 and 1996 for **Wilhelmina**. This appears largely as a result of increases in total marketable stems during the summer months rather than a shift in flushing patterns. Production patterns in 1995 were very different to 1994 and 1996 and correspondingly a different regime (i.e. standard irrigation and high nutrition) produced the highest annual financial returns. It is difficult therefore, to identify the most suitable regime of those tested. Given that for two out of three years high irrigation and standard nutrition was the most productive treatment it may be expected that Wilhelmina would benefit from higher levels of irrigation. In contradiction to this evidence, however, the dry observation treatment in 1996 produced the highest annual financial returns of the treatments assessed.

Overall, whilst there are some trends relating to individual regimes on single varieties, there is little evidence favouring any one of the regimes investigated. This may in part be explained by examining the environmental monitoring records. Records from soil tensiometers indicate that the high irrigation treatment did reduce soil tension (and hence increase soil moisture) during the summer period (i.e. the period during which they were applied). However, while differences in soil temperatures between treatments were detected during the summer period when different irrigation treatments were being applied, they were generally no bigger than the background variation noted during the winter months. Furthermore, any differences observed did not support the theory that high irrigation treatments were resulting in a cooling effect. Since temperature monitoring logged soil temperature at hourly intervals it is possible that high irrigation treatments produced short term drops in temperature that would not be detected by the type of monitoring carried out. Similarly, HDC funded work on chrysanthemum crops grown in soil (PC133), with more frequent logging intervals, has indicated that at the 10cm depth (i.e. where the temperature probe was situated), soil temperature is well buffered against the effects of irrigation water temperature. The effects of different irrigation regimes would also be expected to be dependent on parameters such as soil physical structure and therefore drainage properties and hence the irrigation treatments assessed may have different effects on different sites.

Differences in N:K ratios were noted in soil and leaf samples as a result of the feed treatments applied but they did not appear to have any over-riding influence on production of the varieties assessed.

Conclusion

This experiment has demonstrated the wide variation between *Alstroemeria* varieties to agronomic treatments. Classification of the four varieties assessed in terms of seasonal trends should assist in the prediction of how other varieties, not assessed in the current trial, may respond to the treatments examined.

The irrigation and nutrition treatments applied appeared to have at the most only slight impacts on the soil environment itself (particularly temperature). These treatments have however identified where it may be beneficial to carry out more detailed investigations on irrigation or nutrition levels to manipulate crop production. For Cavalier and Wilhelmina, manipulation irrigation appears likely to produce the greatest benefits, whilst for Libelle nutrition appeared to have the greatest impact. For Samora there appears scope for improving both irrigation and nutrition over the current standard practice.

Despite identifying differences relating to treatments in terms of crop production, it is clear from the seasonal patterns of production that none of the treatments had a significant impact on the timing of flowering peaks and troughs, which was one of the aims of the experiment. It seems likely that larger treatment differences may be necessary to achieve such effects.

Appendix I

Volumes of water applied to experimental plots

Appendix I

Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
11/18/93	5.0	5.0	5.0	5.0	5.0	5.0
12/18/93	5.0	5.0	5.0	5.0	5.0	5.0
01/19/94	5.0	5.0	5.0	5.0	5.0	5.0
01/31/94	5.0	5.0	5.0	5.0	5.0	5.0
02/18/94	5.0	5.0	6.2	6.2	5.0	5.0
03/08/94	5.0	5.0	6.2	6.2	5.0	5.0
03/18/94	5.0	5.0	6.2	6.2	5.0	5.0
03/23/94	5.0	5.0	6.2	6.2	5.0	5.0
03/30/94	5.0	5.0	6.2	6.2	5.0	5.0
04/06/94	5.0	5.0	6.2	6.2	5.0	5.0
04/12/94	5.0	5.0	6.2	6.2	5.0	5.0
04/20/94	5.0	5.0	6.2	6.2	5.0	5.0
04/26/94	5.0	5.0	6.2	6.2	5.0	5.0
04/29/94	5.0	5.0	6.2	6.2	5.0	5.0
05/03/94	5.0	5.0	6.2	6.2	5.0	5.0
05/06/94	5.0	5.0	6.2	6.2	5.0	5.0
05/09/94	5.0	5.0	6.2	6.2	5.0	5.0
05/11/94	5.0	5.0	6.2	6.2	5.0	5.0
05/13/94	5.0	5.0	6.2	6.2	5.0	5.0
05/16/94	5.0	5.0	6.2	6.2	5.0	5.0
05/18/94	5.0	5.0	6.2	6.2	5.0	5.0
05/20/94	7.6	7.6	9.4	9.4	7.6	7.6
05/23/94	7.6	7.6	9.4	9.4	7.6	7.6
05/25/94	7.6	7.6	9.4	9.4	7.6	7.6
05/27/94	7.6	7.6	9.4	9.4	7.6	7.6
05/30/94	7.6	7.6	9.4	9.4	7.6	7.6
06/01/94	10.0	10.0	13.8	13.8	10.0	10.0
06/03/94	10.0	10.0	13.8	13.8	10.0	10.0
06/06/94	10.0	10.0	13.8	13.8	10.0	10.0
06/08/94	10.0	10.0	13.8	13.8	10.0	10.0
06/10/94	10.0	10.0	13.8	13.8	10.0	10.0
06/13/94	10.0	10.0	13.8	13.8	10.0	10.0
06/15/94	10.0	10.0	13.8	13.8	10.0	10.0
06/17/94	10.0	10.0	13.8	13.8	10.0	10.0
06/20/94	10.0	10.0	13.8	13.8	10.0	10.0
06/22/94	10.0	10.0	13.8	13.8	10.0	10.0
06/24/94	10.0	10.0	13.8	13.8	10.0	10.0
06/28/94	10.0	10.0	13.8	13.8	10.0	10.0
06/30/94	10.0	10.0	13.8	13.8	10.0	10.0
07/01/94	10.0	10.0	13.8	13.8	10.0	10.0
07/04/94	10.0	10.0	13.8	13.8	10.0	10.0
07/07/94	10.0	10.0	13.8	13.8	10.0	10.0
07/08/94	10.0	10.0	13.8	13.8	10.0	10.0
07/11/94	10.0	10.0	13.8	13.8	10.0	10.0
07/13/94	10.0	10.0	13.8	13.8	10.0	10.0
07/15/94	10.0	10.0	13.8	13.8	10.0	10.0
07/18/94	10.0	10.0	13.8	13.8	10.0	10.0
07/20/94	10.0	10.0	13.8	13.8	10.0	10.0
07/22/94	10.0	10.0	13.8	13.8	10.0	10.0

Appendix I

Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
07/25/94	10.0	10.0	13.8	13.8	10.0	10.0
07/28/94	10.0	10.0	13.8	13.8	10.0	10.0
07/29/94	10.0	10.0	13.8	13.8	10.0	10.0
08/01/94	10.0	10.0	13.8	13.8	10.0	10.0
08/03/94	10.0	10.0	13.8	13.8	10.0	10.0
08/05/94	10.0	10.0	13.8	13.8	10.0	10.0
08/08/94	10.0	10.0	13.8	13.8	10.0	10.0
08/11/94	10.0	10.0	13.8	13.8	10.0	10.0
08/12/94	10.0	10.0	13.8	13.8	10.0	10.0
08/15/94	10.0	10.0	13.8	13.8	10.0	10.0
08/18/94	10.0	10.0	13.8	13.8	10.0	10.0
08/19/94	10.0	10.0	13.8	13.8	10.0	10.0
08/22/94	10.0	10.0	13.8	13.8	10.0	10.0
08/24/94	10.0	10.0	13.8	13.8	10.0	10.0
08/26/94	10.0	10.0	13.8	13.8	10.0	10.0
08/29/94	10.0	10.0	13.8	13.8	10.0	10.0
08/31/94	10.0	10.0	13.8	13.8	10.0	10.0
09/02/94	10.0	10.0	13.8	13.8	10.0	10.0
09/05/94	10.0	10.0	13.8	13.8	10.0	10.0
09/08/94	10.0	10.0	13.8	13.8	10.0	10.0
09/09/94	10.0	10.0	13.8	13.8	10.0	10.0
09/12/94	10.0	10.0	13.8	13.8	10.0	10.0
09/14/94	10.0	10.0	13.8	13.8	10.0	10.0
09/16/94	10.0	10.0	13.8	13.8	10.0	10.0
09/19/94	10.0	10.0	13.8	13.8	10.0	10.0
09/21/94	10.0	10.0	13.8	13.8	10.0	10.0
09/23/94	10.0	10.0	13.8	13.8	10.0	10.0
09/26/94	10.0	10.0	13.8	13.8	10.0	10.0
09/28/94	10.0	10.0	13.8	13.8	10.0	10.0
10/03/94	10.0	10.0	13.8	13.8	10.0	10.0
10/07/94	10.0	10.0	13.8	13.8	10.0	10.0
10/11/94	10.0	10.0	13.8	13.8	10.0	10.0
10/13/94	10.0	10.0	13.8	13.8	10.0	10.0
10/17/94	10.0	10.0	13.8	13.8	10.0	10.0
10/21/94	10.0	10.0	13.8	13.8	10.0	10.0
10/24/94	7.6	7.6	9.4	9.4	7.6	7.6
10/27/94	7.6	7.6	9.4	9.4	7.6	7.6
10/31/94	5.0	5.0	6.2	6.2	5.0	5.0
11/04/94	5.0	5.0	6.2	6.2	5.0	5.0
11/07/09	5.0	5.0	6.2	6.2	5.0	5.0
11/11/94	5.0	5.0	6.2	6.2	5.0	5.0
11/14/94	0.0	0.0	0.0	0.0	0.0	0.0
11/18/94	5.0	5.0	6.2	6.2	5.0	5.0
11/25/94	5.0	5.0	6.2	6.2	5.0	5.0
12/09/94	5.0	5.0	6.2	6.2	5.0	5.0
12/22/94	5.0	5.0	6.2	6.2	5.0	5.0
01/20/95	5.0	5.0	6.2	6.2	5.0	5.0
02/23/95	5.0	5.0	6.2	6.2	5.0	5.0
03/08/95	5.0	5.0	6.2	6.2	3.8	7.4

Appendix I

Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
03/13/95	7.4	7.4	9.3	9.3	5.7	9.3
03/20/95	7.4	7.4	9.3	9.3	5.7	9.3
03/27/95	7.4	7.4	9.3	9.3	5.7	9.3
04/03/95	7.4	7.4	9.3	9.3	5.7	9.3
04/06/95	10.0	10.0	13.8	13.8	7.6	14.9
04/10/95	10.0	10.0	13.8	13.8	7.6	14.9
04/13/95	10.0	10.0	13.8	13.8	7.6	14.9
04/17/95	10.0	10.0	13.8	13.8	7.6	14.9
04/20/95	10.0	10.0	13.8	13.8	7.6	14.9
04/24/95	10.0	10.0	13.8	13.8	7.6	14.9
04/27/95	10.0	10.0	13.8	13.8	7.6	14.9
05/01/95	10.0	10.0	13.8	13.8	7.6	14.9
05/04/95	10.0	10.0	13.8	13.8	7.6	14.9
05/08/95	10.0	10.0	13.8	13.8	7.6	14.9
05/11/95	10.0	10.0	13.8	13.8	7.6	14.9
05/15/95	10.0	10.0	13.8	13.8	7.6	14.9
05/18/95	10.0	10.0	13.8	13.8	7.6	14.9
05/22/95	10.0	10.0	13.8	13.8	7.6	14.9
05/25/95	10.0	10.0	13.8	13.8	7.6	14.9
05/29/95	10.0	10.0	13.8	13.8	7.6	14.9
06/01/95	10.0	10.0	13.8	13.8	7.6	14.9
06/05/95	10.0	10.0	13.8	13.8	7.6	14.9
06/08/95	10.0	10.0	13.8	13.8	7.6	14.9
06/12/95	10.0	10.0	13.8	13.8	7.6	14.9
06/15/95	10.0	10.0	13.8	13.8	7.6	14.9
06/19/95	10.0	10.0	13.8	13.8	7.6	14.9
06/22/95	10.0	10.0	13.8	13.8	7.6	14.9
06/26/95	10.0	10.0	13.8	13.8	7.6	14.9
06/29/95	10.0	10.0	13.8	13.8	7.6	14.9
07/03/95	10.0	10.0	13.8	13.8	7.6	14.9
07/06/95	10.0	10.0	13.8	13.8	7.6	14.9
07/10/95	10.0	10.0	13.8	13.8	7.6	14.9
07/13/95	10.0	10.0	13.8	13.8	7.6	14.9
07/17/95	10.0	10.0	13.8	13.8	7.6	14.9
07/20/95	10.0	10.0	13.8	13.8	7.6	14.9
07/24/95	10.0	10.0	13.8	13.8	7.6	14.9
07/27/95	10.0	10.0	13.8	13.8	7.6	14.9
07/31/95	10.0	10.0	13.8	13.8	7.6	14.9
08/03/95	10.0	10.0	13.8	13.8	7.6	14.9
08/07/95	10.0	10.0	13.8	13.8	7.6	14.9
08/10/95	10.0	10.0	13.8	13.8	7.6	14.9
08/14/95	10.0	10.0	13.8	13.8	7.6	14.9
08/17/95	10.0	10.0	13.8	13.8	7.6	14.9
08/21/95	10.0	10.0	13.8	13.8	7.6	14.9
08/24/95	10.0	10.0	13.8	13.8	7.6	14.9
08/28/95	10.0	10.0	13.8	13.8	7.6	14.9
08/31/95	10.0	10.0	13.8	13.8	7.6	14.9
09/04/95	10.0	10.0	13.8	13.8	7.6	14.9
09/07/95	10.0	10.0	13.8	13.8	7.6	14.9

Appendix I

Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
09/11/95	10.0	10.0	13.8	13.8	7.6	14.9
09/14/95	10.0	10.0	13.8	13.8	7.6	14.9
09/18/95	10.0	10.0	13.8	13.8	7.6	14.9
09/21/95	5.0	5.0	6.2	6.2	3.8	7.4
09/25/95	5.0	5.0	6.2	6.2	3.8	7.4
09/28/95	5.0	5.0	6.2	6.2	3.8	7.4
10/02/95	5.0	5.0	5.0	5.0	5.0	5.0
10/06/95	5.0	5.0	5.0	5.0	5.0	5.0
10/09/95	5.0	5.0	5.0	5.0	5.0	5.0
10/12/95	5.0	5.0	5.0	5.0	5.0	5.0
10/16/95	5.0	10.0	5.0	5.0	5.0	5.0
10/19/95	5.0	5.0	5.0	5.0	5.0	0.0
10/22/95	5.0	5.0	5.0	5.0	5.0	0.0
10/27/95	5.0	5.0	5.0	5.0	5.0	5.0
10/30/95	5.0	5.0	5.0	5.0	5.0	5.0
11/02/95	5.0	5.0	5.0	5.0	5.0	5.0
11/06/95	5.0	5.0	5.0	5.0	5.0	5.0
11/13/95	5.0	5.0	5.0	5.0	5.0	5.0
11/20/95	5.0	5.0	5.0	5.0	5.0	5.0
11/27/95	5.0	5.0	5.0	5.0	5.0	5.0
12/04/95	5.0	5.0	5.0	5.0	5.0	5.0
12/11/95	5.0	5.0	5.0	5.0	5.0	5.0
12/18/95	5.0	5.0	5.0	5.0	5.0	5.0
12/25/95	5.0	5.0	5.0	5.0	5.0	5.0
01/01/96	5.0	5.0	5.0	5.0	5.0	5.0
01/08/96	5.0	5.0	5.0	5.0	5.0	5.0
01/15/96	5.0	5.0	5.0	5.0	5.0	5.0
01/22/96	5.0	5.0	5.0	5.0	5.0	5.0
01/29/96	5.0	5.0	5.0	5.0	5.0	5.0
02/05/96	5.0	5.0	5.0	5.0	5.0	5.0
02/12/96	5.0	5.0	5.0	5.0	5.0	5.0
02/22/96	5.0	5.0	5.0	5.0	5.0	5.0
02/26/96	5.0	5.0	5.0	5.0	5.0	5.0
03/04/96	5.0	5.0	5.0	5.0	5.0	5.0
03/11/96	7.6	7.6	9.5	9.5	5.6	10.0
03/18/96	7.6	7.6	9.5	9.5	5.6	10.0
03/25/96	7.6	7.6	9.5	9.5	5.6	10.0
04/01/96	7.6	7.6	9.5	9.5	5.6	10.0
04/08/96	10.0	10.0	12.4	12.4	7.6	15.0
04/11/96	10.0	10.0	12.4	12.4	7.6	15.0
04/15/96	10.0	10.0	12.4	12.4	7.6	15.0
04/18/96	10.0	10.0	12.4	12.4	7.6	15.0
04/22/96	10.0	10.0	12.4	12.4	7.6	15.0
04/25/96	10.0	10.0	12.4	12.4	7.6	15.0
04/29/96	10.0	10.0	12.4	12.4	7.6	15.0
05/03/96	10.0	10.0	12.4	12.4	7.6	15.0
05/06/96	10.0	10.0	12.4	12.4	7.6	15.0
05/09/96	10.0	10.0	12.4	12.4	7.6	15.0
05/13/96	10.0	10.0	12.4	12.4	7.6	15.0

Appendix I

Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
05/16/96	10.0	10.0	12.4	12.4	7.6	15.0
05/20/96	10.0	10.0	12.4	12.4	7.6	15.0
05/24/96	10.0	10.0	12.4	12.4	7.6	15.0
05/27/96	10.0	10.0	12.4	12.4	7.6	15.0
05/30/96	10.0	10.0	12.4	12.4	7.6	15.0
06/03/96	10.0	10.0	12.4	12.4	7.6	15.0
06/06/96	10.0	10.0	12.4	12.4	7.6	15.0
06/10/96	10.0	10.0	12.4	12.4	7.6	15.0
06/13/96	10.0	10.0	12.4	12.4	7.6	15.0
06/17/96	10.0	10.0	12.4	12.4	7.6	15.0
06/20/96	10.0	10.0	12.4	12.4	7.6	15.0
06/26/96	10.0	10.0	12.4	12.4	7.6	15.0
06/28/96	10.0	10.0	12.4	12.4	7.6	15.0
07/01/96	10.0	10.0	12.4	12.4	7.6	15.0
07/03/96	10.0	10.0	12.4	12.4	7.6	15.0
07/05/96	10.0	10.0	12.4	12.4	7.6	15.0
07/10/96	10.0	10.0	12.4	12.4	7.6	15.0
07/12/96	10.0	10.0	12.4	12.4	7.6	15.0
07/15/96	10.0	10.0	12.4	12.4	7.6	15.0
07/17/96	10.0	10.0	12.4	12.4	7.6	15.0
07/19/96	10.0	10.0	12.4	12.4	7.6	15.0
07/22/96	10.0	10.0	12.4	12.4	7.6	15.0
07/24/96	10.0	10.0	12.4	12.4	7.6	15.0
07/26/96	10.0	10.0	12.4	12.4	7.6	15.0
07/29/96	10.0	10.0	12.4	12.4	7.6	15.0
08/31/96	10.0	10.0	12.4	12.4	7.6	15.0
08/02/96	10.0	10.0	12.4	12.4	7.6	15.0
08/05/96	10.0	10.0	12.4	12.4	7.6	15.0
08/07/96	10.0	10.0	12.4	12.4	7.6	15.0
08/09/96	10.0	10.0	12.4	12.4	7.6	15.0
08/12/96	10.0	10.0	12.4	12.4	7.6	15.0
08/14/96	10.0	10.0	12.4	12.4	7.6	15.0
08/16/96	10.0	10.0	12.4	12.4	7.6	15.0
08/11/96	10.0	10.0	12.4	12.4	7.6	15.0
08/21/96	10.0	10.0	12.4	12.4	7.6	15.0
08/23/96	10.0	10.0	12.4	12.4	7.6	15.0
08/26/96	10.0	10.0	12.4	12.4	7.6	15.0
08/28/96	10.0	10.0	12.4	12.4	7.6	15.0
08/30/96	10.0	10.0	12.4	12.4	7.6	15.0
09/04/96	10.0	10.0	12.4	12.4	7.6	15.0
09/06/96	10.0	10.0	12.4	12.4	7.6	15.0
09/09/96	10.0	10.0	12.4	12.4	7.6	15.0
09/11/96	10.0	10.0	12.4	12.4	7.6	15.0
09/13/96	10.0	10.0	12.4	12.4	7.6	15.0
09/16/96	10.0	10.0	12.4	12.4	7.6	15.0
09/18/96	10.0	10.0	12.4	12.4	7.6	15.0
09/20/96	10.0	10.0	12.4	12.4	7.6	15.0
09/23/96	10.0	10.0	12.4	12.4	7.6	15.0
09/25/96	10.0	10.0	12.4	12.4	7.6	15.0

