Meat Research Corporation

FINAL REPORT

CS.224

"Integration and extrapolation of regional grazing management sites, Temperate pasture Sustainability Key Program, sub program 5.1"

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Meat Research Corporation

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1. Abstract

This project was established to train a scientist from a State Department of Agriculture in the use of the GRAZPLAN decision support systems. Stephen Clark of the Pastoral and Veterinary Institute, Hamilton, Vic. was seconded to CSIRO, Plant Industry, Canberra from January 1995 to January 1997. He is now a competent user of these decision support systems - particularly GrassGro and MetAccess.

Data from the Temperate Pasture Sustainability Key Program was used to evaluate the GrassGro pasture model and subsequently to evaluate information gathered in the Key Program. Six sites were simulated with a high degree of accuracy. At two sites a range of grazing management scenarios were simulated to assess their potential for increasing the clover content of pasture. The model indicated that "resting" pasture could have a small but positive impact on clover content. However, seasonal changes in clover content were much larger than changes due to resting.

New parameter sets for GrassGro were developed for several species and cultivars, existing sets for other species were improved and improvements were suggested to alter the way the pasture model predicted rooting depth. Seed dynamics, clumpiness and interspecies competition were identified as areas needing further improvement.

2. Executive Summary

2.1 Project objectives

The CSIRO Division of Plant Industry has developed a suite of decision support systems under the umbrella GRAZPLAN project. The applications include GrazFeed, LambAlive, MetAccess and GrassGro - a program incorporating biophysical models to assess how weather, soils and management factors combine to affect pastoral productivity and profitability.

This project was established to train a scientist from a State Department of Agriculture in the use of the GRAZPLAN decision support systems in general and GrassGro in particular. Data from the Temperate Pasture Sustainability Key Program (TPSKP) sites was to be used to evaluate the GrassGro pasture model. If this was successful GrassGro would then be used to extrapolate information gathered in the Key Program to other sites and over a longer range of seasons.

Stephen Clark, Agriculture Victoria was seconded to CSIRO, Canberra in January 1995 for a two year period.

2.2 Significant results

A high level of competence in the use of the GRAZPLAN family of decision support systems - particularly GrassGro - was achieved.

Excellent predictions were achieved with GrassGro of measured pasture and animal performance at the following sites: Hamilton, Vic (wethers and steers), Delamere, SA, Dundee, NSW, Hall, NSW, Cootamundra, NSW and Springhurst, Vic. These sites had a range of pasture types and contained species such as phalaris, perennial ryegrass, tall fescue, cocksfoot, annual ryegrass, *Microlaena*, subterranean clover and white clover. Two sites - Delany's (Hamilton, Vic) and Delamere (SA) were subjected to more detailed analysis. Grazing management strategies were examined for their effect on pasture clover content.

Sites with summer-active annual and perennial grasses (Northern Tablelands of NSW) were not able to be simulated as parameter sets for these species are not available. A preliminary generic parameter set for a summer active annual grass was developed but not evaluated. A parameter set was also developed for a late maturing, more productive subterranean clover cultivar. This more closely simulates the recently released cultivars (e.g. Leura) for high rainfall areas.

GrassGro's predictions of pasture and animal production deviated most from measured data at three sites - Dundee, Hall and Springhurst - during the 1994/95 drought. At the peak of the drought GrassGro underestimated animal production. A possible reason identified for the discrepancy was the clumpy nature of the pasture at low availabilities. This provided sheep with an opportunity to eat more and to select a higher quality diet than that predicted by GrassGro.
At Delany's, Vic, GrassGro predicted pasture senescence four weeks earlier than observed. Simulated pasture roots failed to reach soil moisture at depth at this time of the year. Increasing the rooting depth parameter corrected the situation. Subsequent measurements at the site showed deeper roots and confirmed this analysis. The current version of GrassGro has been modified to correct the simulation of rooting depth.

GrassGro was used to evaluate potential pasture plant breeding goals with tall fescue and predicted a good economic return from improved winter activity. An economic analysis of pasture improvement was incorporated in a paper presented to the NSW Grasslands Society conference in 1996.

Both GrassGro and MetAccess were under intensive development during the two years of this project and a significant contribution to improvements of the models was made.

2.3 Conclusions

The project achieved it's primary goal of training an employee of a state department of agriculture in the use of the GRAZPLAN decision support systems. The successful evaluation of GrassGro at a diverse range of TPSKP sites gives confidence in the underlying strength of its design and its ability to predict grazing management outcomes accurately.

Grazing management manipulations were tested for grass-clover balance and the model indicated that "resting" pasture could shift the balance towards clover. However, the changes achieved were small relative to seasonal fluctuations in clover content. Considered in this context, the value of "resting" strategies for improving clover content is in doubt.

The objective analysis of grazing options by the model highlighted the difficulty that site teams faced when collecting and analysing pasture data during the drought. In some cases, the data did not support the conclusion reached indicating inadequate sampling techniques.

GrassGro also had difficulty predicting animal production on very sparse pastures during the drought. This may be due to "clumpy" distribution of sparse pasture which is not modelled at present.

2.4 Recommendations

For GrassGro to be more widely useful, parameter sets are essential for a greater range of pasture species. An assessment of the importance of "clumpy" pasture distribution and its incorporation into GrassGro is recommended.

Pasture and animal measurements should be made more frequently in grazing management experiments at crucial times and if unusual events occur. A photographic record should be made of pasture conditions for the duration of the experiment. Some weather data loggers and pasture measurements proved to be unreliable. Greater attention to accurate data collection is indicated. The ability to accurately monitor key climatic data is even more important for SGSKP sites as the emphasis is on sustainability issues such as water use.
Many of the problems encountered in this project were due to its being an add-on to the TPSKP (already underway for a year). In order to get the support of all concerned it is important that a modelling component be incorporated into all research programs from the very beginning.

3. Main Research Report

3.1 Introduction

This project was established to train Stephen Clark, a pasture agronomist from the Victorian Department of Agriculture, in the use of the GRAZPLAN decision support systems. Once the training was completed data from the Temperate Pasture Sustainability Key program grazing management sites was to be used to validate the GrassGro DSS. GrassGro would then be run over long time periods so that site results could be extrapolated to different climatic conditions and so that the effects of different management regimes could be tested.

3.2 Training phase

I was seconded from the Victorian Department of Agriculture and began work at CSIRO, Division of Plant Industry, Canberra on 9th January 1995. Initially training was undertaken on the use of the three commercially available DSS's - GrazFeed, LambAlive and MetAccess.

LambAlive and MetAccess were useful in my gaining an understanding of the climatic environment at the grazing management sites. MetAccess was also the main tool used to examine potential weather data files for the grazing management sites. Effective use of GrazFeed involves a substantial amount of understanding of ruminant nutrition. My knowledge of was lacking and a great deal of reading was undertaken to become more familiar with the concepts.

Beginning in mid-March 1995 I started work with GrassGro (DOS version). This is a comprehensive paddock-scale pasture and animal production model and requires an investment of time to achieve expertise. I achieved a reasonable level of skill in using GrassGro by July 1995 and gained more experience as I moved into the next phase of the project - "validation of the model against data collected in the key program."

There are a large number of user inputs which can be varied in GrassGro and initially I kept things quite simple. I defined a farm for Hamilton, Victoria - a district with which I was familiar - and with help from colleagues at the Pastoral & Veterinary Institute, Hamilton (PVI) a reasonable simulation of a wether system grazing perennial ryegrass/subterranean clover pastures was achieved. Major events like the 1967/68 and 1982/83 droughts were simulated successfully.

My first attempt at simulating one of the grazing management sites followed a visit to Denys Garden's (NSW Agriculture) site at Hall - just north of the ACT. This site was a native pasture dominated by the summer-active perennial grasses *Microlaena* and *Danthonia*. The wethers at the time were growing quite rapidly and had been for the previous few months. In the simulation I used the parameter set for tall fescue as it was the only summer-active perennial grass available. Although I was able to simulate the animal weight changes quite well for most of the period of the experiment I was unable to simulate the strong growth of animals over the late spring 1994 to mid summer 1995 period. This led me to investigate the growth patterns and animal production potential of *Microlaena* and *Danthonia* species.

There is not a great deal in the literature regarding animal production with these species but, what there is, points to higher pasture quality at certain times of the year. It may be that these species do not lose quality to the same extent as conventional pasture grasses when flowering commences and this would account for the animals better performance in reality than was predicted by GrassGro.