Appendix I

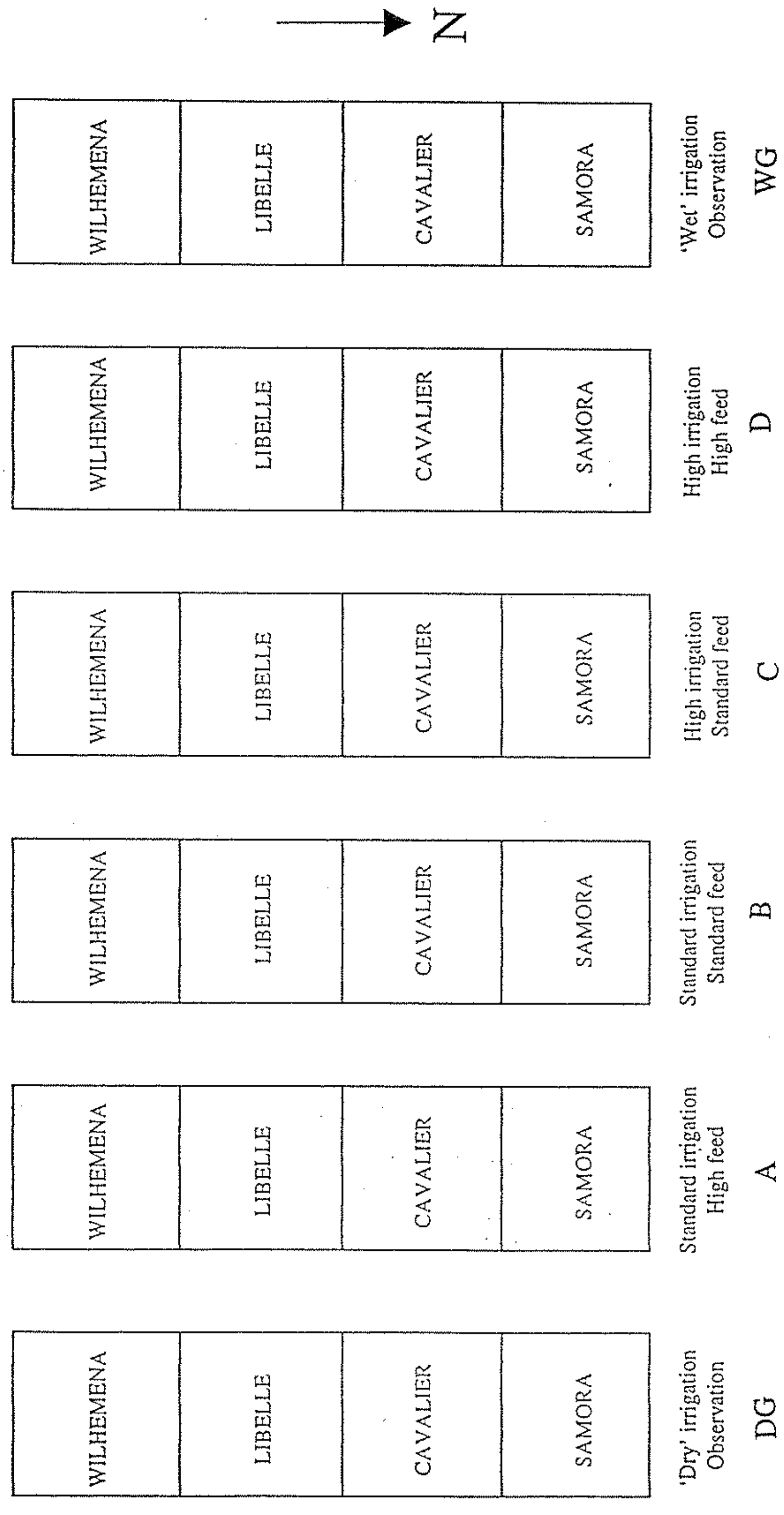
Volume of irrigation water supplied (in litres/m²):						
	Treatment:					
Date	A	B	C	D	G1	G2
09/27/96	10.0	10.0	12.4	12.4	7.6	15.0
09/30/96	7.6	7.6	9.4	9.4	5.7	11.3
10/03/96	7.6	7.6	9.4	9.4	5.7	11.3
10/07/96	7.6	7.6	9.4	9.4	5.7	11.3
10/10/96	7.6	7.6	9.4	9.4	5.7	11.3
10/14/96	7.6	7.6	9.4	9.4	5.7	11.3
10/21/96	7.6	7.6	9.4	9.4	5.7	11.3
10/28/96	7.6	7.6	9.4	9.4	5.7	11.3
11/06/96	7.6	7.6	9.4	9.4	5.7	11.3
11/11/96	7.6	7.6	9.4	9.4	5.7	11.3
11/19/96	7.6	7.6	9.4	9.4	5.7	11.3
11/25/96	7.6	7.6	9.4	9.4	5.7	11.3
12/02/96	0.0	0.0	0.0	0.0	0.0	0.0
12/06/96	0.0	0.0	0.0	0.0	0.0	0.0
12/09/96	0.0	0.0	0.0	0.0	0.0	0.0
12/12/96	0.0	0.0	0.0	0.0	0.0	0.0

Appendix II

Trial layout plan

Appendix II

Appendix II: Trial Layout

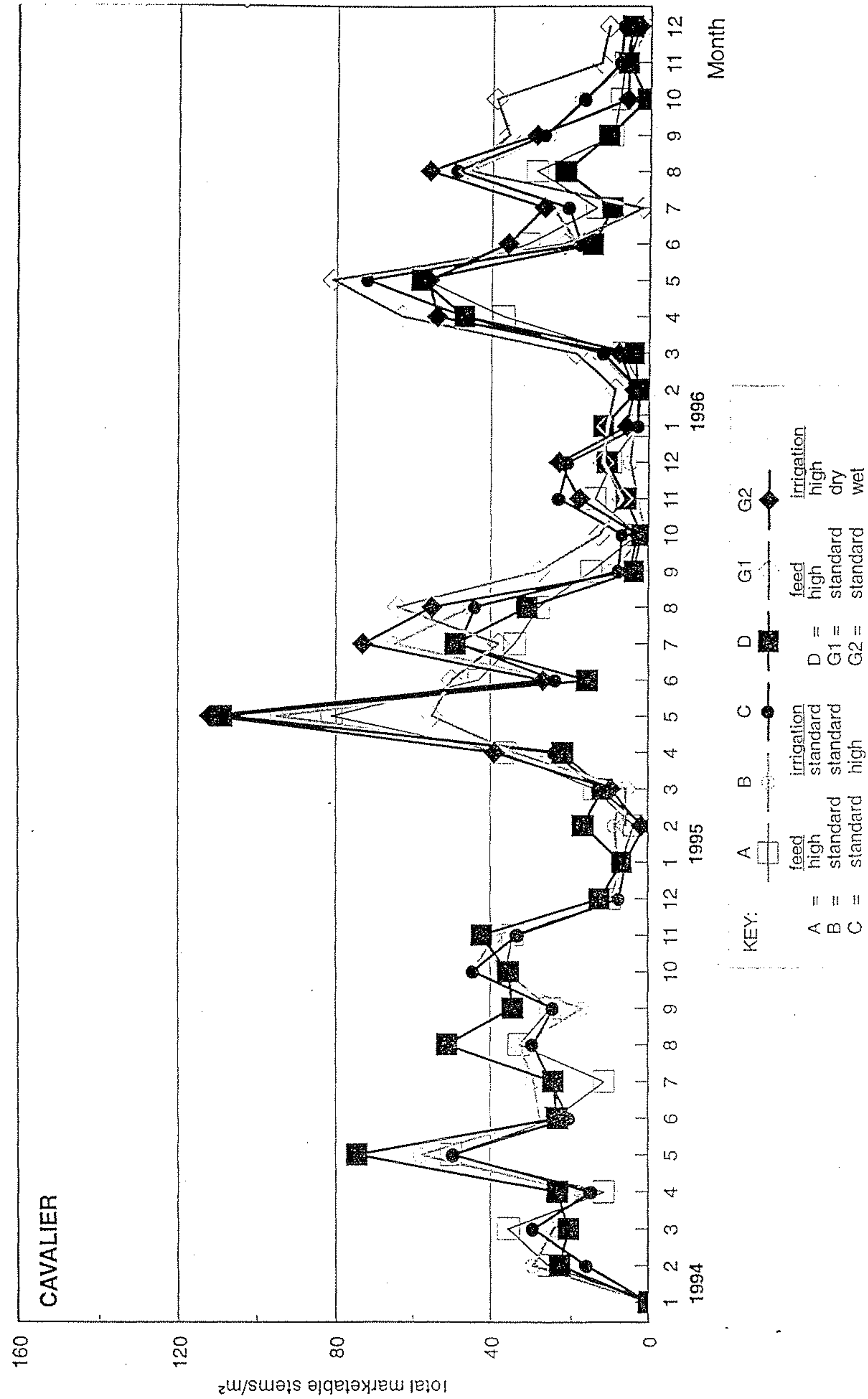


Appendix III

Seasonal and treatment effects on crop production – figures

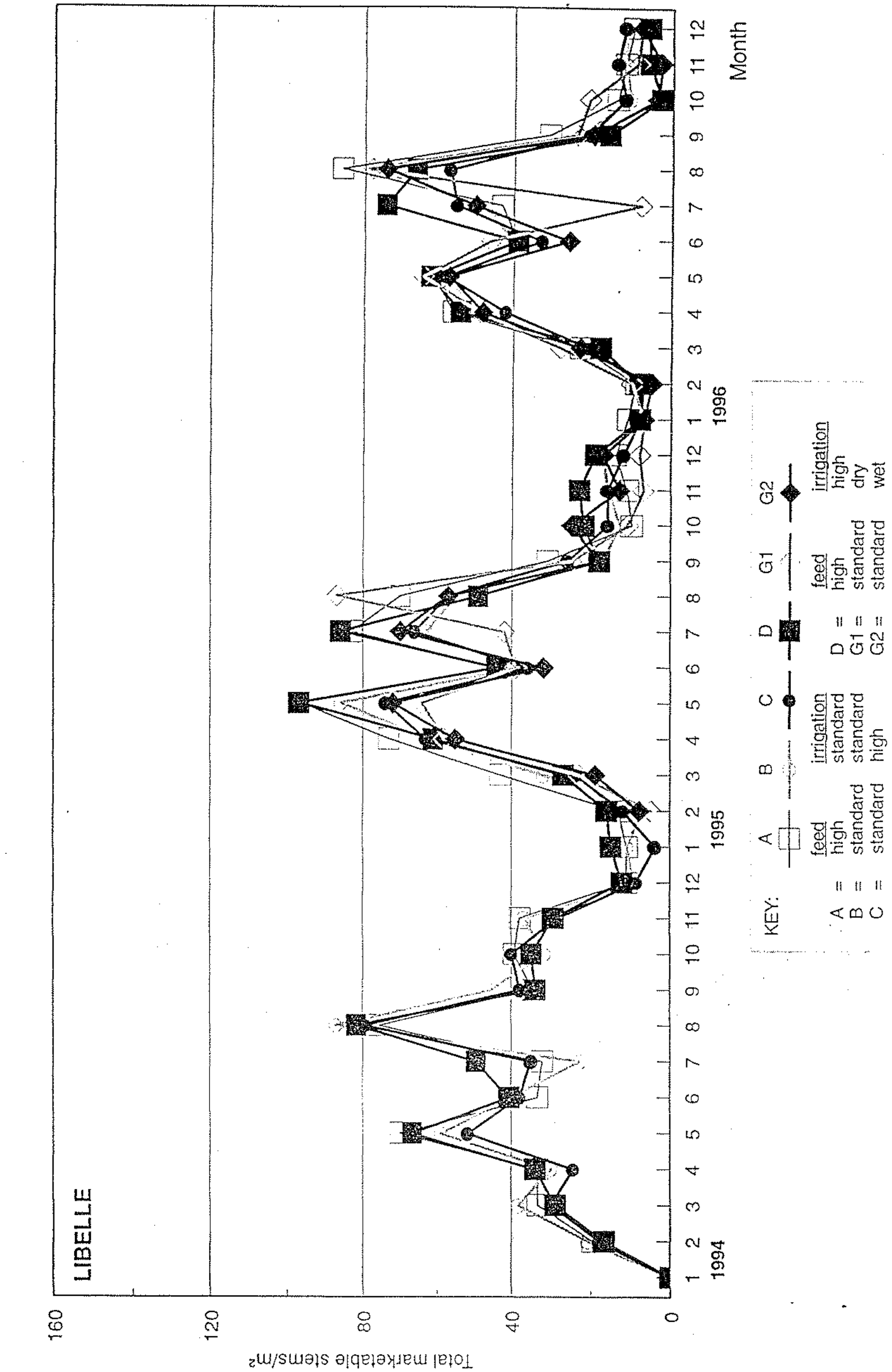
Appendix III

Figure 1. Seasonal effects on production of marketable stems



Appendix III

Figure 2. Seasonal effects on production of marketable stems



Appendix III

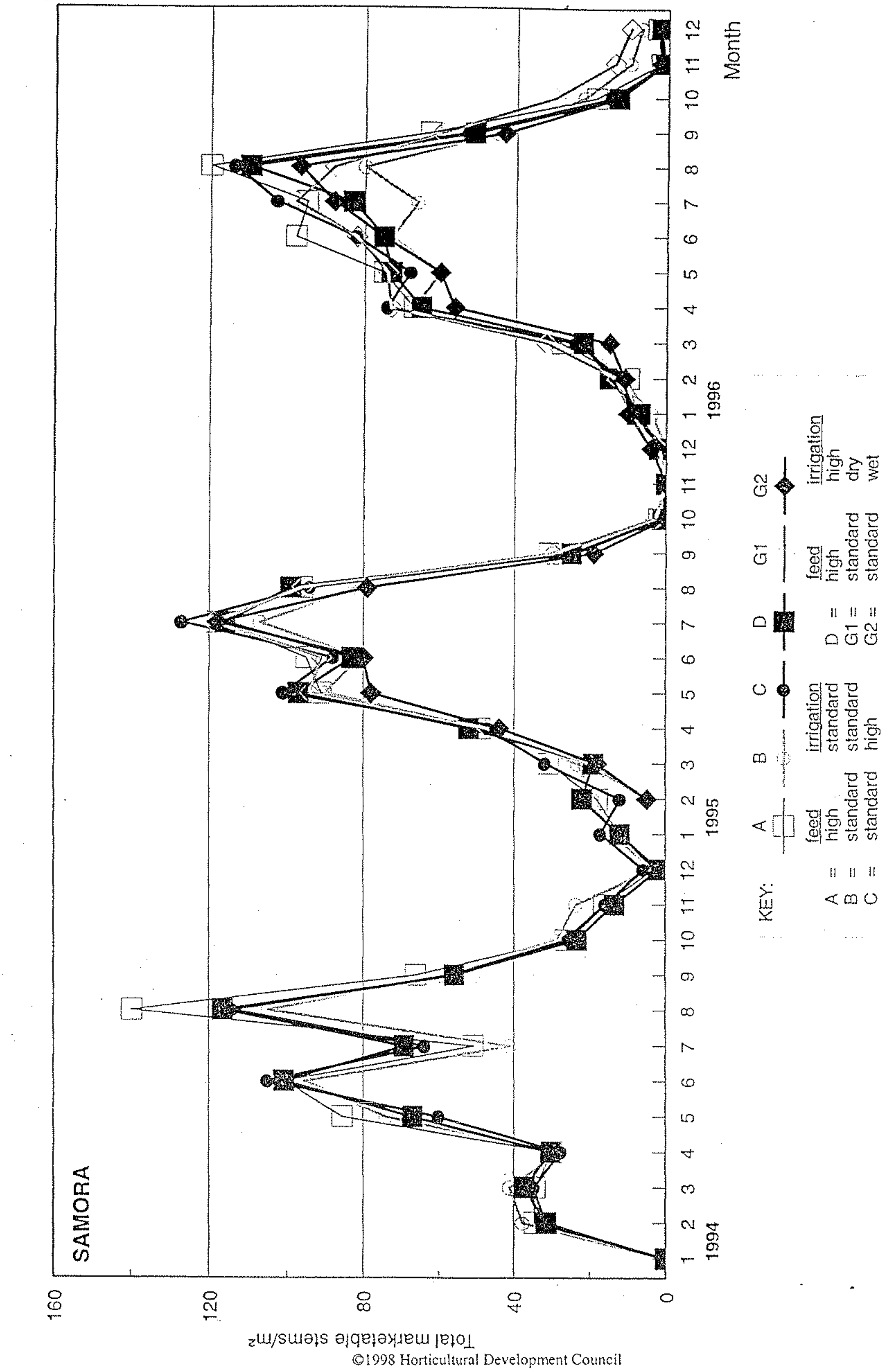
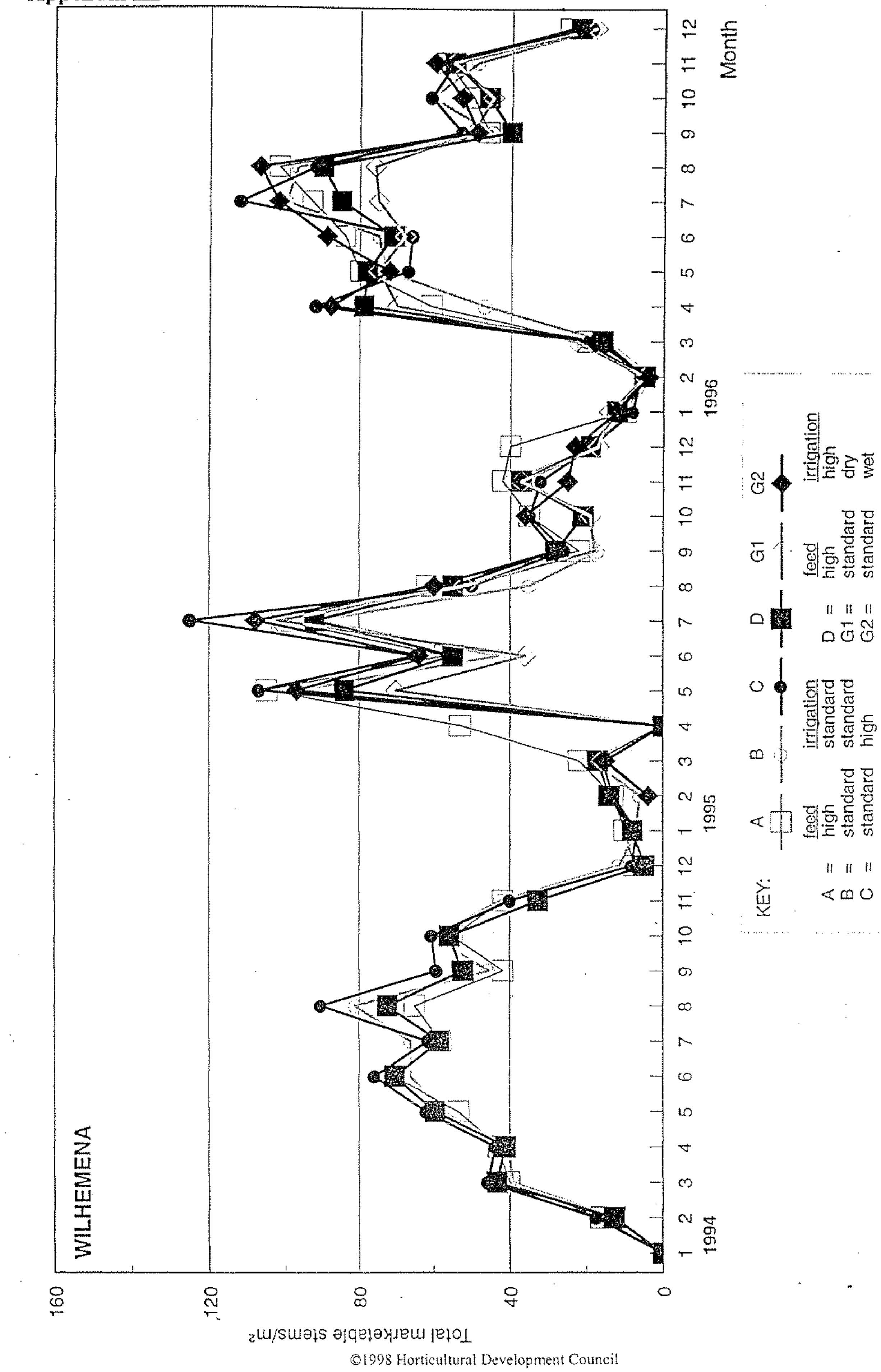