During the first few months of my secondment I collected weather files for many of the grazing management sites. I contacted the site operators in March and asked them to supply me with data from the weather loggers. As this was received it was converted to the file format required for use by MetAccess and GrassGro.

In March 1995 I visited CSIRO Armidale where Dr. Mike Hill and Graham Donald demonstrated the integration of geographical information systems and remote sensing technology with GrassGro. This is a technique where GrassGro is used to calibrate maps of farms and districts for any of its outputs (animal production, pasture growth and composition, gross margin etc.). I took part in the planning for future development work which includes generating maps for PVI Hamilton and south western Victoria.

On May 29-30 1995 I attended a TPSKP workshop in Canberra. This enabled me to meet many of the grazing management site managers for the first time and to learn more about their sites. I gave a short presentation of my progress and in the discussion I was presented with several challenges. It become apparent that there have been some management events at the sites that GrassGro will not be able to account for. For instance, at some sites the stocking rate was changed frequently over short periods as the drought took hold. GrassGro assumes a constant stocking rate and handles feed shortages by the use of supplementary feeding. It does, however, have the ability to feed animals away from the paddock. This problem was subsequently solved by adding several small GrassGro runs together.

Some managers reported the occurrence of phalaris or ryegrass seedlings. GrassGro initially assumed seeds of perennial species to be of no consequence in regeneration. Monitoring of seedlings at some of the sites indicated that the assumption was valid for grasses but not for white clover. Consequently the white clover parameter set now includes parameters for seed dynamics and seedling behaviour. No validation work has yet been carried out.

3.3 TPSKP Site modelling

Successful validation exercises were conducted for six sites. More detailed analyses were conducted at two of these. A number of sites were not simulated. Reasons for this include lack of cooperation from some site managers, lack of climatic information or pastures containing species for which parameter sets were not available.

3.3.1 Delany's Sheep - Hamilton, Victoria

Validation of GrassGro

A weather file was created based on the PVI Hamilton weather records. The file covered the period 1st January 1964 - 16th August 1995. Missing rainfall data were obtained from Casterton PO. Missing temperature, evaporation and wind data were obtained by calculating mean values using Dr. Andrew Moore's "BuildMet" program. Some radiation data were imported from the PVI data set. The remainder were computed from sunshine hour data in the PVI set or by using wet and dry days.

The site was on a degraded perennial ryegrass pasture. The major species present were perennial ryegrass, fog grass, onion grass and subterranean clover. For the simulation, a pasture mixture of perennial ryegrass and subterranean clover was used. The fertility scalar was set to 0.80.

The simulation ran from 9th September 1993 to 16th August 1995.

Livestock description:

- Medium merino wethers
- Standard Reference Weight = 50 kg
- Potential greasy fleece weight = 5.0 kg
- Maximum fibre diameter = 22 microns
- Initial stocking rate = 10 wethers/ha
- Initial mean liveweight = 51.0 kg
- Initial mean greasy fleece weight = 3.5 kg

Management:

- Shearing date is 12th November
- No supplementary feeding

Initial state of soil:

Area of paddock	100 ha
Steepness	Level
SCS curve number I:	75
Stage II soil evapn:	3.8 mm/d½
Fertility scalar	0.80
Initial soil moisture	
Topsoil	20 %
Subsoil	36 %

	Topsoil	Subsoil
Texture	Sandy clay loam	Sandy clay loam
Cumulative depth	150	600 mm
Porosity	42	42 %
Water content at F.C.	27	27 %
Water content at W.P.	17	17%
Sat. hyd. conductivity	3.0	3.0 mm/h

Initial state of pastures:

	Herbage components (DM kg/ha)					Phenological	
Species	Green	Dead	Litter	Root	Seed	stage	Index
Perennial ryegrass	656	80	31	1178	0	Reproductive	1
Subterranean clover	13	2	1	200	140	Reproductive	0

During the period simulated there were stocking rate changes, periods when sheep were removed (shearing) and complete replacement of the mob. Because GrassGro is designed as a single mob program, the period was split into 10 separate simulation runs from 3 days to 9 months in duration. The pasture and animal conditions at the end of one run were used as the starting condition for the next.

Initial attempts to simulate this grazing system were encouraging, although there were some sharp discrepancies between the observed and predicted values. These discrepancies were reduced when further information on site characteristics was sought from the site manager - John Graham. Figure 1 shows actual versus predicted mean animal weight. It is apparent in these initial analyses that although the simulated animals performed much worse than the real sheep the pattern of weight change is correct. Figure 2 shows green herbage DM. The simulated pasture appears to begin growing earlier and to finish earlier than the real pasture. In 1994, for example, the simulated pasture ceases growth on the 25th November, whereas the real pasture kept growing for at least another two weeks.

Experimenting with variations of site specific parameters on the first attempt demonstrated that a marked improvement could be obtained by increasing the rooting depth of the ryegrass from 300mm to 600mm. Another change with positive effects was to consider the replacement wethers (put onto plots on 20th January 1994) as large instead of medium frame size. Figures 3 and 4 illustrate some significant improvements in the resulting simulations of animal and pasture growth.

There were occasions when the simulated pasture grew faster than the real pasture yet the simulated animals grew less than the real animals. Investigation showed that the simulated pasture had a clover content of less than 10% at any time whereas the real pasture exceeded 50% clover at times. To test if protein was limiting it was decided to increase the protein content of the pasture on offer. The table below shows the changes that were made:

Digestibility Class	Old Protein Content (%)	New Protein Content (%)
80%	25	28
70%	18	20
60%	12	16
50%	7	9
40%	3	4

Increasing the protein content of the pasture produced the simulations depicted in Figures 5 & 6. These simulations provide a reasonable mimic of the data observed in the field trial. The main discrepancy occurs in the simulated pasture in winter/spring 1994, but the deviation is mostly within experimental error. The final two actual sheep liveweight points on Figure 5 are 2-3 kg higher that the predictions. This could be explained by the wet conditions prevailing at the time and the likelihood that the fleeces were saturated when the animals were weighed.

Grazing management studies with GrassGro

In February 1995 the site manager - John Graham, PVI, Hamilton - spent two days with me to conduct GrassGro simulation runs of the grazing management treatments imposed on the site.

Treatments examined were as follows:

Set stocking }
Summer rest }
Autumn rest } Perennial ryegrass / sub clover
Winter rest }
Spring rest }

Set stocking	}	Perennial ryegrass / sub clover / annual grass
Spring rest	}	
Double SR in summer	}	
Rotation-2wks on/6 wks off	}	

Most livestock and paddock parameters were as described above. All simulations ran from 1st January 1970 to 31st December 1979.

1. Seasonal rests - perennial ryegrass / sub. clover

Figure 7 shows the subterranean clover proportion of total green pasture DM at the spring peak over 10 years in a continuous simulation. It is apparent that annual fluctuations are larger than the treatment effects. A continuous simulation was used initially as this is how the treatments are applied on the TPSKP sites.

In order to remove the large variation from one year to the next tactical simulations were run. In a tactical simulation the starting parameters are the same for each year and the simulation runs for a year and then reverts to the initial parameters for the next year. So the starting point is the same for each year and the treatments are imposed upon the seasonal conditions of each of the 10 years. Figure 8 presents the peak spring clover green DM proportions for each year. The spring and winter rests appear to have improved clover content in some years.

Tactical simulations can only be run for up to a year so treatment effects in the second years cannot be seen. In order to get an idea of the likely treatment effects in the second years the seed bank at the end of each year is presented in Figure 9. Differences between management treatments were small and probably of minimal benefit to the grazing system.

Referring again to Figure 7 - another way to look at this data is to plot the ratio of clover content in year 2 to clover content in year 1. Similarly if the clover content in one year is 50% and 20% in the next then the ratio is 0.4. A ratio of 1.0 means that the clover content in a given year is the same as in the previous year. These ratios are best plotted on a log scale as shown in Figure 10. The graph shows the relative magnitude of the treatments. It is apparent that in 1971-72 spring rest had a detrimental effect and in 1972-73 it had a beneficial effect. Similarly with winter rest in 1975-76 and 1976-77.

One of the aims of the TPSKP was to develop grazing management strategies which will increase desirable pasture components. Such a strategy should not need to be implemented year after year. The simplest strategy would be one which could be implemented once to remedy pasture composition. Figure 10 indicates that a treatment may have an effect or not depending on the year and the effect (if any) may be positive or negative.