Figure 3. Seasonal effects on production of marketable stems

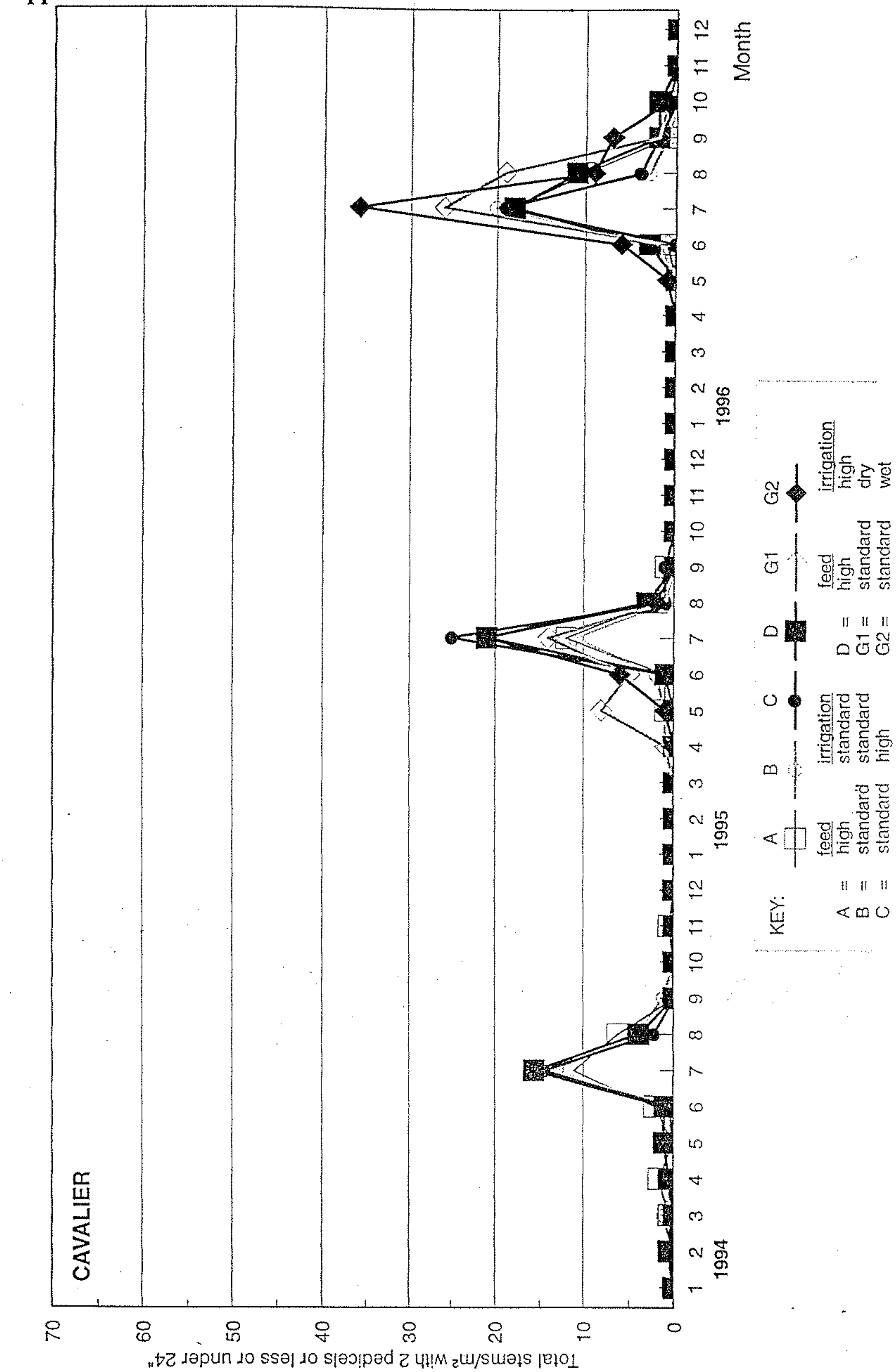
Appendix III

Figure 4. Seasonal effects on production of marketable stems



Appendix III

Figure 5. Seasonal effects on production of short and low quality stems



Appendix III

Figure 6. Seasonal effects on production of short and low quality stems

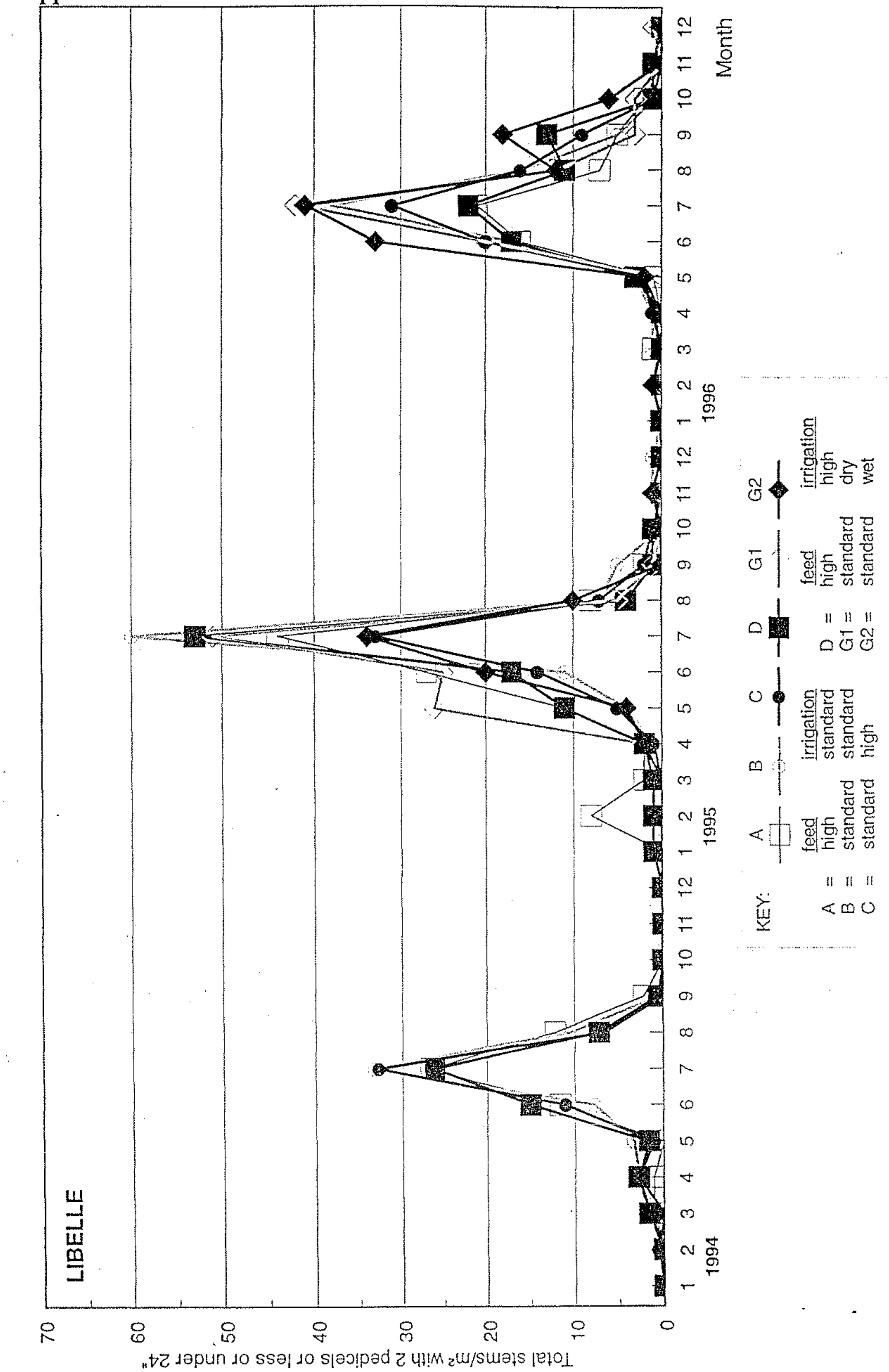
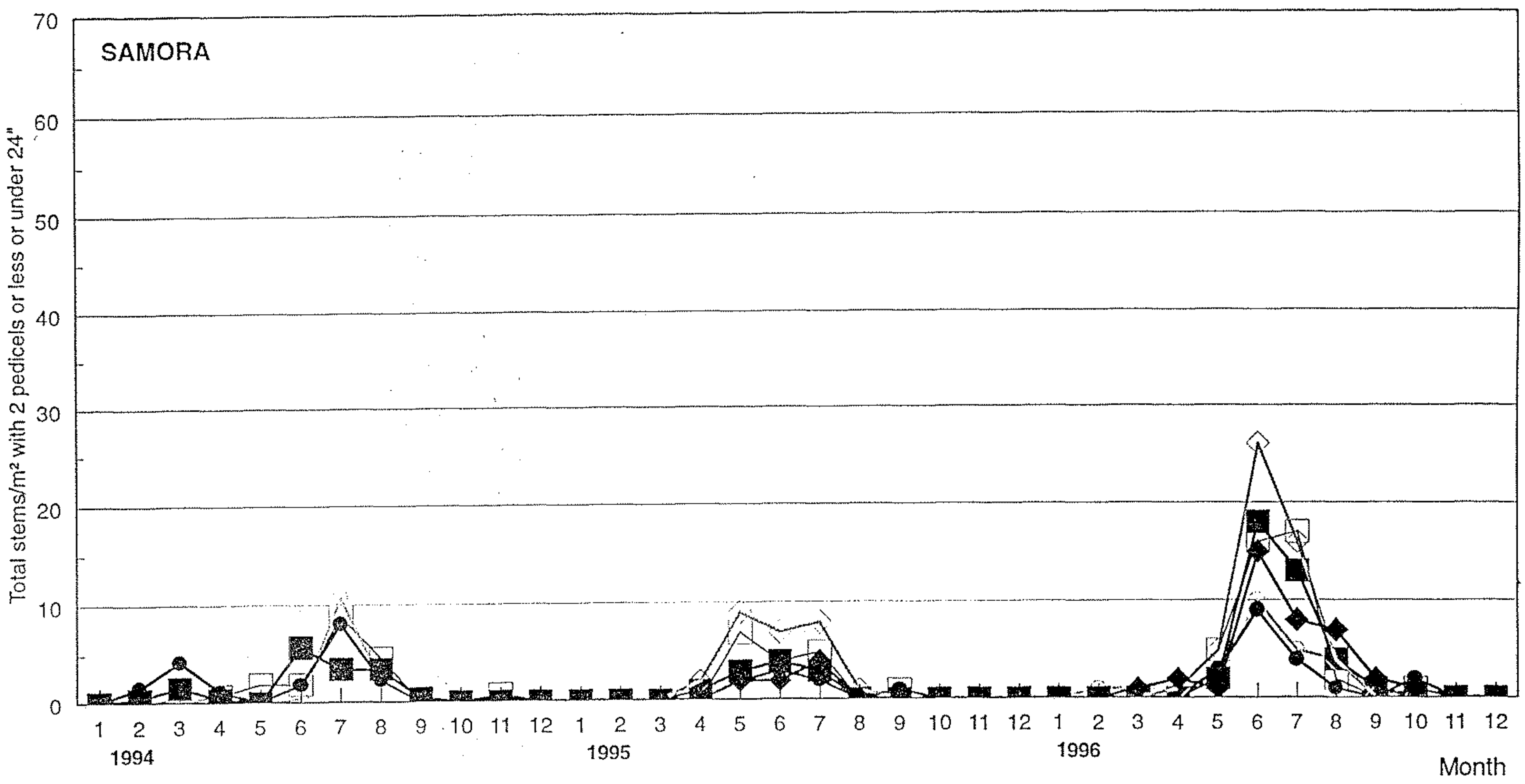
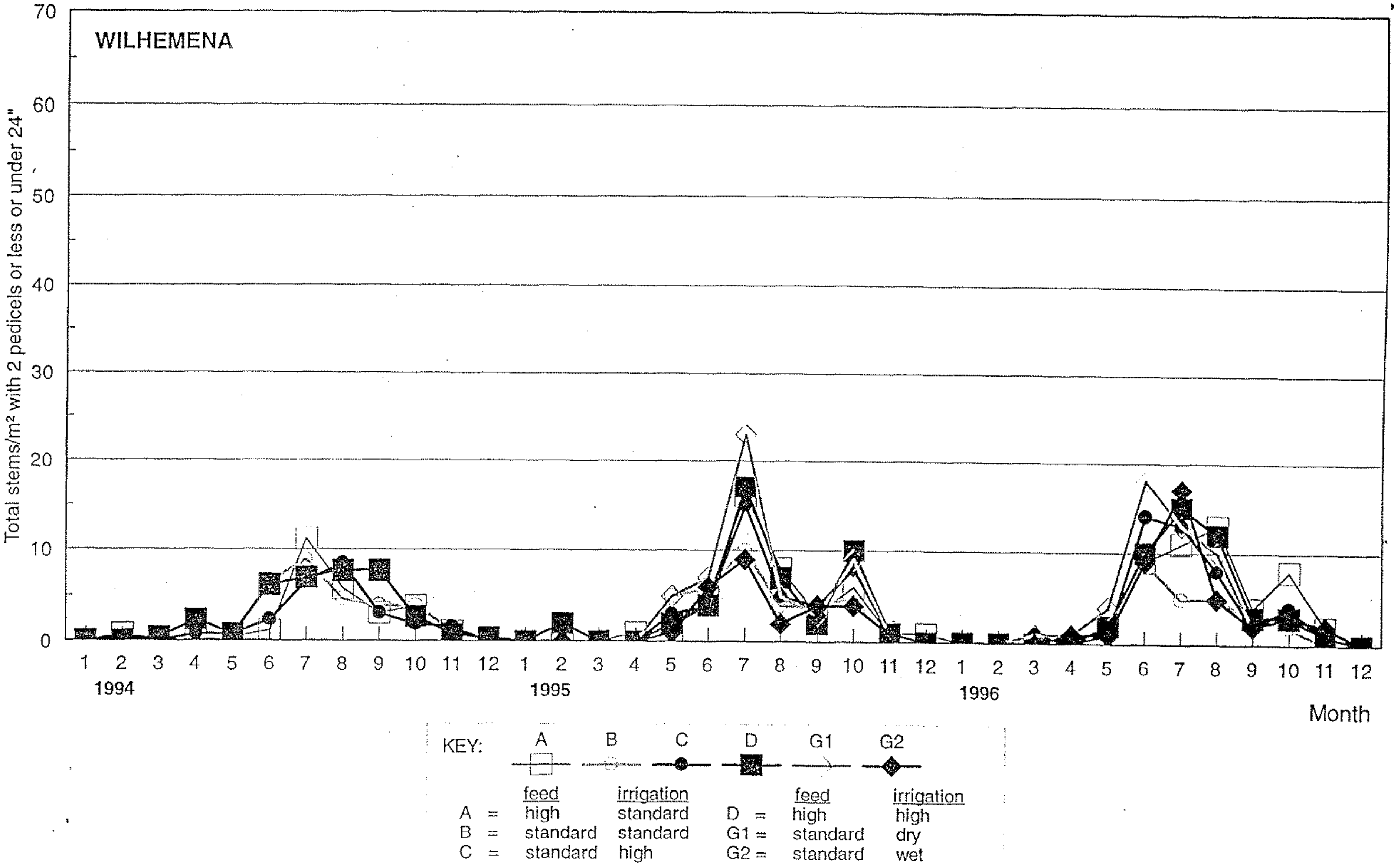


Figure 7. Seasonal effects on production of short and low quality stems



	feed	irrigation		feed	irrigation
A =	high	standard	D =	high	high
B =	standard	standard	G1 =	standard	dry
C =	standard	high	G2 =	standard	wet