The year 1972 was a poor one for sub clover. All four seasonal rest strategies were simulated beginning with summer rest on December 1st 1972 to see which (if any) could improve the sub clover proportion of the sward by the spring of 1973. Figure 11 presents these simulations. Winter and spring rest both seemed to be beneficial to sub clover production. All treatments affected perennial ryegrass also however. The clover proportions of total live herbage DM in mid spring 1973 are presented in the following table:

Treatment	Clover %
Set stocked	23.1
Summer rest	19.1
Autumn rest	23.5
Winter rest	31.2
Spring rest	28.7

The winter rest treatment was the most beneficial in terms of clover yield and proportion of the sward.

An examination of the growth limits for sub clover shows that green area index (which indicates the ability of a sward component to intercept light and therefore grow) is the most limiting factor in winter. Figure 12 presents the green area index for the set stocked, winter rest and spring rest treatments. Winter rest is the most beneficial of the two rest treatments. With winter rest the sub clover component of the sward is in a much better position at the start of spring to take advantage of warmer temperatures for rapid growth.

Figure 13 presents the effects of the treatments on the clover seed bank. The best treatments again are winter rest and spring rest. Winter rest leads to a 26% increase in the seed bank at the end of 1973.

GrassGro indicated that the spring rest treatment is also useful in increasing sub clover content after a poor year. In reality this would be a more desirable option than winter rest as it is easier to spell a paddock in spring than in winter. However it is probable that a spring rest would not be as beneficial as implied by the simulations. Firstly, because the benefit was relatively small and, secondly, because the GrassGro's competition model is fairly rudimentary. We cannot be certain that extra perennial ryegrass grown in a spring pasture rest would not suppress clover growth.

2. Other grazing managements - Perennial ryegrass, annual grass & subterranean clover

Figure 14 shows the sub clover proportion of total green pasture DM at the spring peak over 10 years in a continuous simulation. Again annual fluctuations are greater than treatment effects. When the data is plotted as ratios of clover content in year 2 to clover content in year 1 (Figure 15) it is again apparent that the effect of a treatment may be positive, negative or neutral depending on the clover content in the previous year and the seasonal conditions prevailing. Can any of these treatments be of use in improving a pasture with poor sub clover content? What will be the effect on the annual grass component?

Looking again at 1972 - a poor clover year - Figure 16 presents simulations of the effect of set stocking and the other grazing management systems on clover green DM. None of the treatments had a large positive effect and spring rest had a large negative effect. Clover green DM in spring 1993 after a spring rest in 1992 was less than half that of the set stocking treatment. Spring rest resulted in more seed being set in 1972 but less in the following year (Figure 17). Figures 18 and 19 present simulations of annual grass green DM and seed bank respectively. Possibly because of slightly increased seed set in 1972 under spring rest the annual ryegrass grew strongly in 1973 and suppressed the sub clover.

As stated earlier it is unlikely that the clover content of a real pasture would increase following a spring rest as the extra perennial ryegrass and annual grass DM would suppress clover growth and seed set.

Of all the grazing management strategies examined using GrassGro only winter rest appeared to be beneficial in increasing the clover content of a pasture after a bad clover year. Winter rest appears to be successful because it allows the clover to produce more green area for light interception and subsequent growth. At the end of the winter rest period the clover is better placed to take advantage of warmer temperature in spring than it would have been if set stocked through winter. However, it must be emphasised that seasonal variations in the clover content of the pastures are larger than the gains made by any treatment. This probably seriously reduces the true value of the treatments for shifting pasture composition.

Figure 1. Delany (Hamilton) sheep site. Predicted v actual animal liveweight

(initial estimate for site specific parameters)

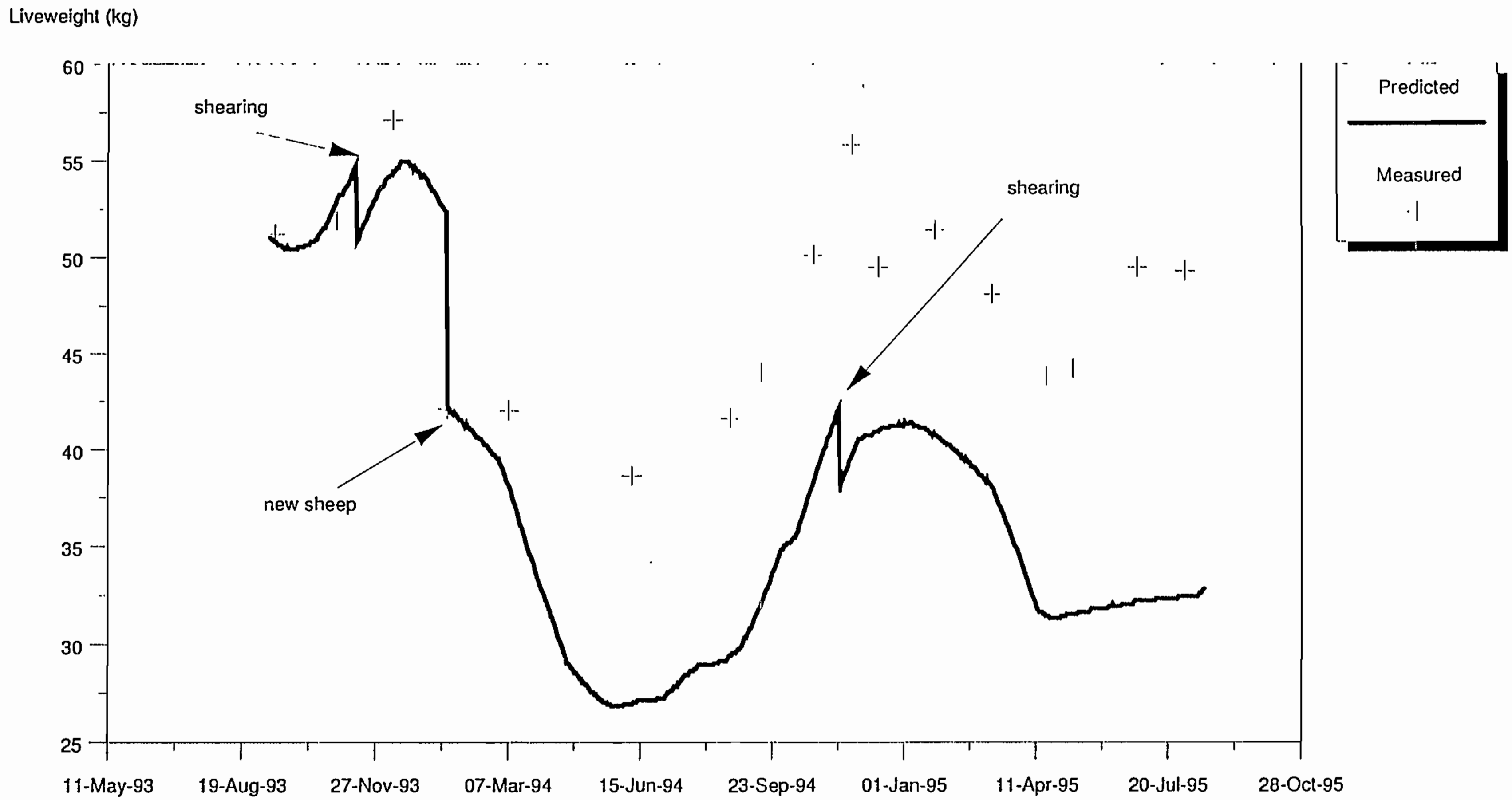


Figure 2. Delany (Hamilton) sheep site. Predicted v actual green pasture DM

(initial estimate for site specific parameters)