Figure 8. Seasonal effects on production of short and low quality stems



Appendix III

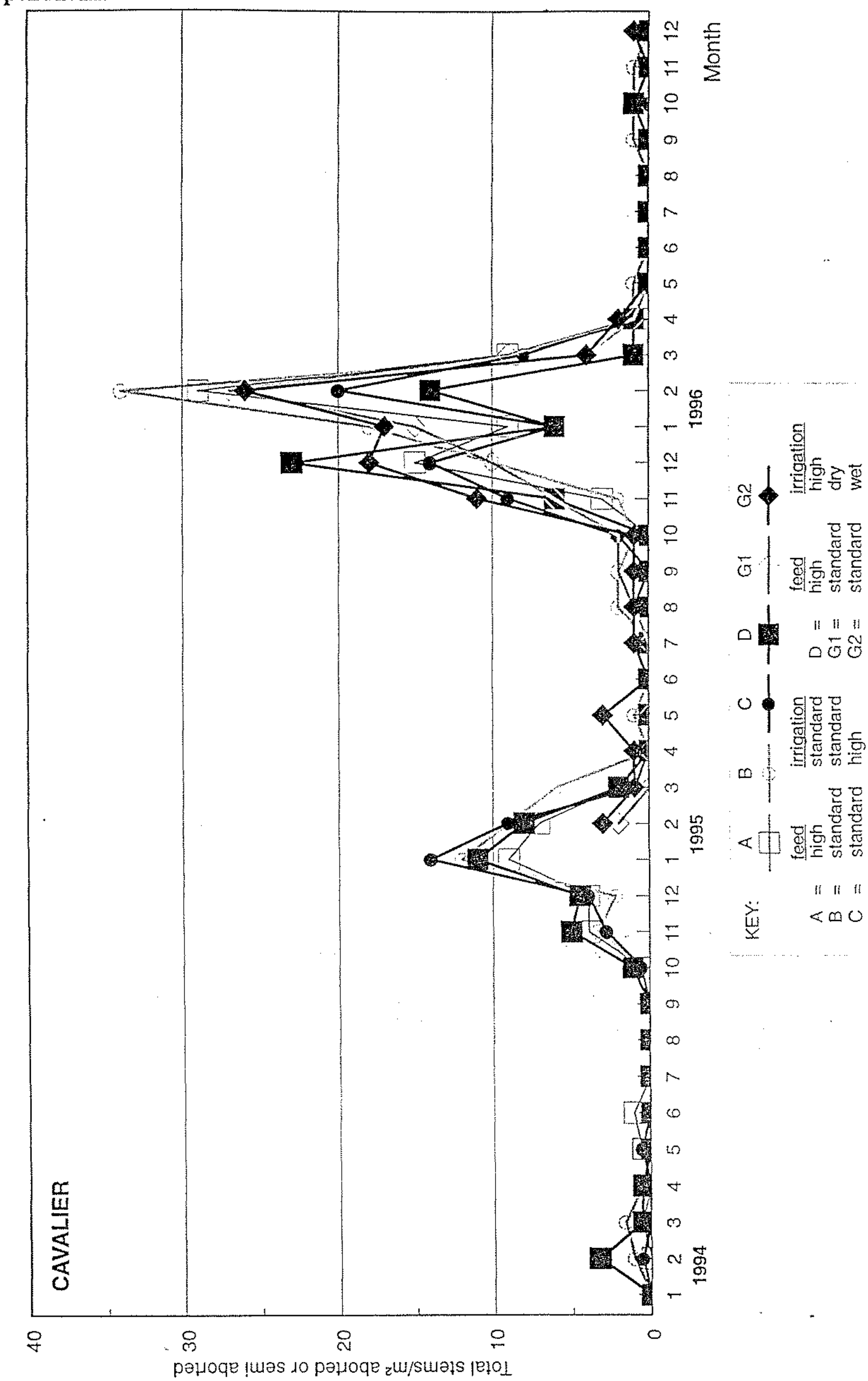
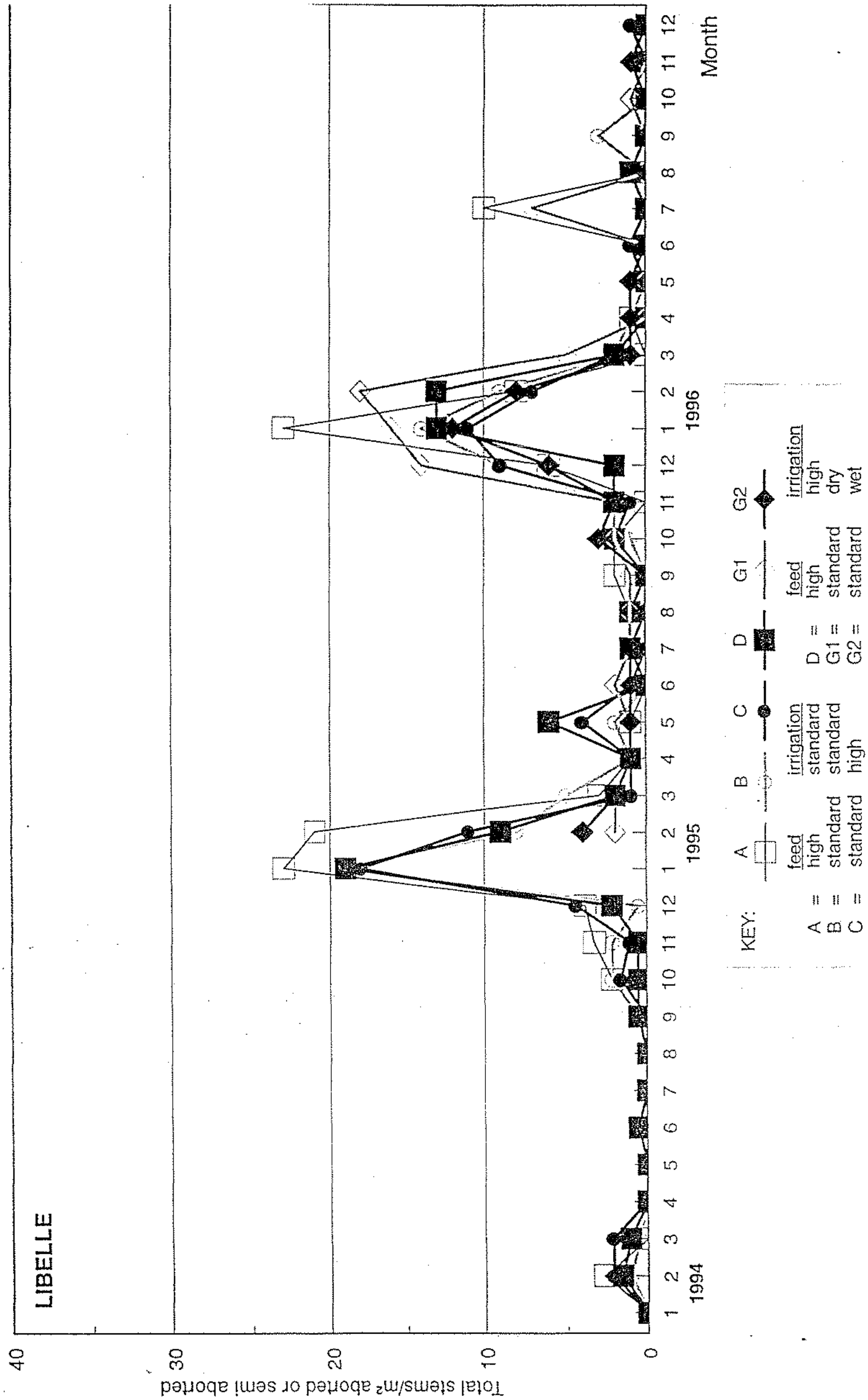


Figure 9. Seasonal effects on production of aborted and semi aborted stems

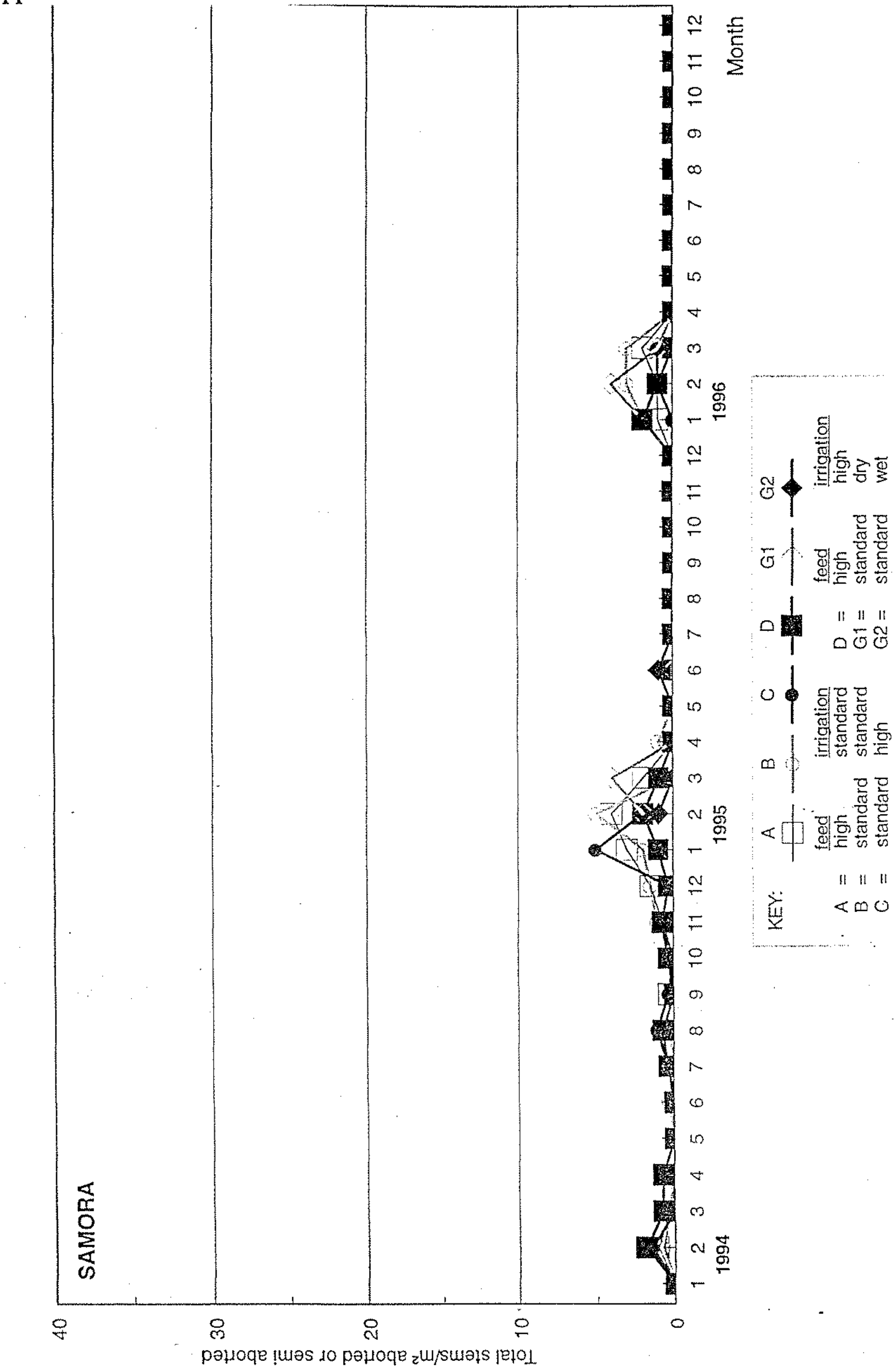
Appendix III

Figure 10. Seasonal effects on production of aborted and semi aborted stems



Appendix III

Figure 11. Seasonal effects on production of aborted and semi aborted stems



Appendix III

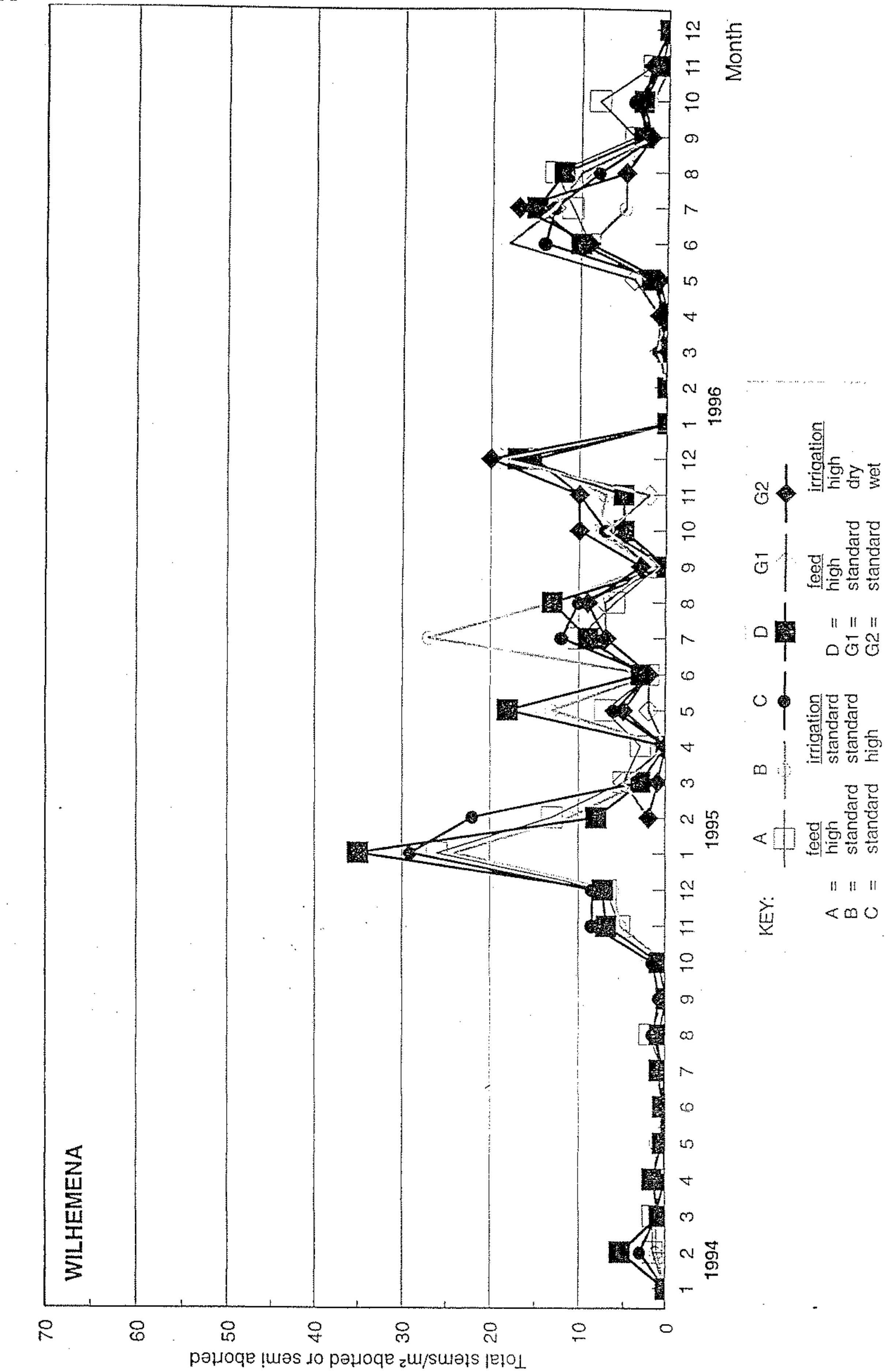


Figure 12. Seasonal effects on production of aborted and semi aborted stems

Figure 13. Seasonal effects on production of vegetative shoots

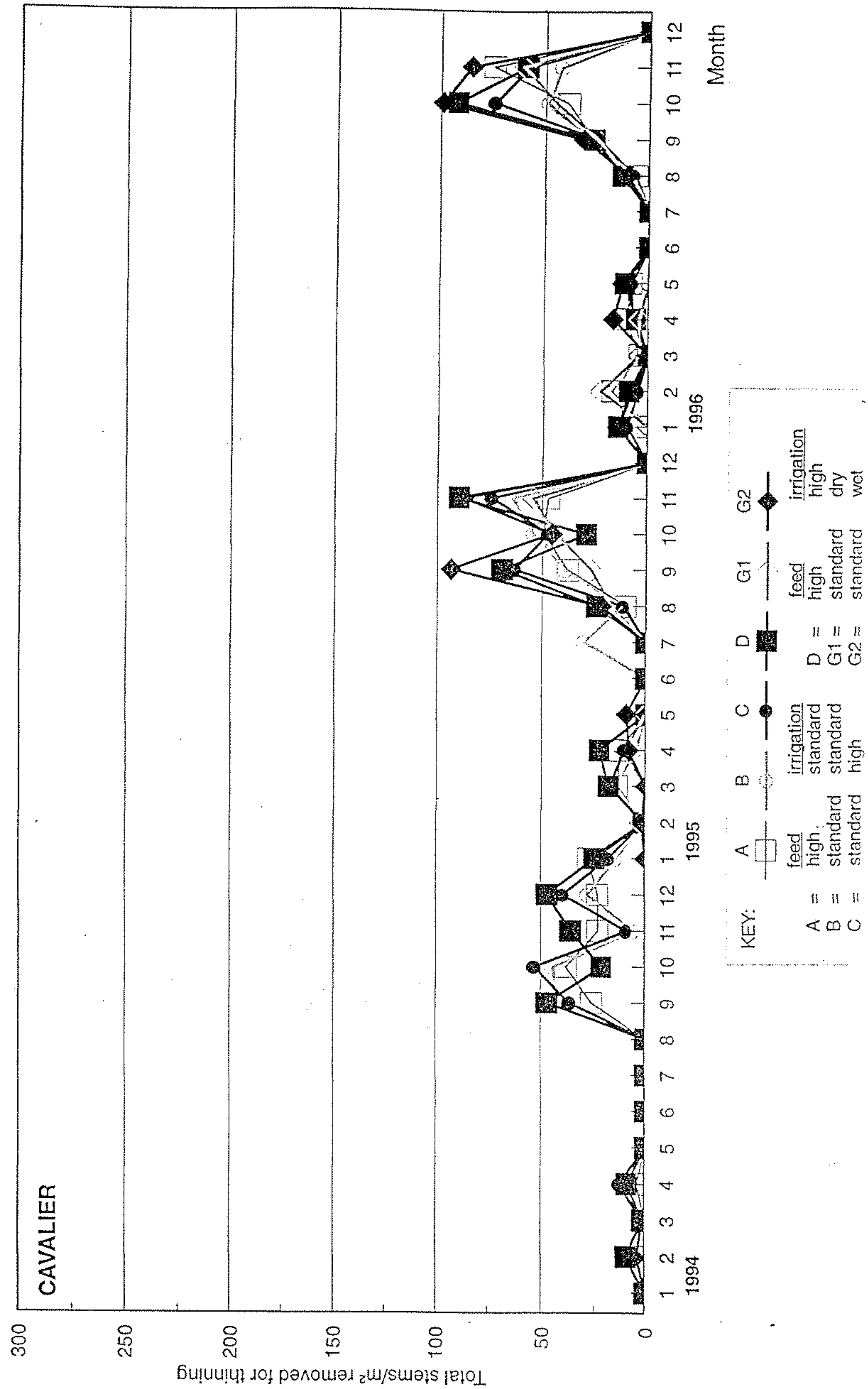
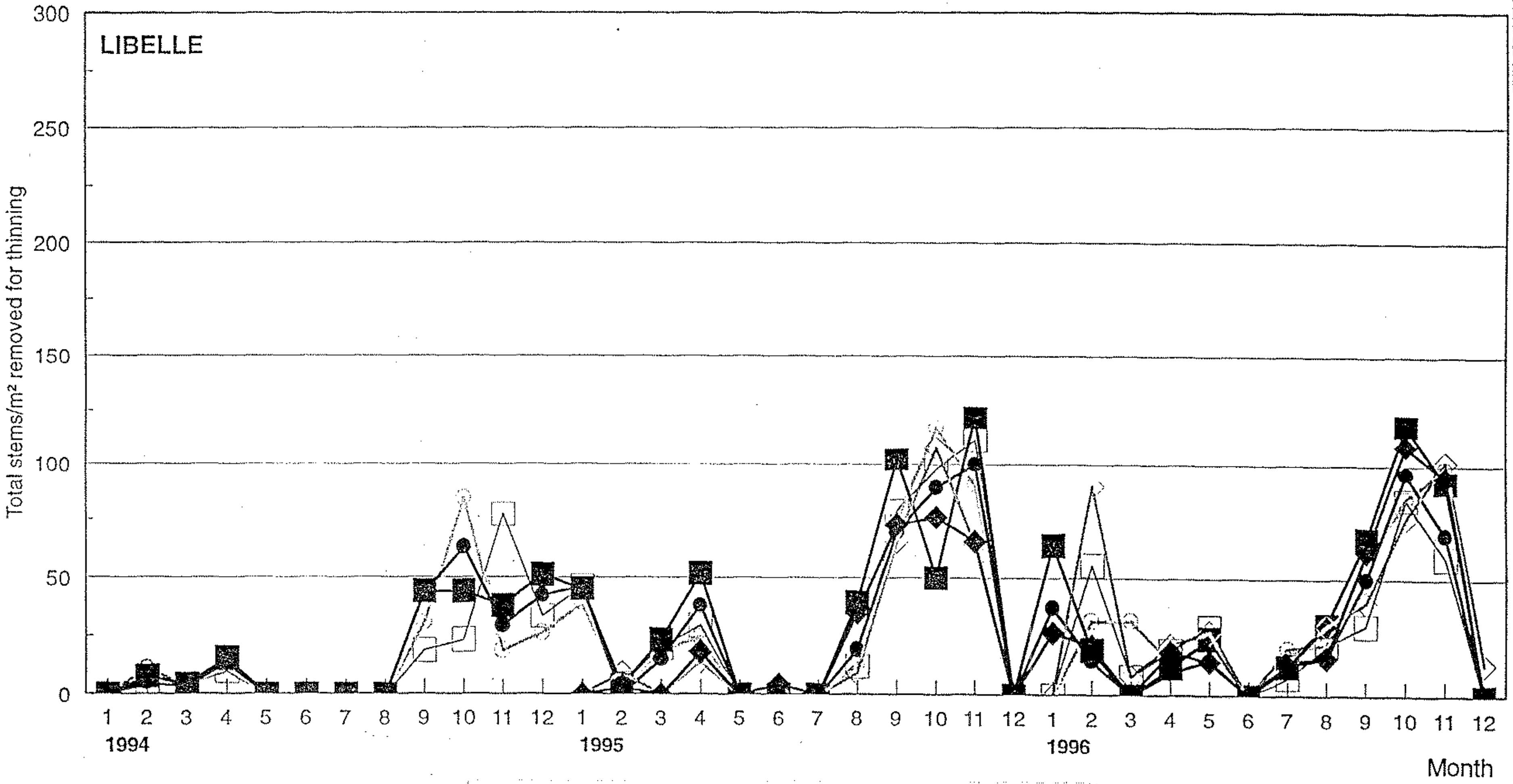


Figure 14. Seasonal effects on production of vegetative shoots



KEY: A B C D G1 G2

	feed	irrigation		feed	irrigation
A =	high	standard	D =	high	high
B =	standard	standard	G1 =	standard	dry
C =	standard	high	G2 =	standard	wet

Appendix III

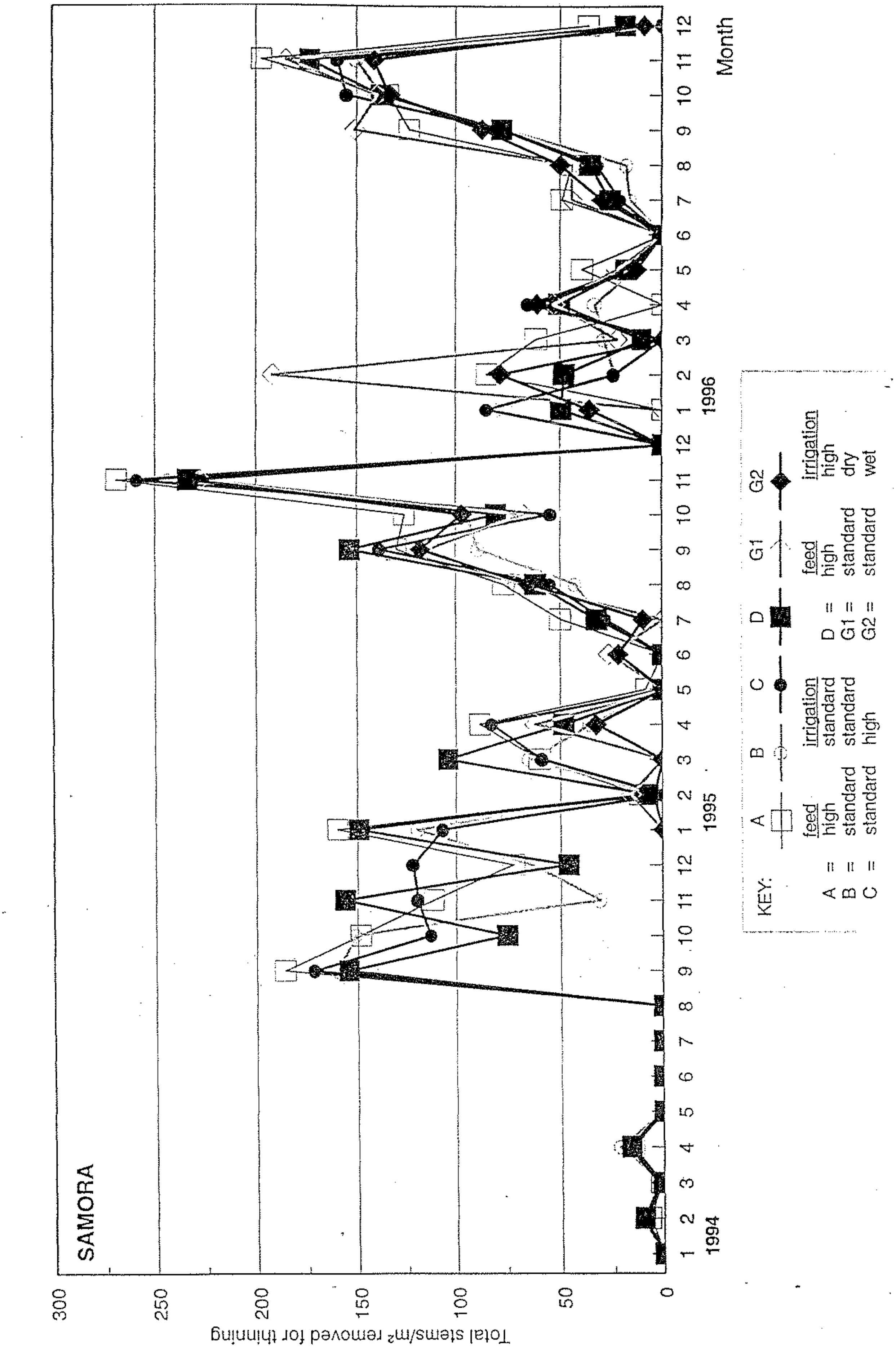


Figure 15 Seasonal effects on production of vegetative shoots

Appendix III

Figure 15 Seasonal effects on production of vegetative shoots

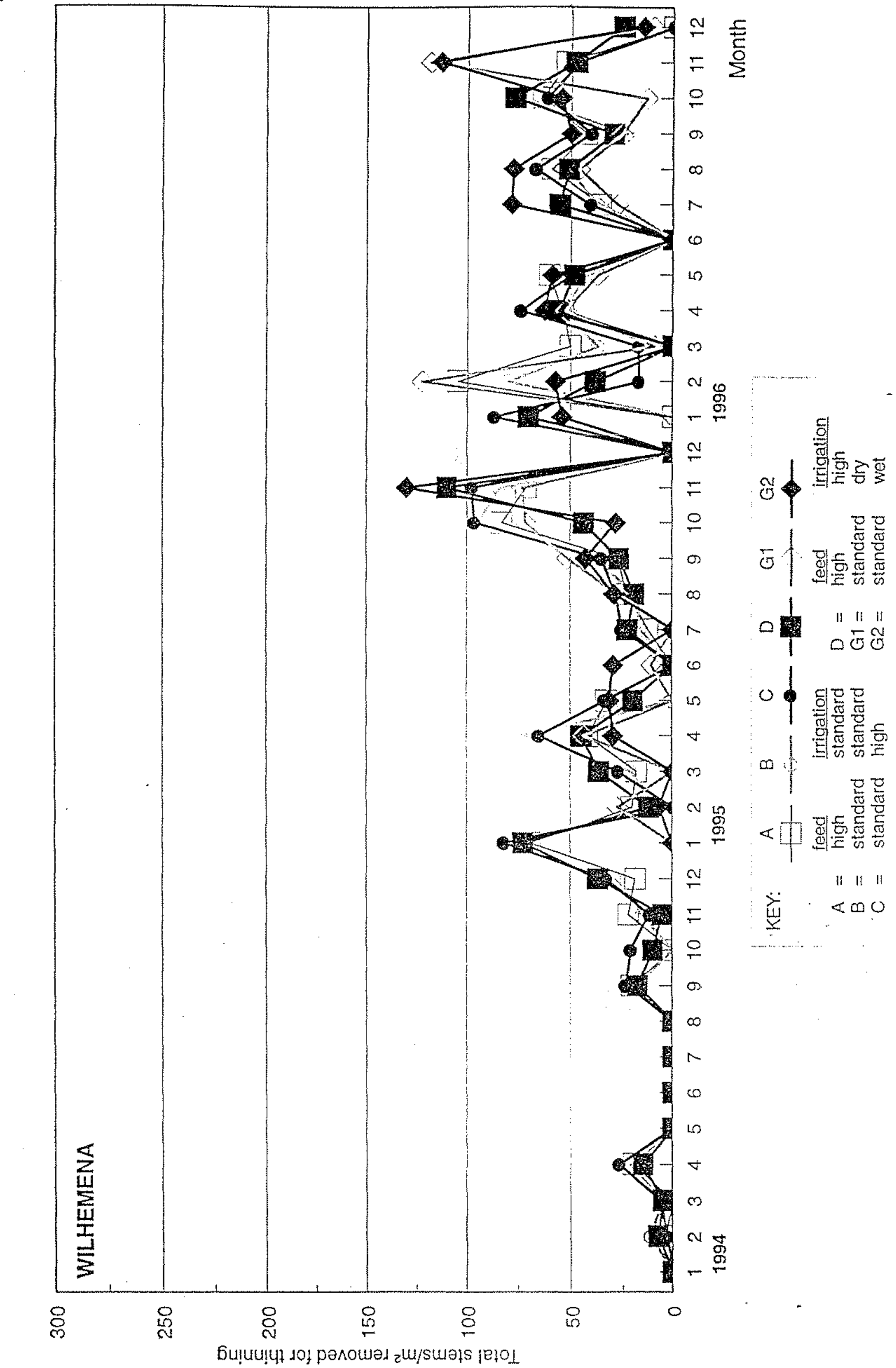


Figure 17. Effects of irrigation and nutrition on production of total marketable stems

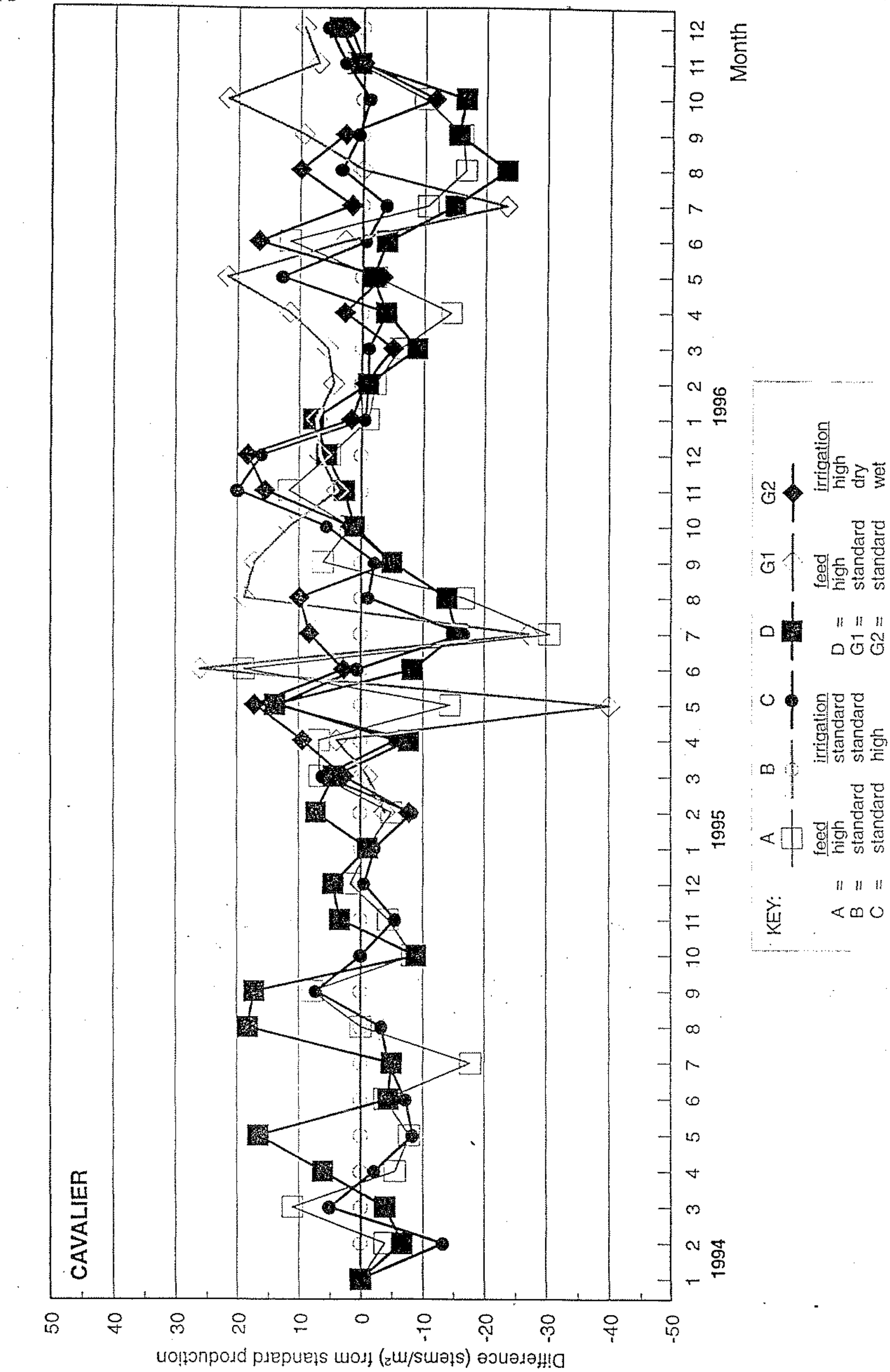
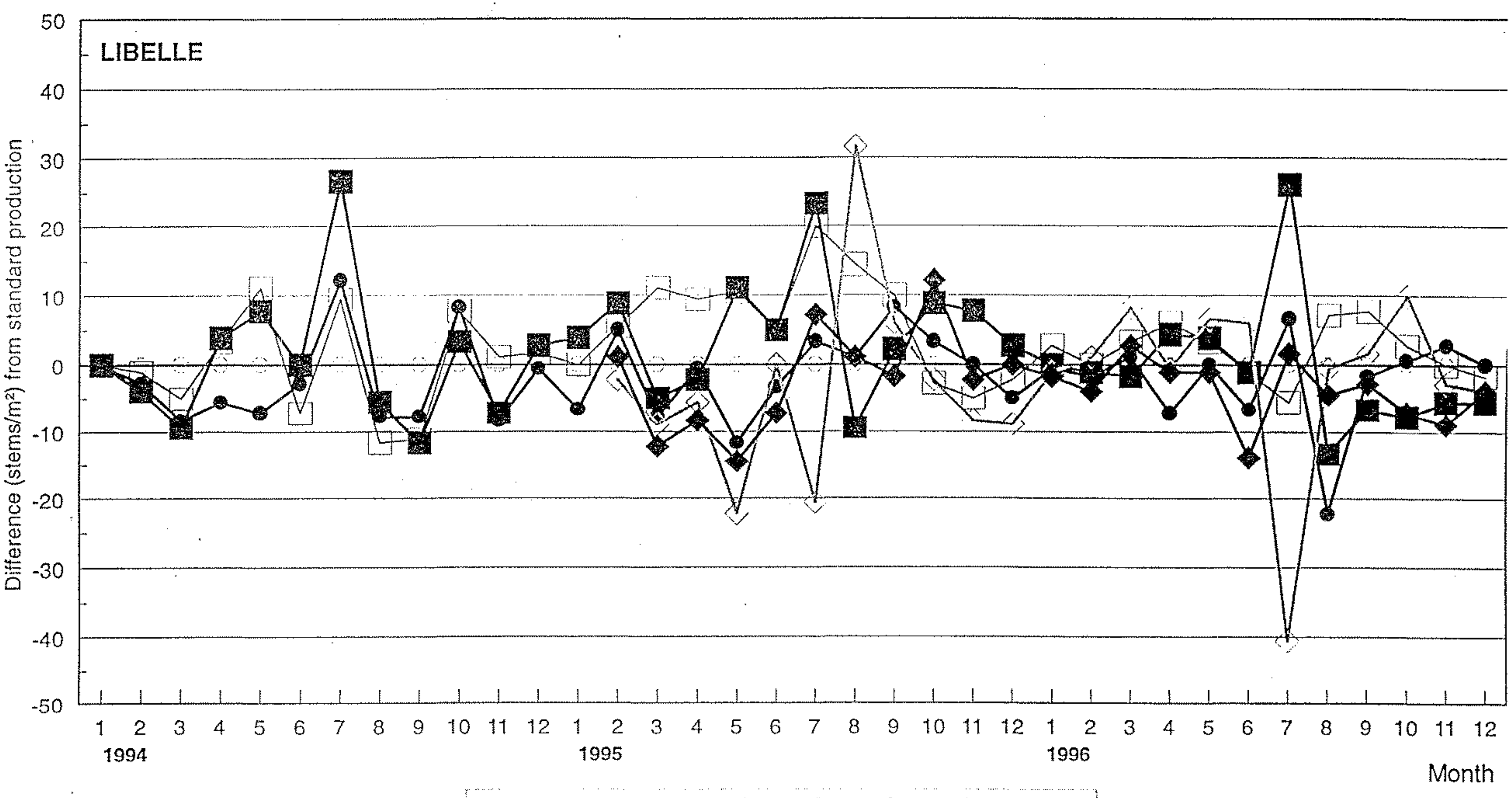


Figure 18. Effects of irrigation and nutrition on production of total marketable stems



KEY: A B C D G1 G2

	feed	irrigation		feed	irrigation
A =	high	standard	D =	high	high
B =	standard	standard	G1 =	standard	dry
C =	standard	high	G2 =	standard	wet