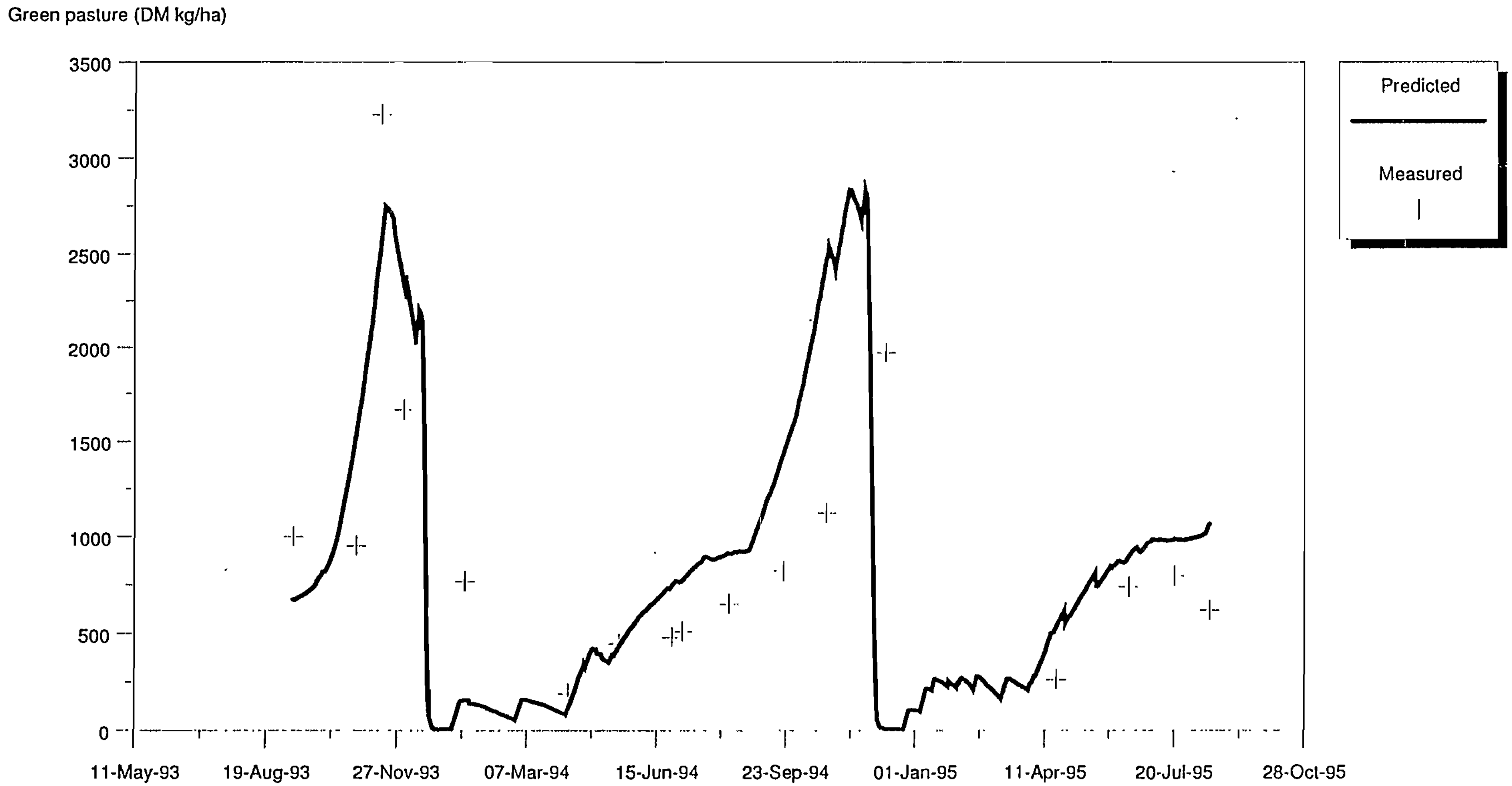


Figure 3. Delany (Hamilton) sheep site. Predicted v actual animal liveweight

(revised estimates for site specific parameters)

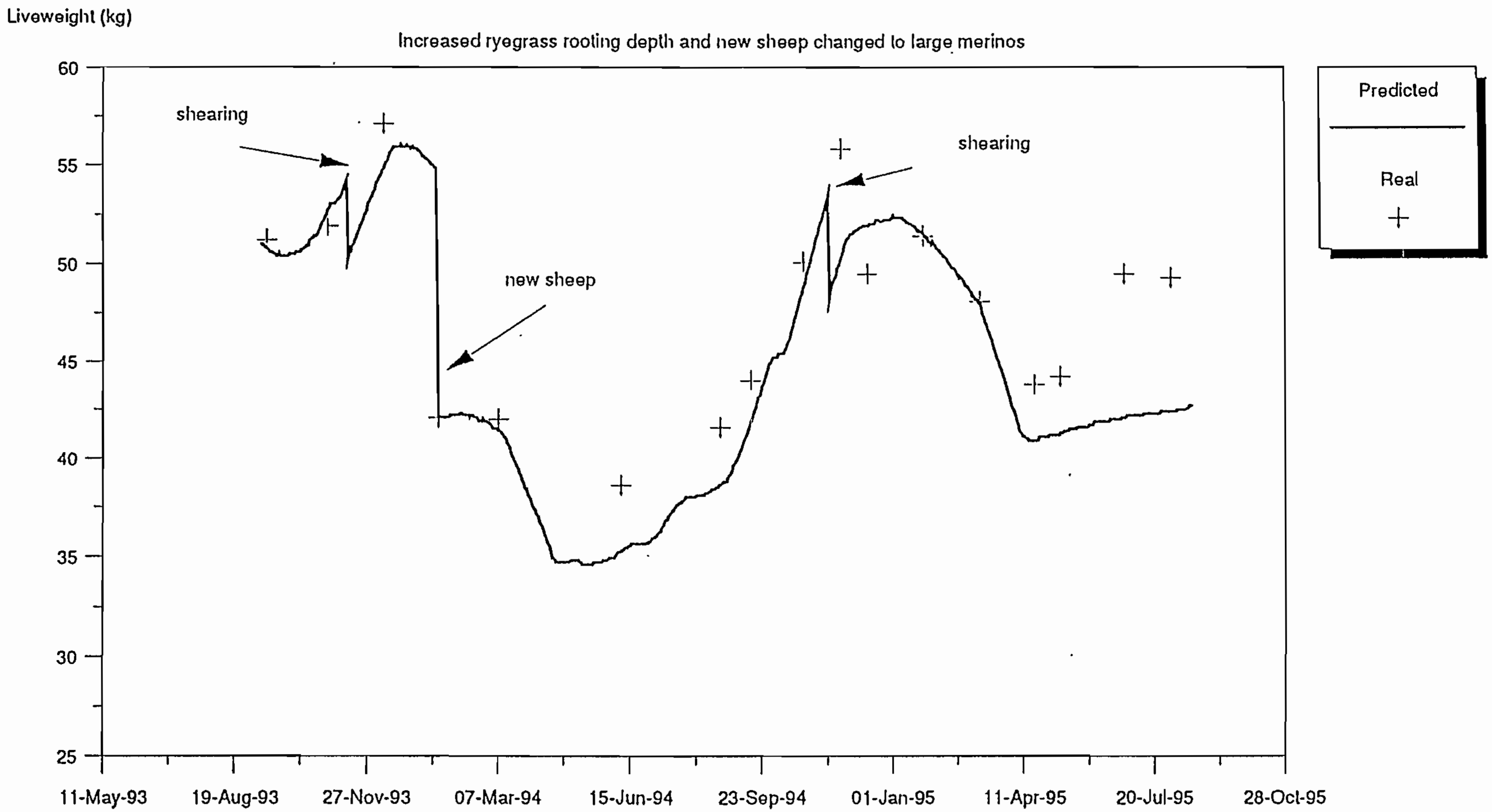


Figure 4. Delany (Hamilton) sheep site. Predicted v actual green pasture DM

(revised estimates for site specific parameters)