Appendix III

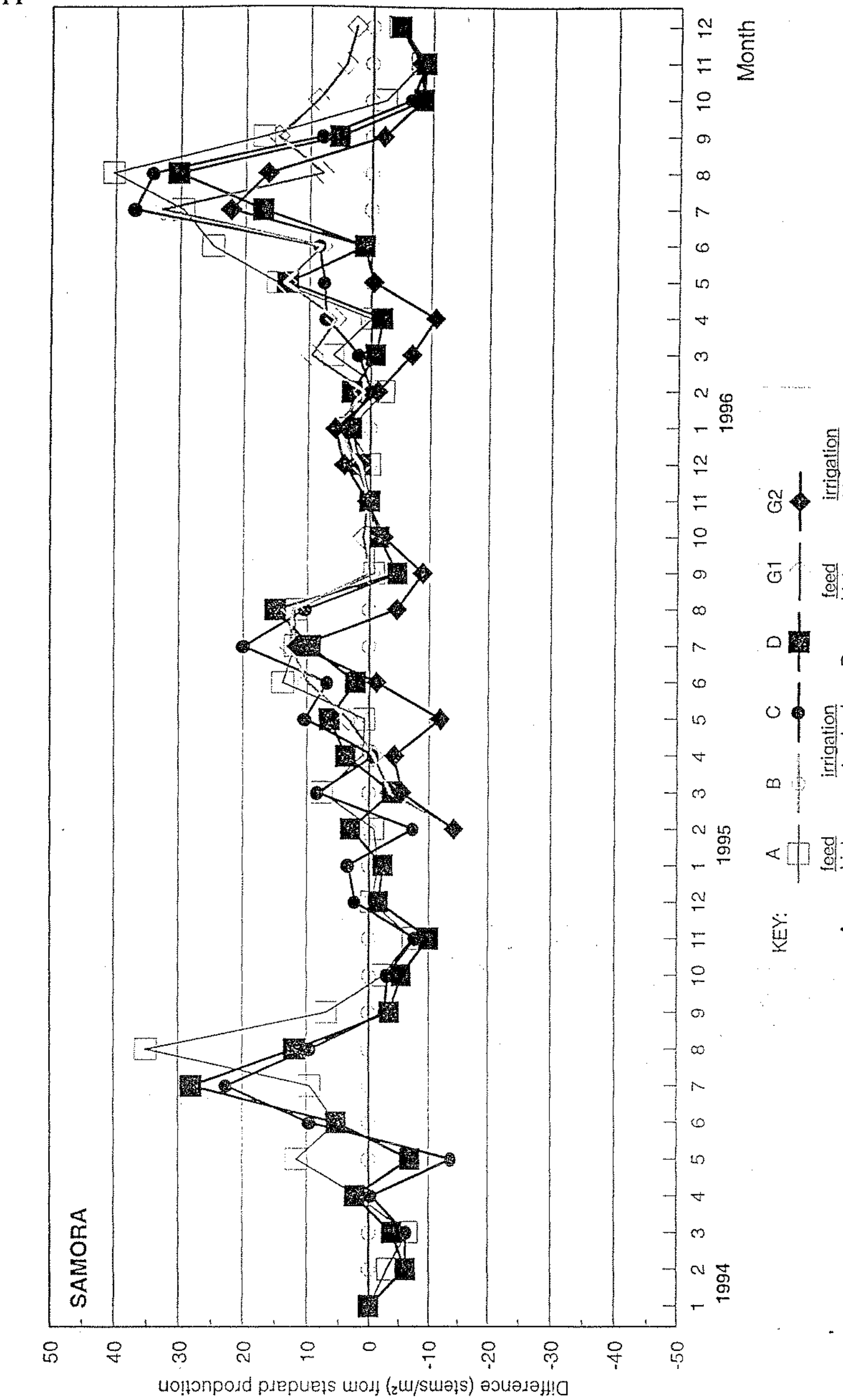
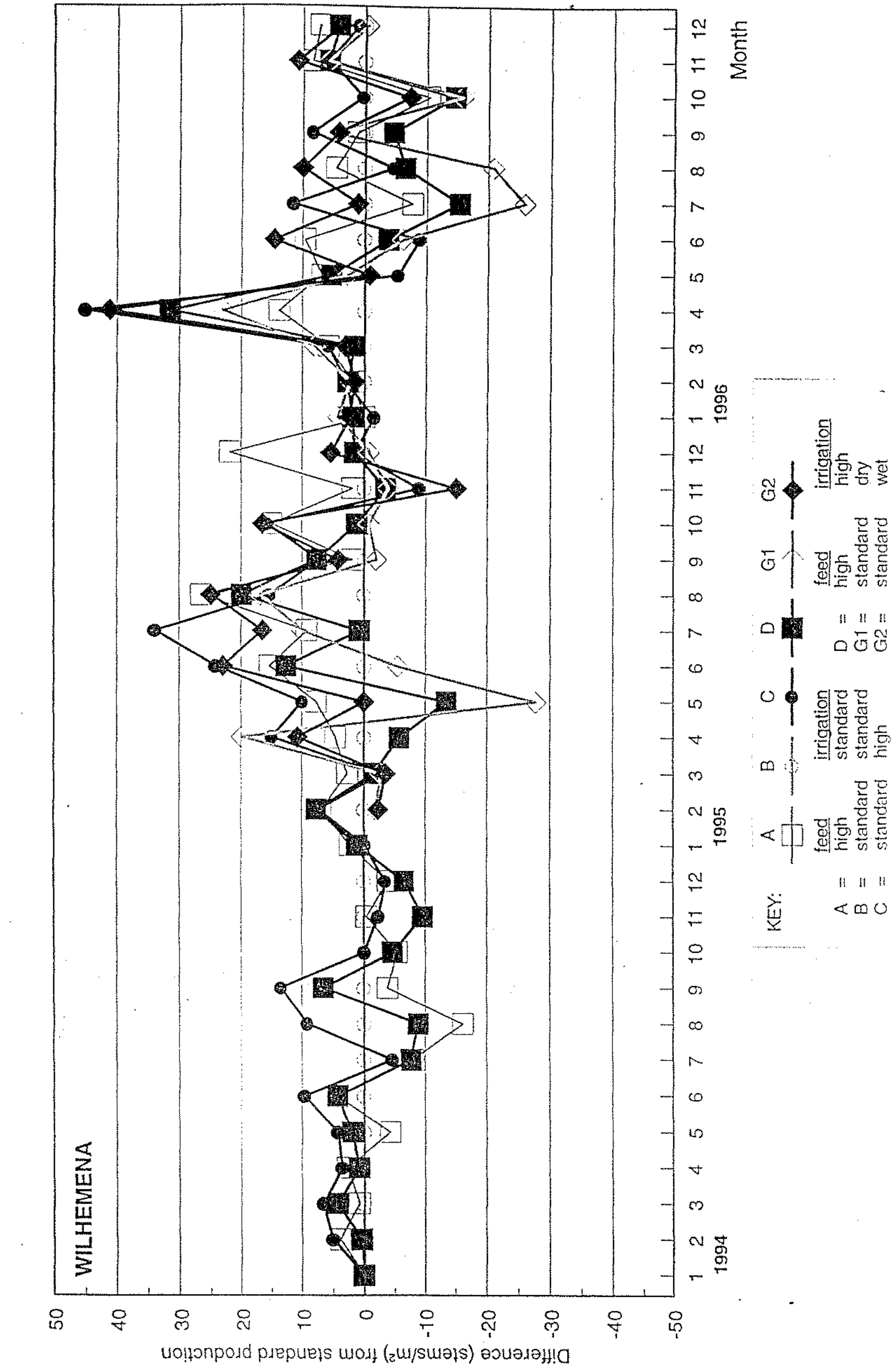


Figure 19. Effects of irrigation and nutrition on production of total marketable stems

Appendix III

Figure 20. Effects of irrigation and nutrition on production of total marketable stems



Appendix III

Figure 21. Effects of irrigation and nutrition on production of short and low quality stems

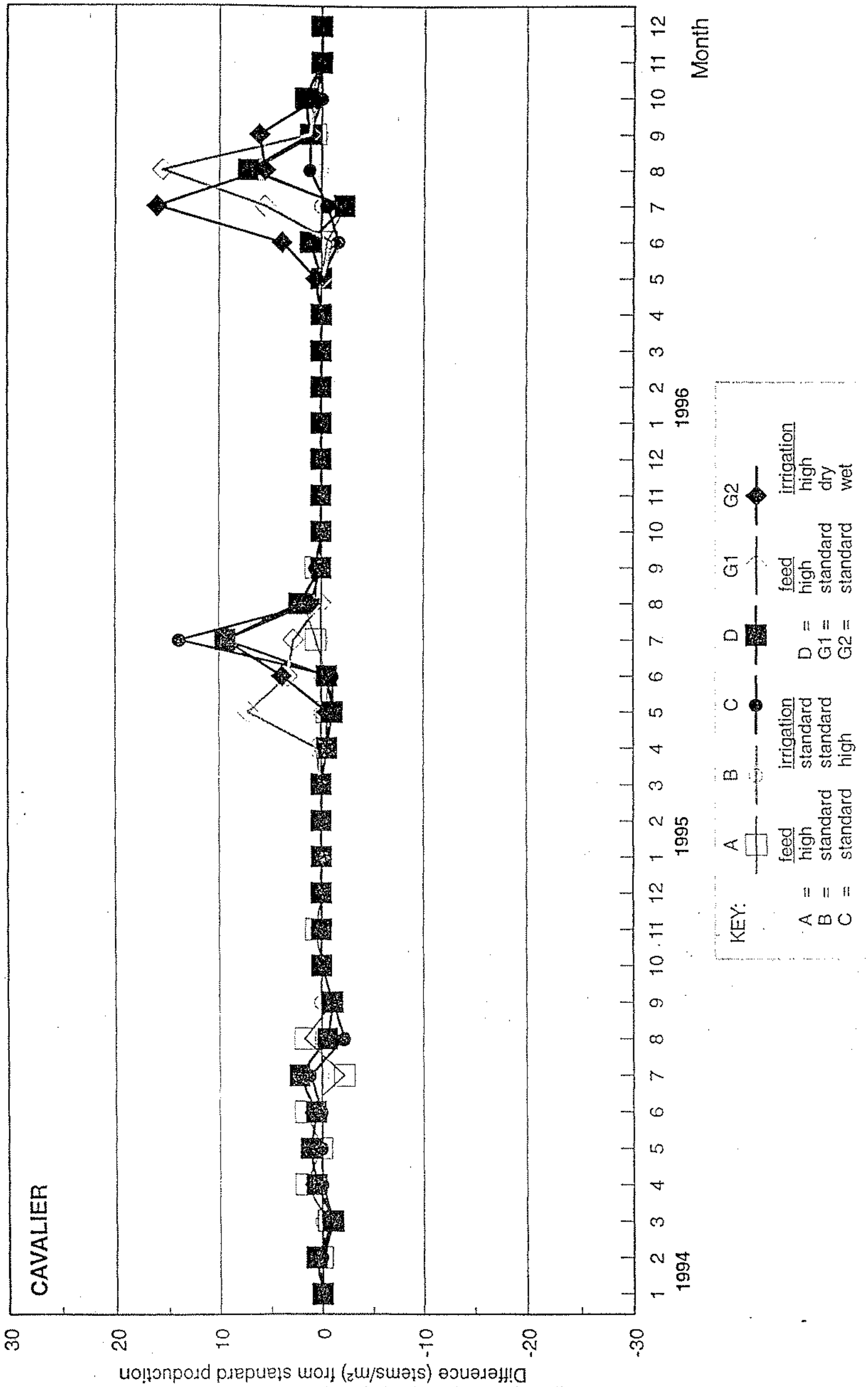


Figure 22. Effects of irrigation and nutrition on production of short and low quality stems

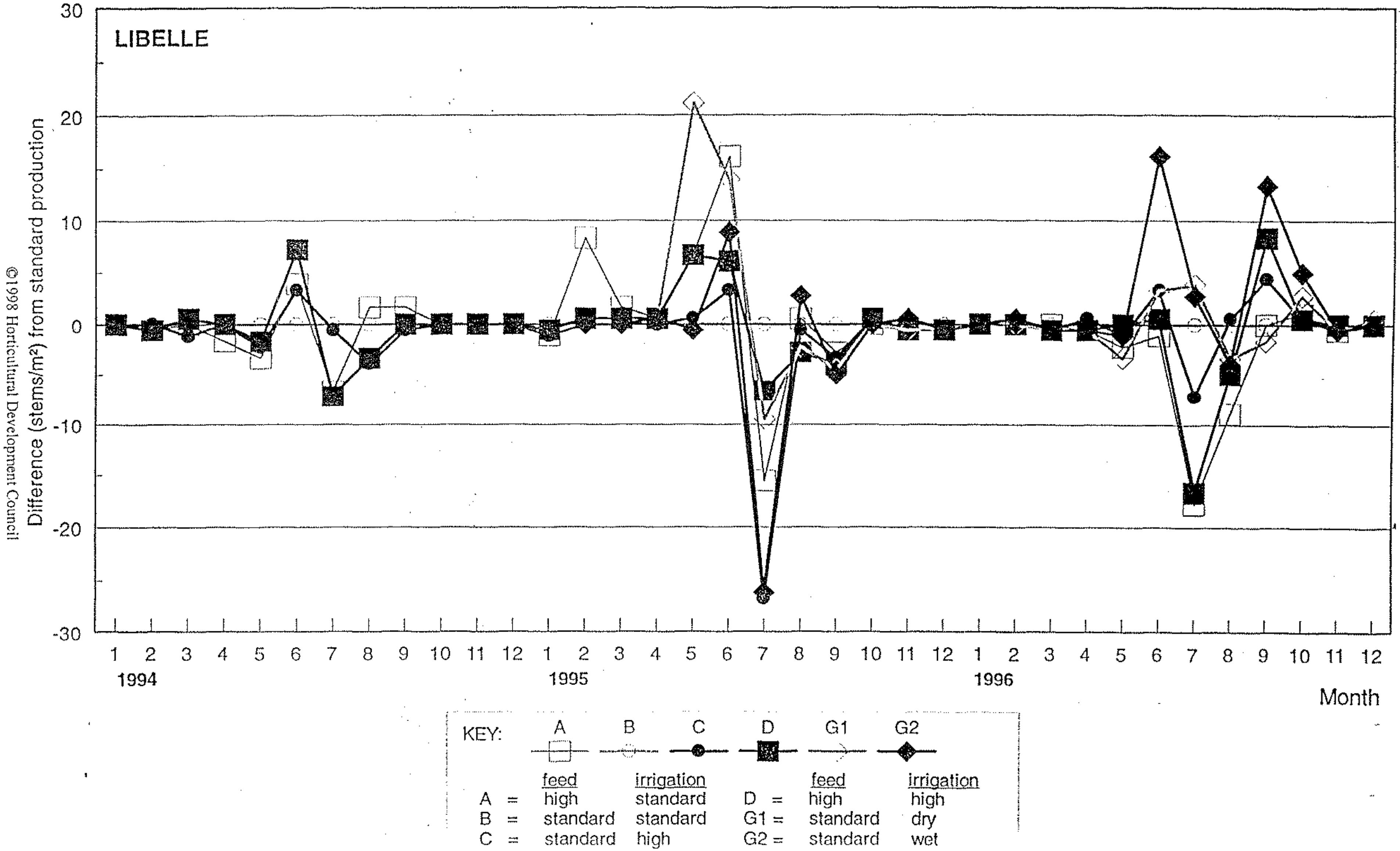
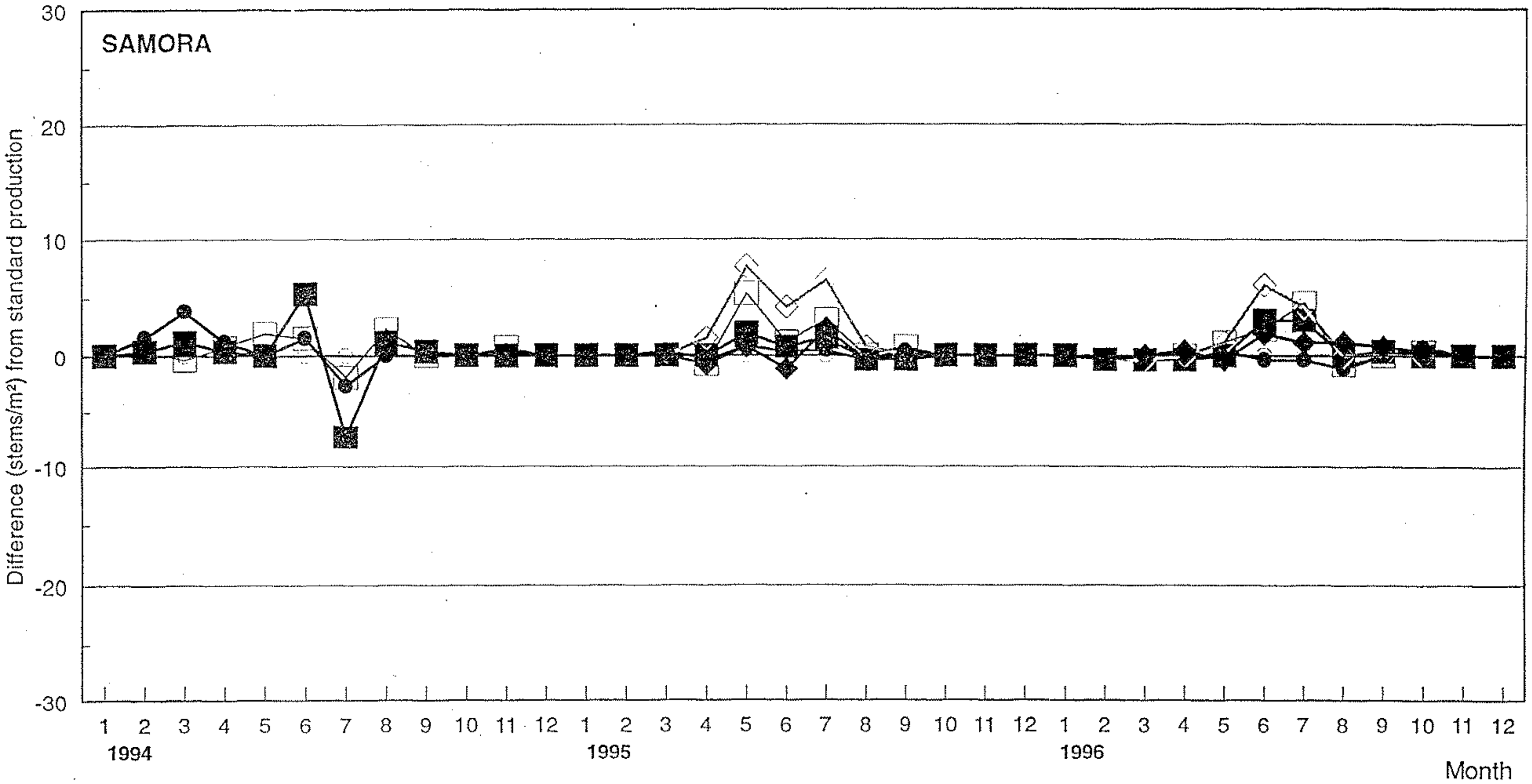


Figure 23. Effects of irrigation and nutrition on production of short and low quality stems



KEY: A B C D G1 G2

	feed	irrigation		feed	irrigation
A =	high	standard	D =	high	high
B =	standard	standard	G1 =	standard	dry
C =	standard	high	G2 =	standard	wet

Appendix III

Figure 24. Effects of irrigation and nutrition on production of short and low quality stems