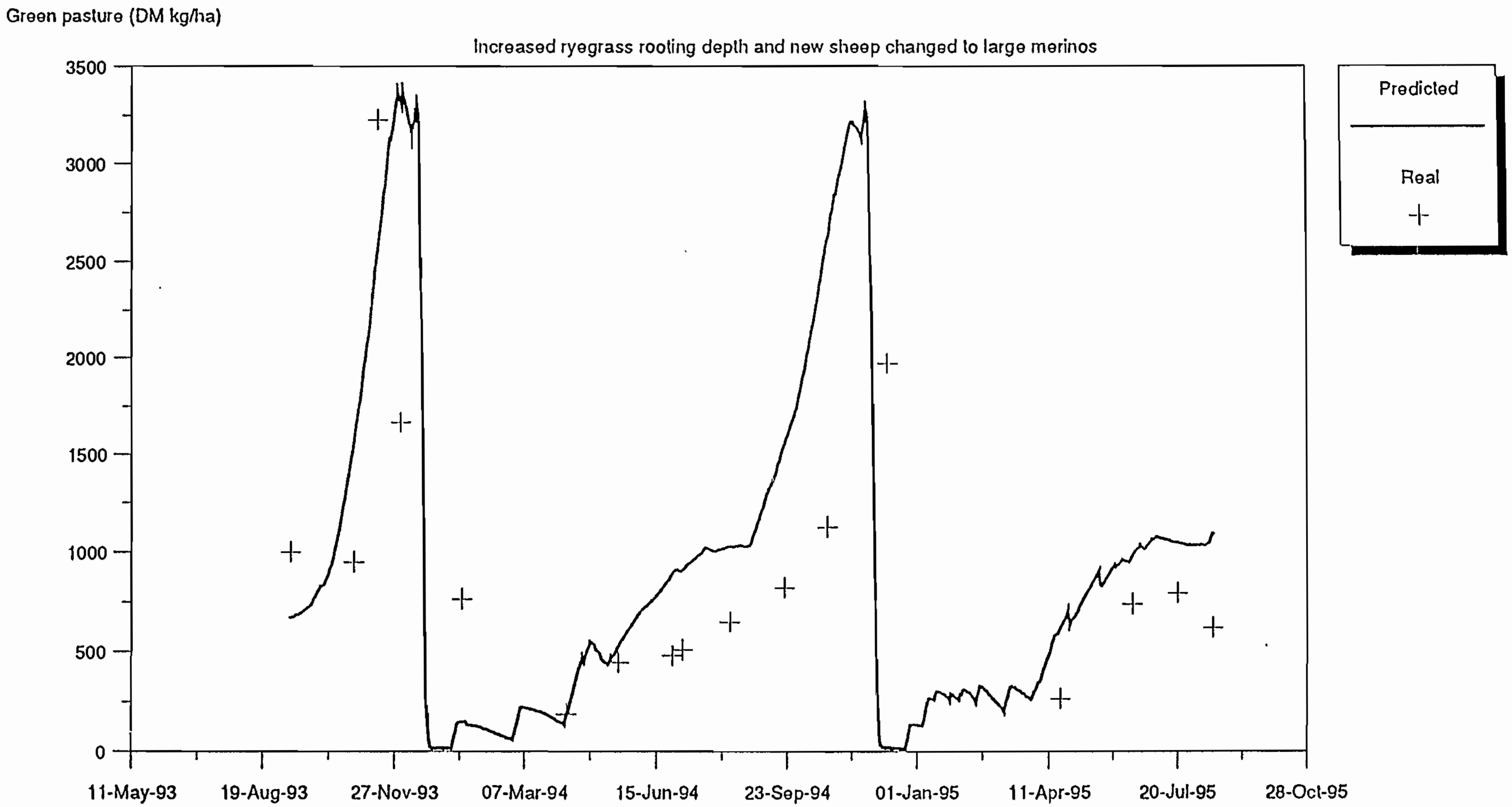


Figure 5. Delany (Hamilton) sheep site. Predicted v actual animal liveweight

(modified protein content of pasture on offer)

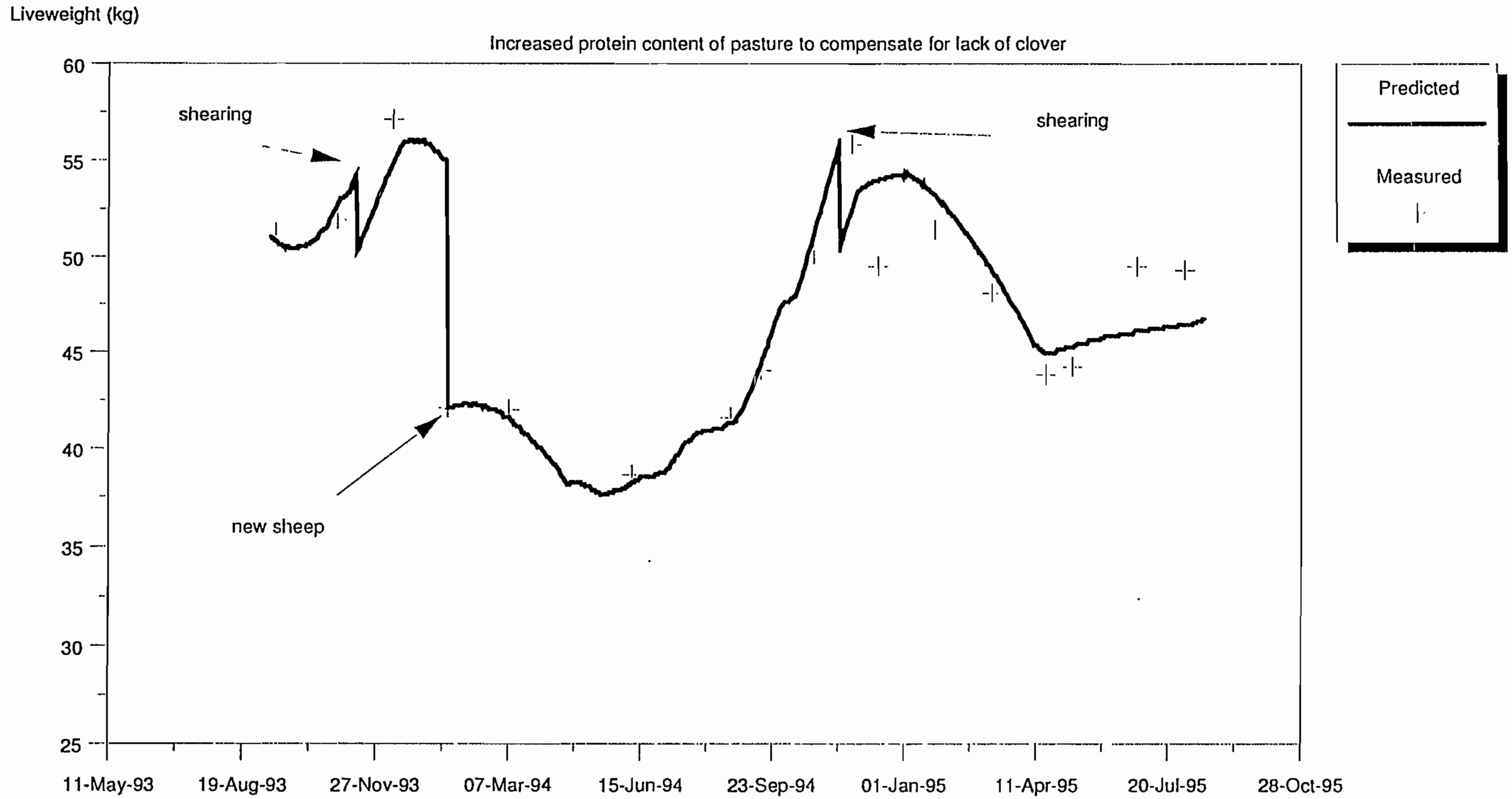


Figure 6. Delany (Hamilton) sheep site. Predicted v actual green pasture DM

(modified protein content of pasture on offer)

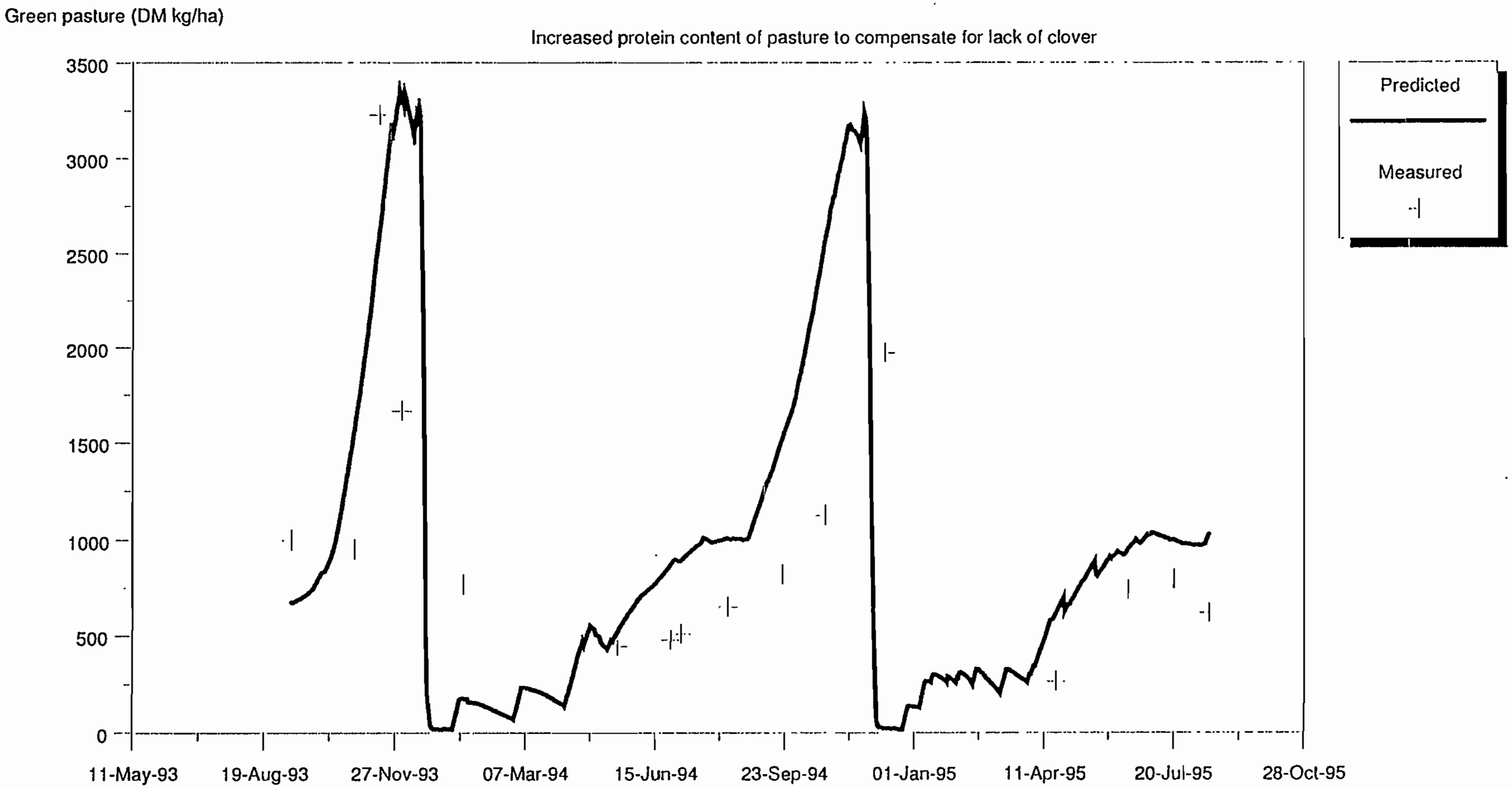


Fig. 1 Sub clover proportion of total green pasture DM in mid November each year

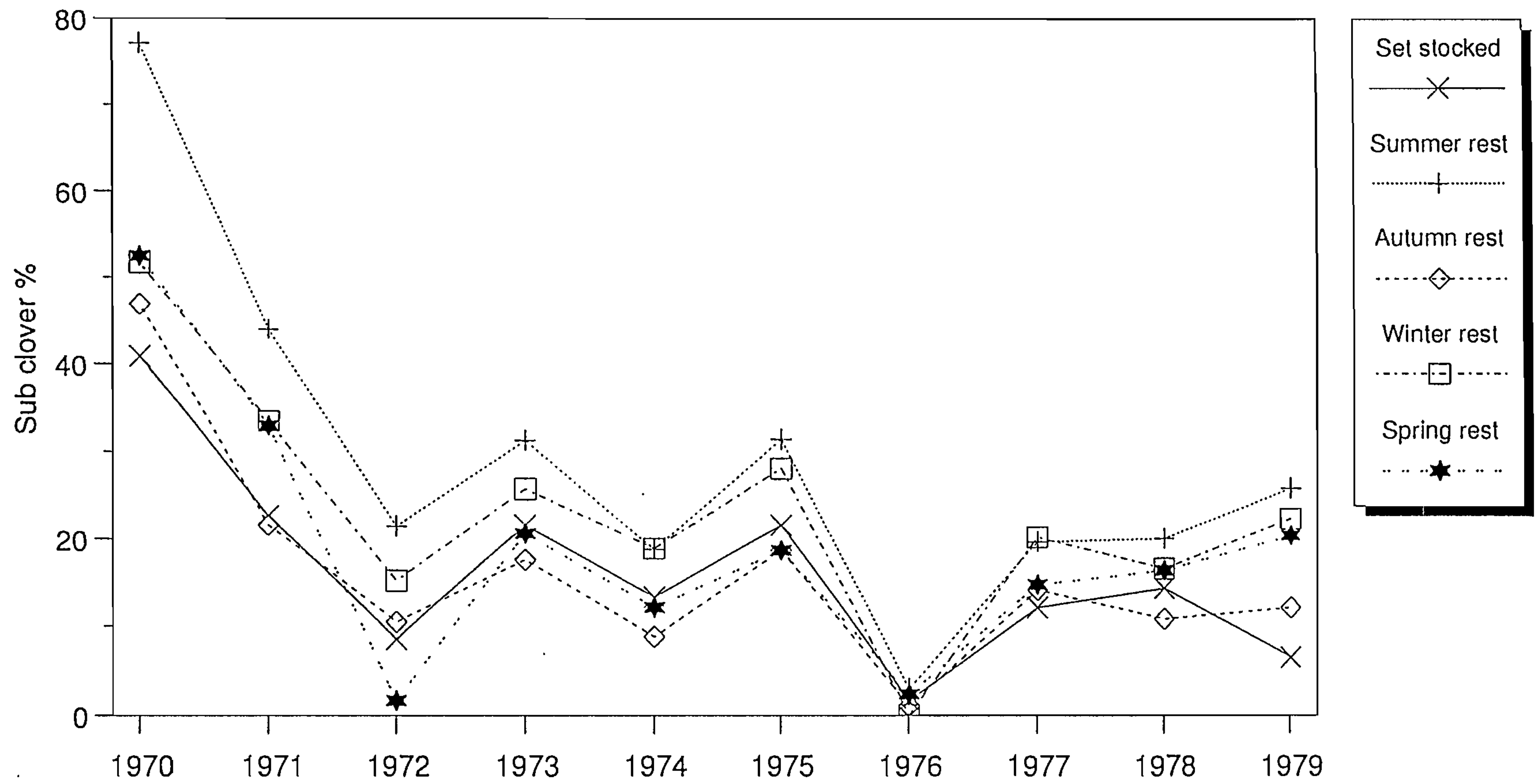


Fig. 8 Sub clover proportion of total green pasture DM in mid November each year

(Each point represents a one year tactical simulation)