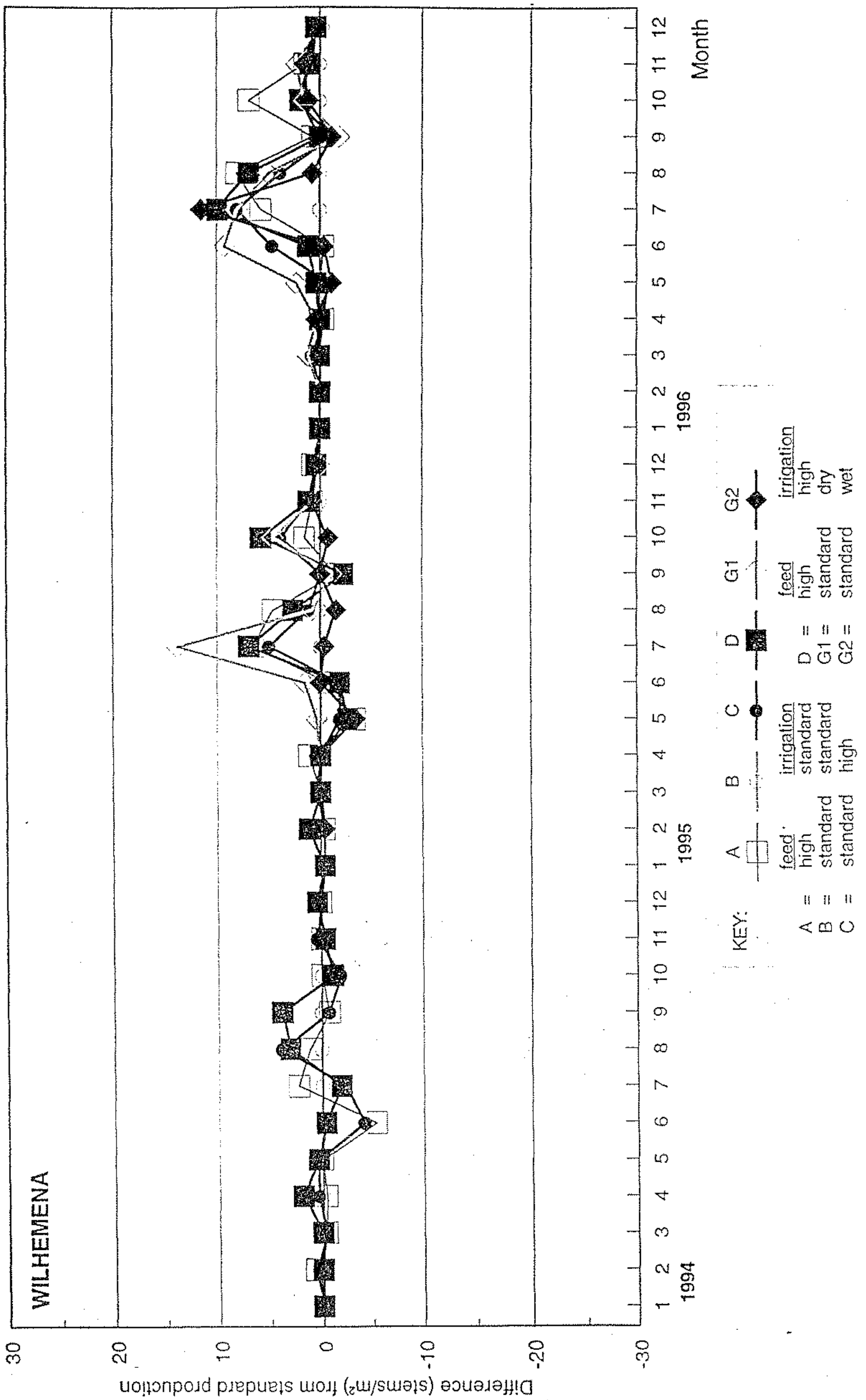
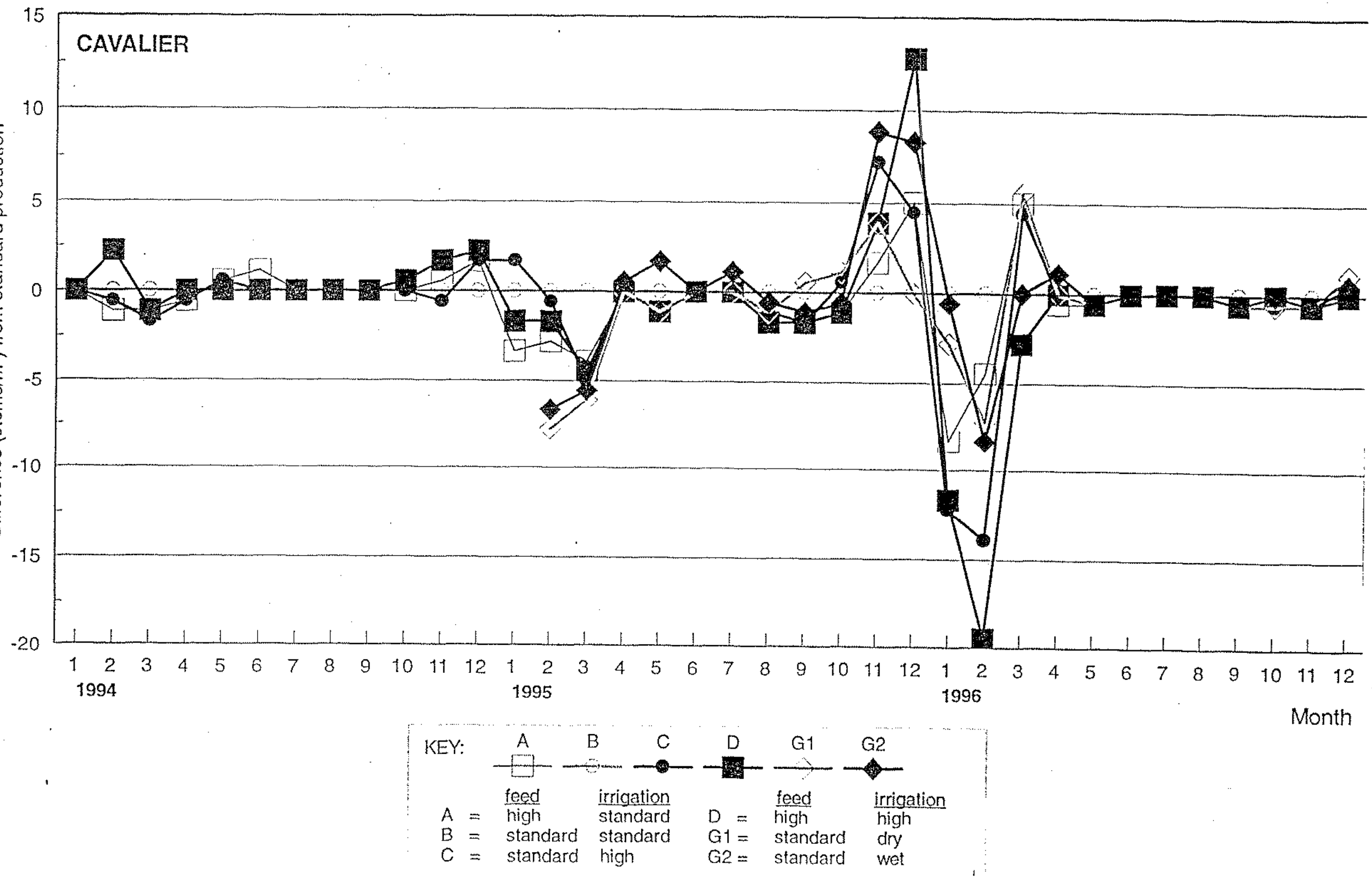


Figure 25. Effects of irrigation and nutrition on production of aborted and semi aborted stems



Appendix III

Figure 26. Effects of irrigation and nutrition on production of aborted and semi aborted stems

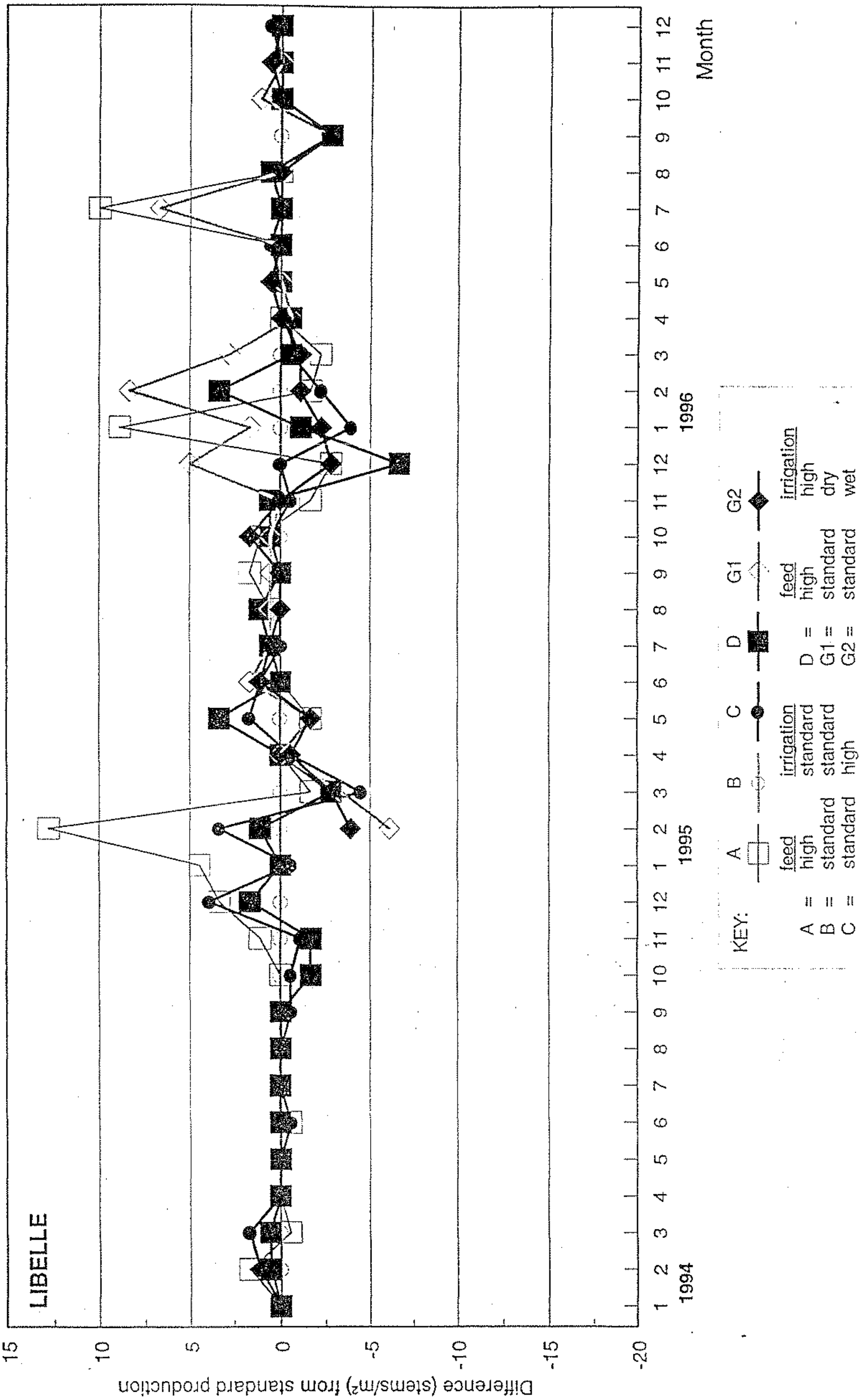
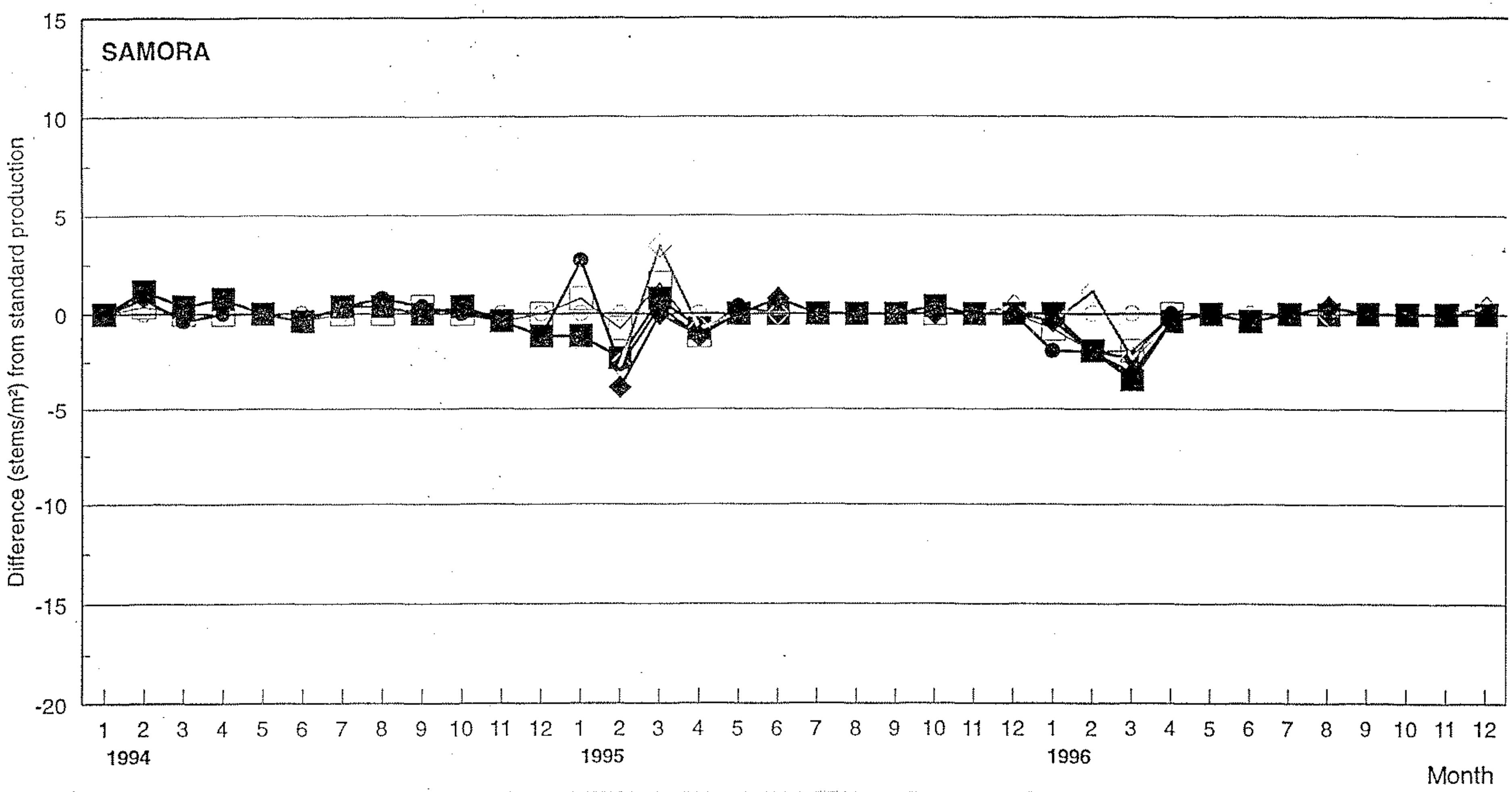
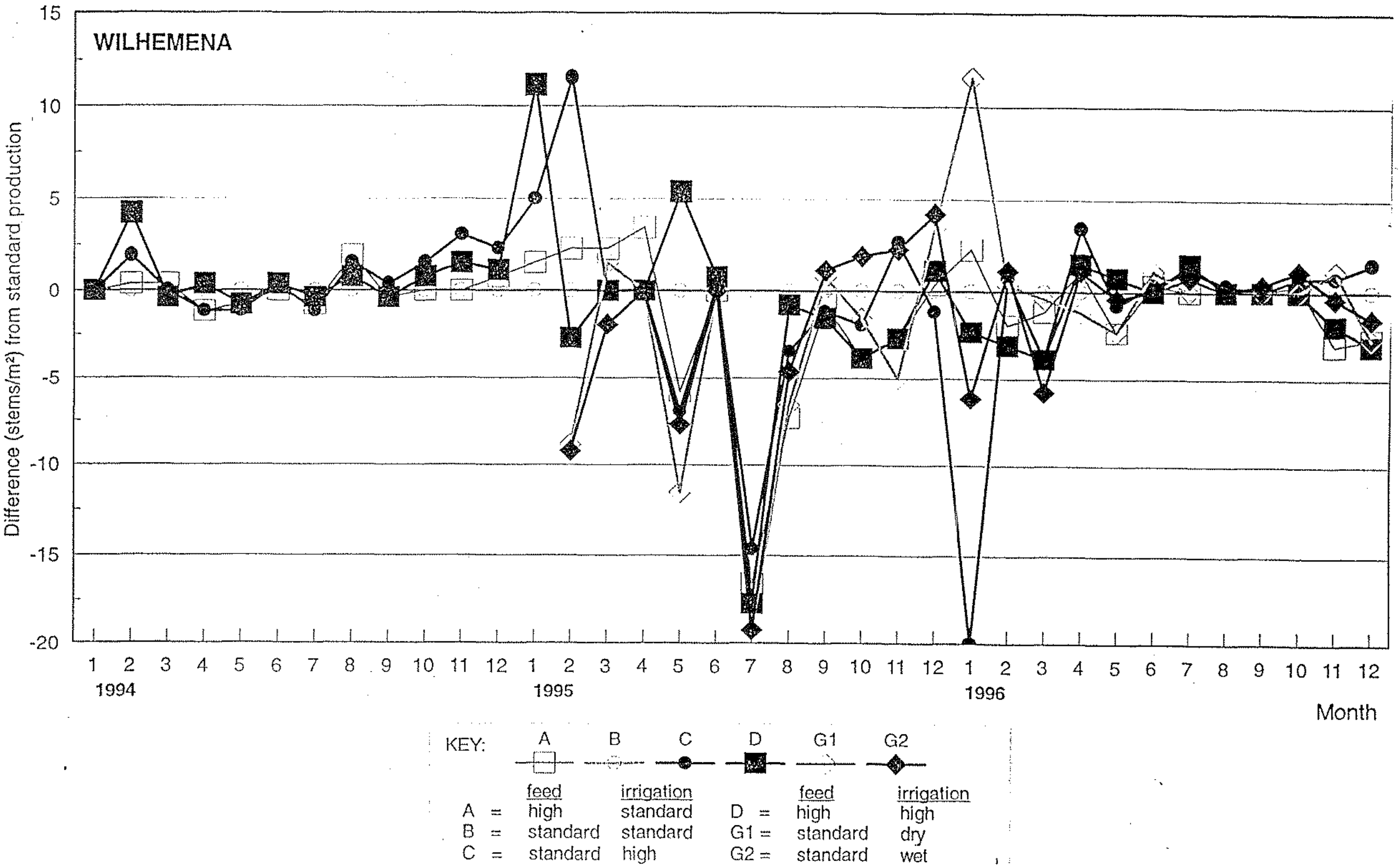


Figure 27. Effects of irrigation and nutrition on production of aborted and semi aborted stems