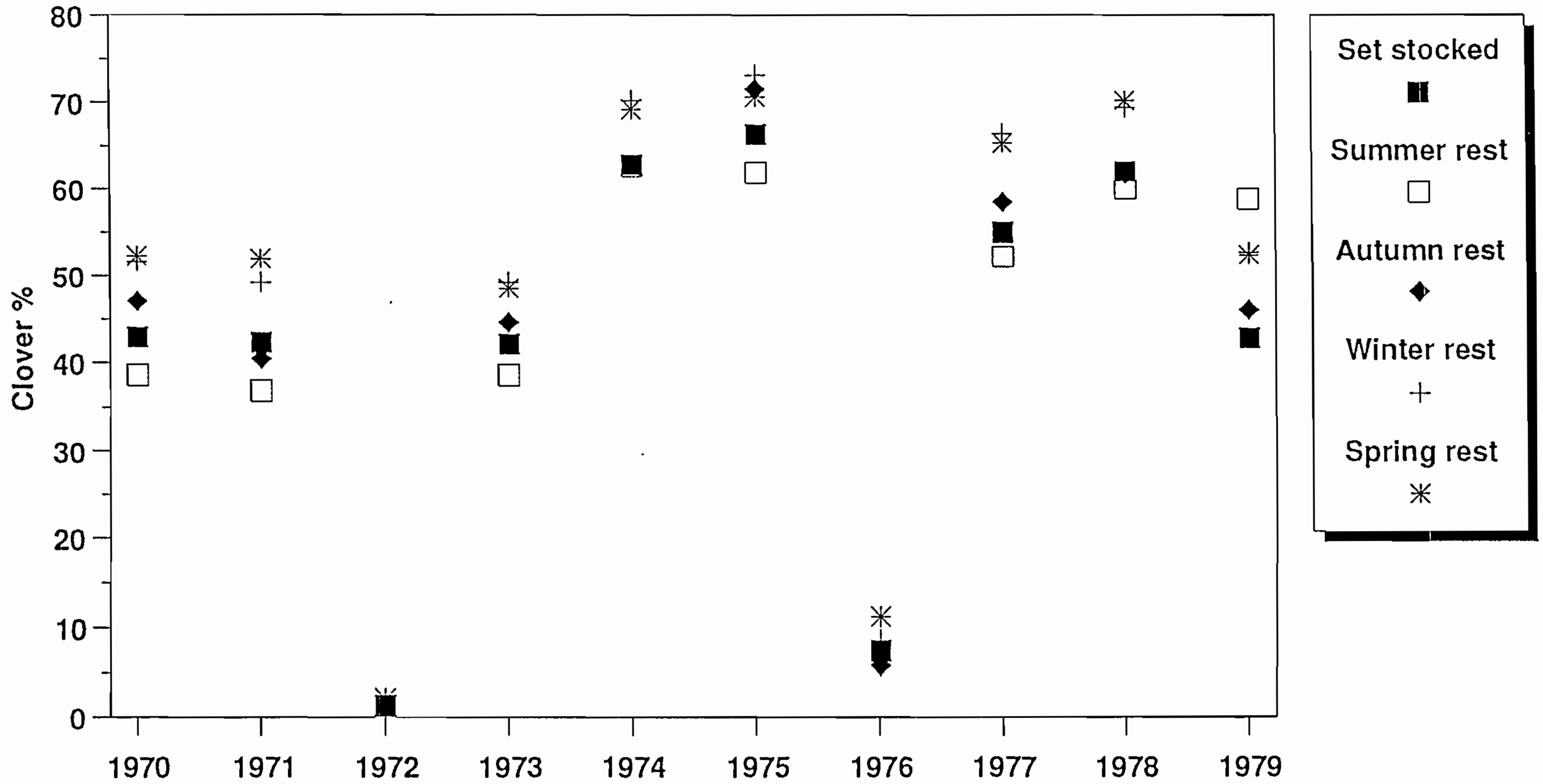


Fig. 9 Sub clover seed bank on 31st December each year

(Each point represents a one year tactical simulation)

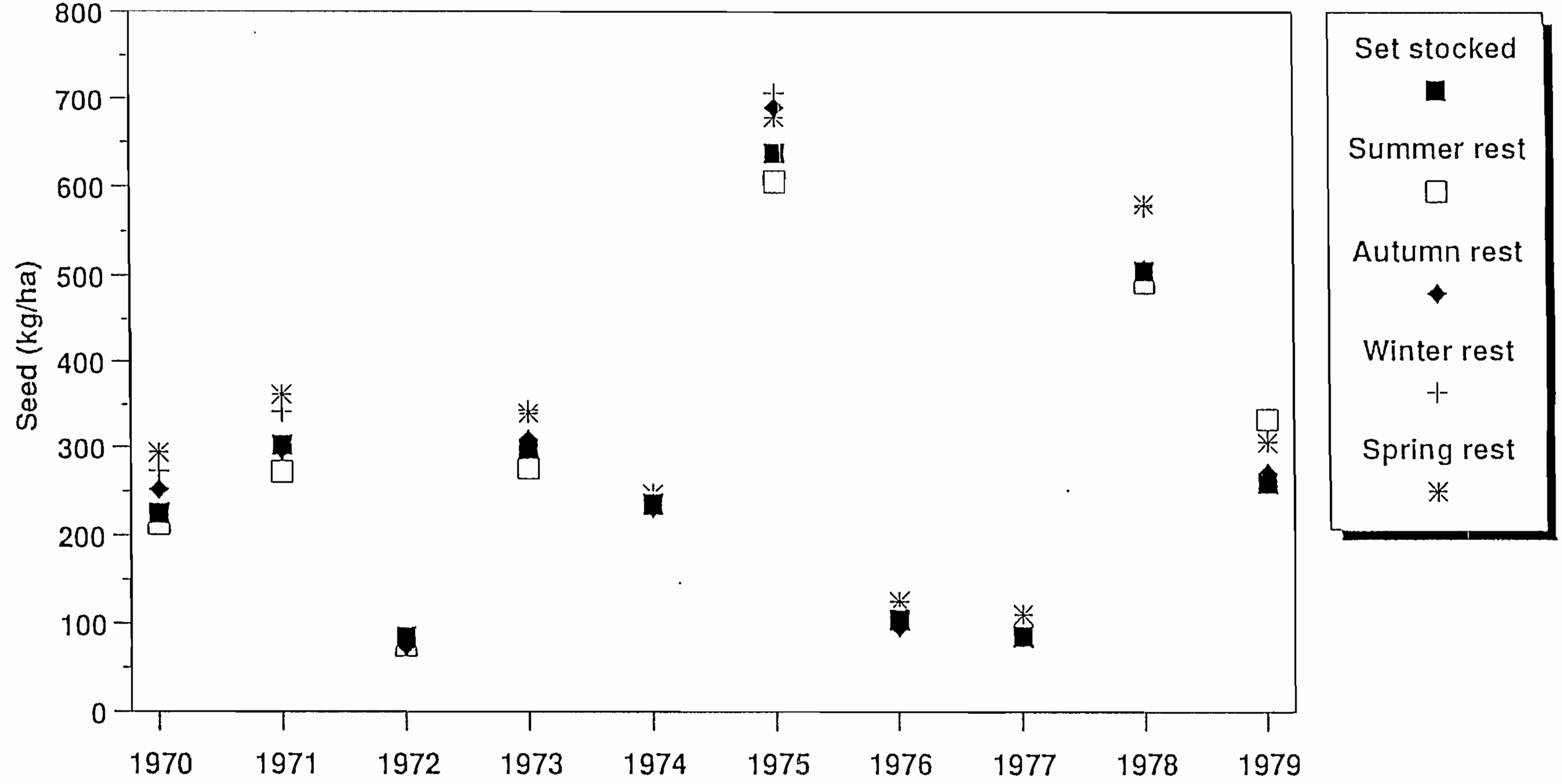


Fig. 10 Effect of treatment on proportion of live sub clover in sward in spring

(A ratio of 1 means the treatment had no effect on sub clover content from one year to another)