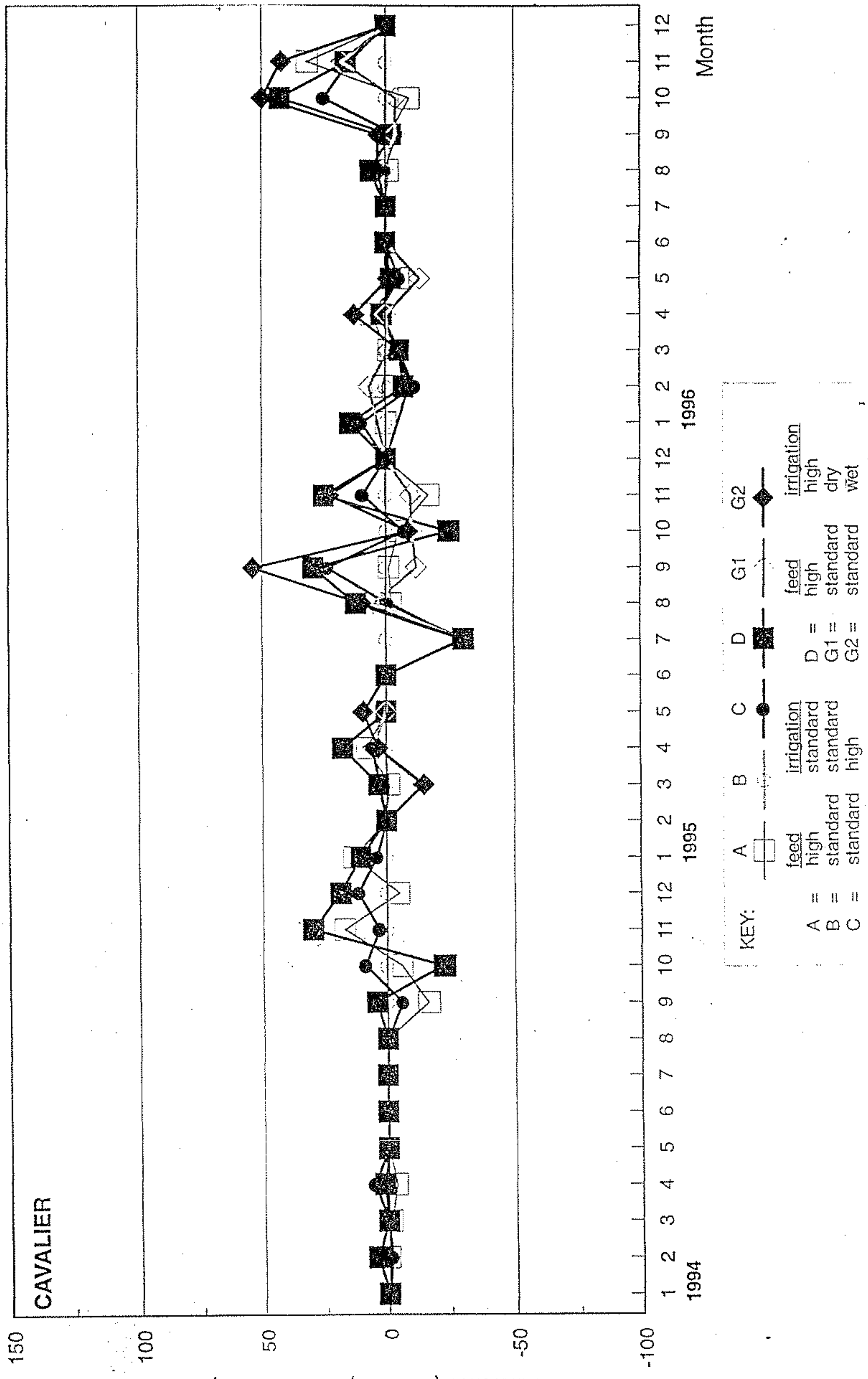
	feed	irrigation		feed	irrigation
A =	high	standard	D =	high	high
B =	standard	standard	G1 =	standard	dry
C =	standard	high	G2 =	standard	wet

Figure 28. Effects of irrigation and nutrition on production of aborted and semi aborted stems



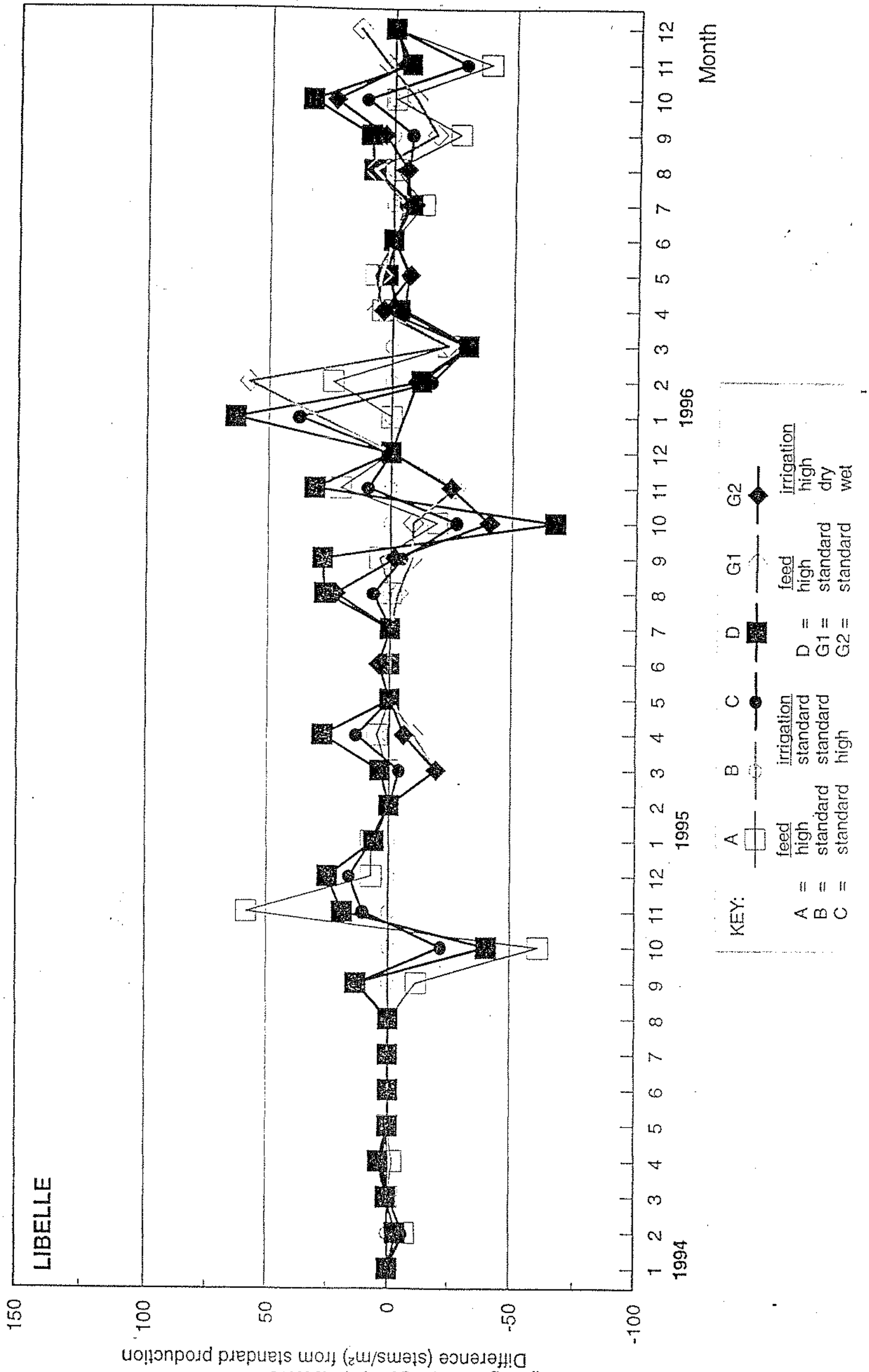
Appendix III

Figure 29. Effects of irrigation and nutrition on production of vegetative shoots



Appendix III

Figure 30. Effects of irrigation and nutrition on production of vegetative shoots



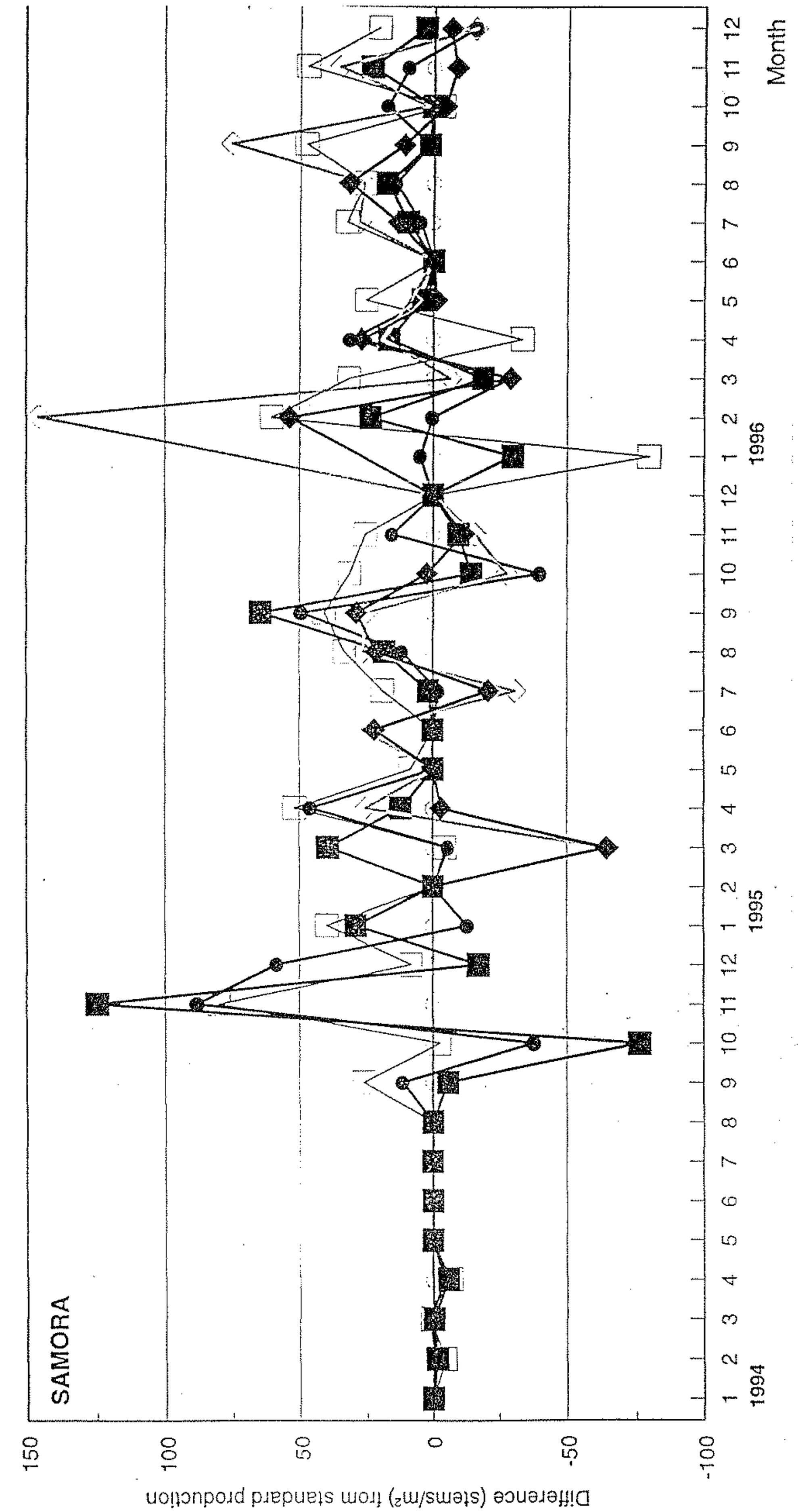
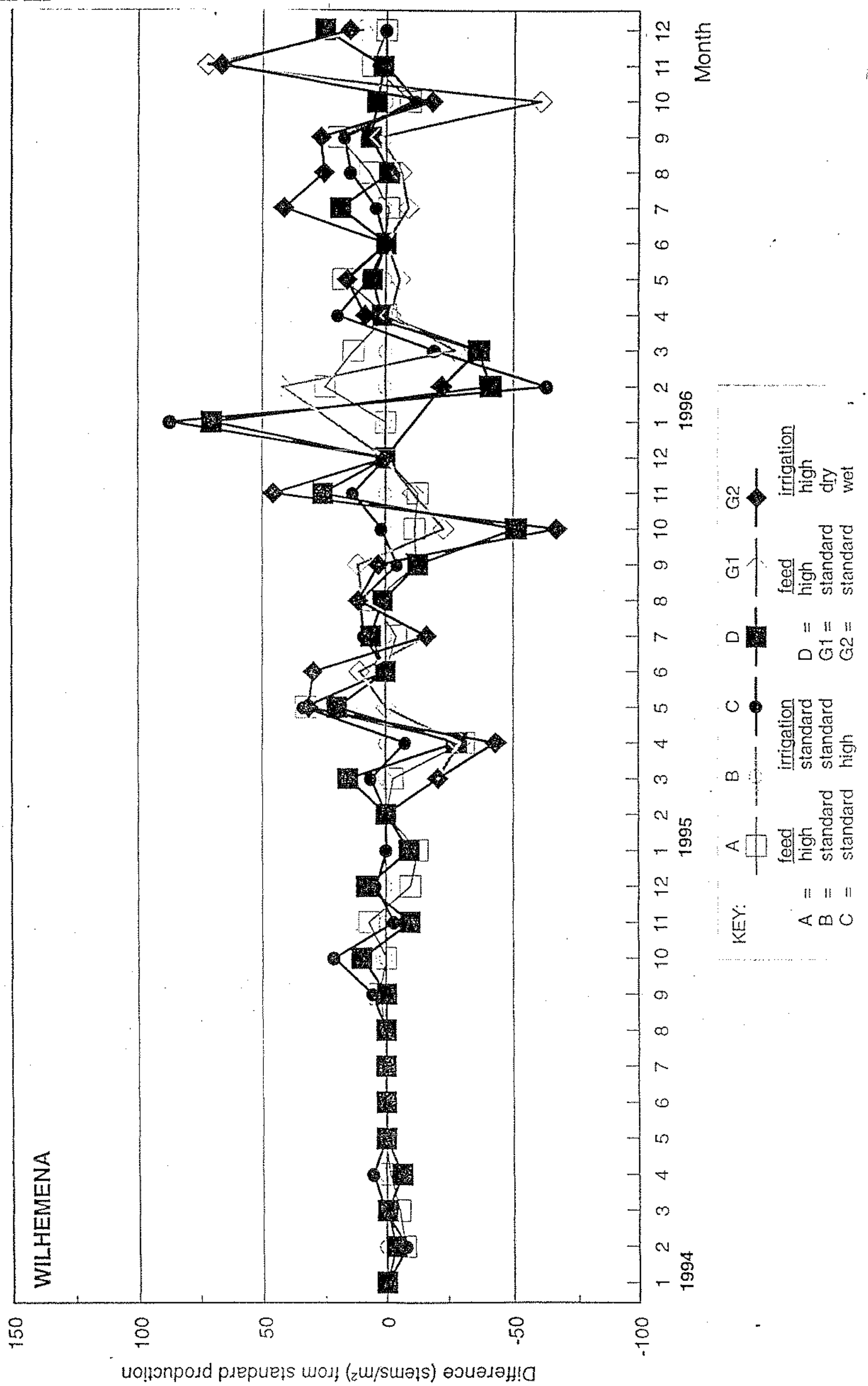


Figure 31. Effects of irrigation and nutrition on production of vegetative shoots

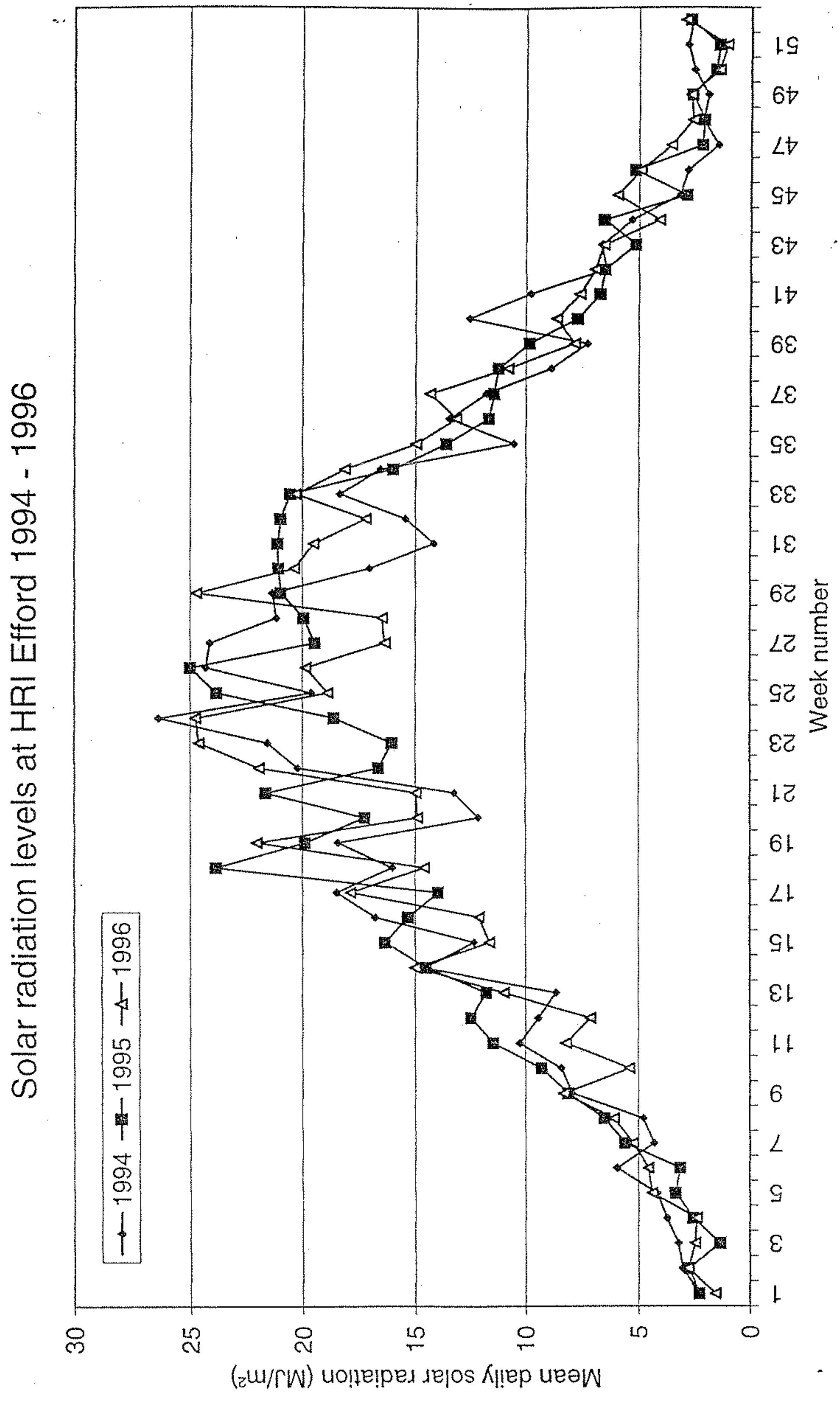
Figure 32. Effects of irrigation and nutrition on production of vegetative shoots



Appendix IV

Environmental data

Appendix IV


Solar radiation levels at HRI Efford 1994 - 1996
1994
1995
1996
Mean daily solar radiation (MJ/m²)
0
5
10
15
20
25
30
Week number
1
3
5
7
9
11
13
15
17
19
21
23
25
27
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Appendix V

References

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MAFF (1988) Fertiliser recommendations for agricultural and horticultural crops. MAFF reference book RB 209, HMSO.

Wilson, D. P. (1994) Alstroemeria: Varietal response to planting date. HDC Final report PC 33.