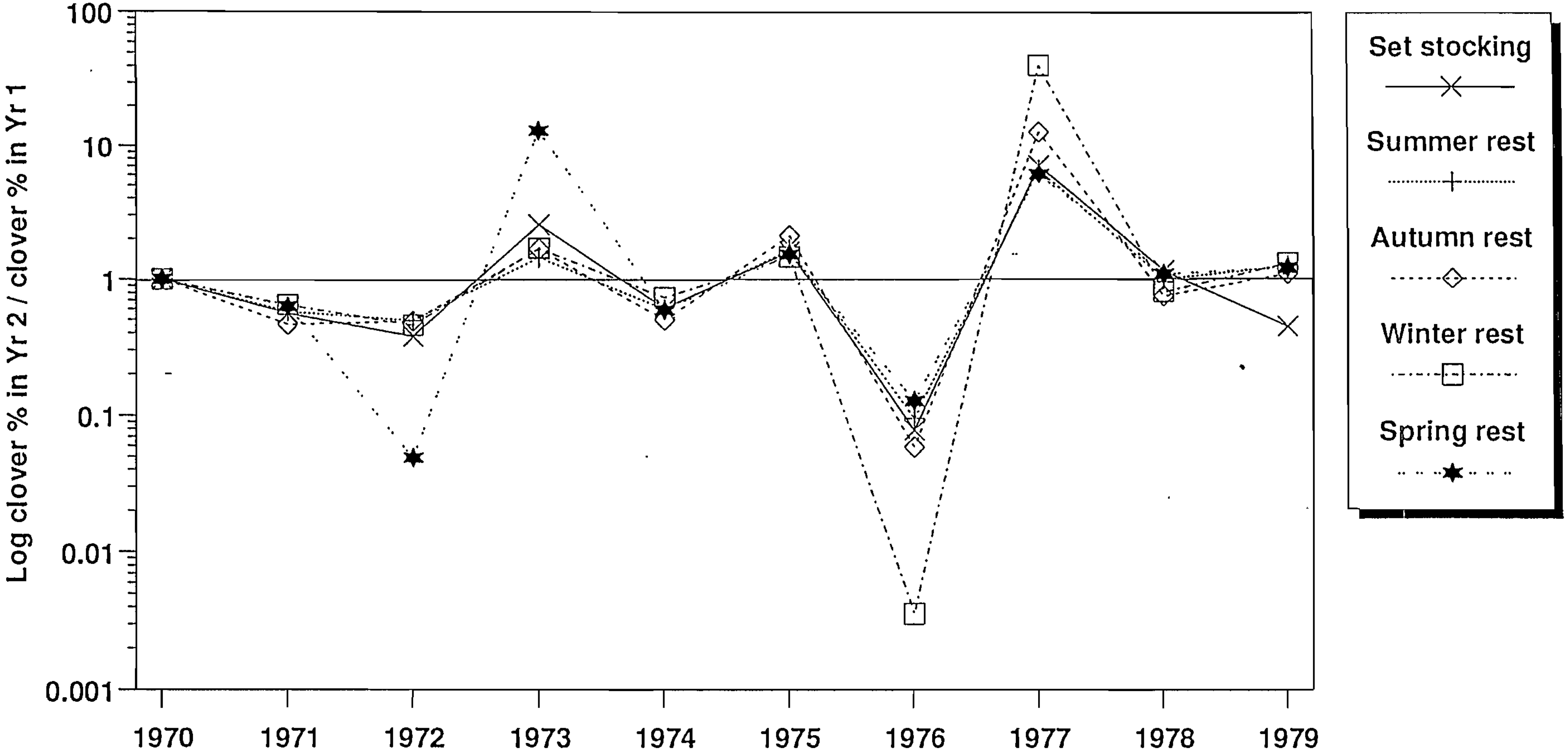


Fig. 11 Effect of seasonal rest on green sub clover DM

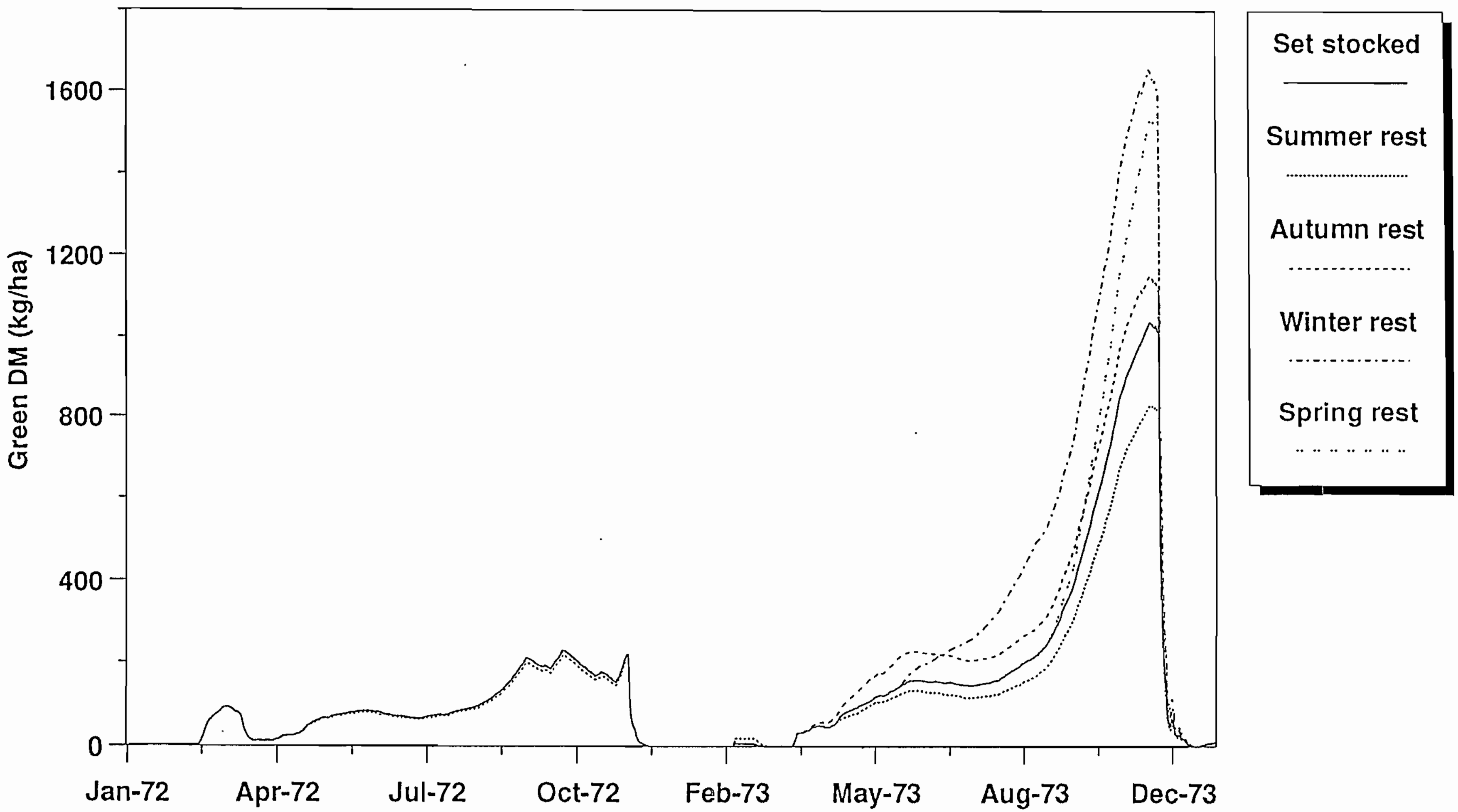


Fig. 12 Green area index limitation to sub clover growth in 1973
(The lower the value the more limiting)

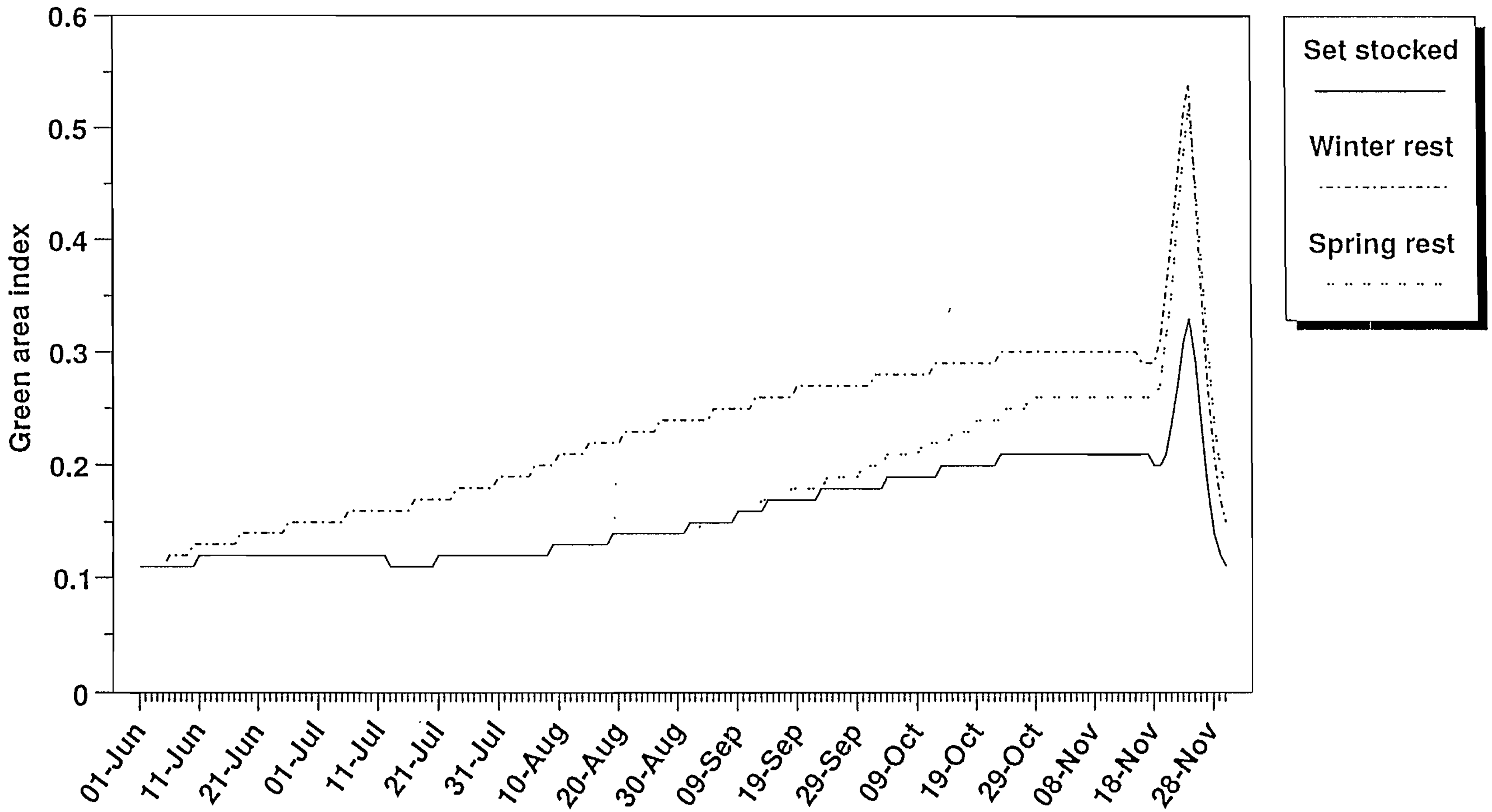


Fig. 13 Effect of seasonal rest on sub clover seed bank

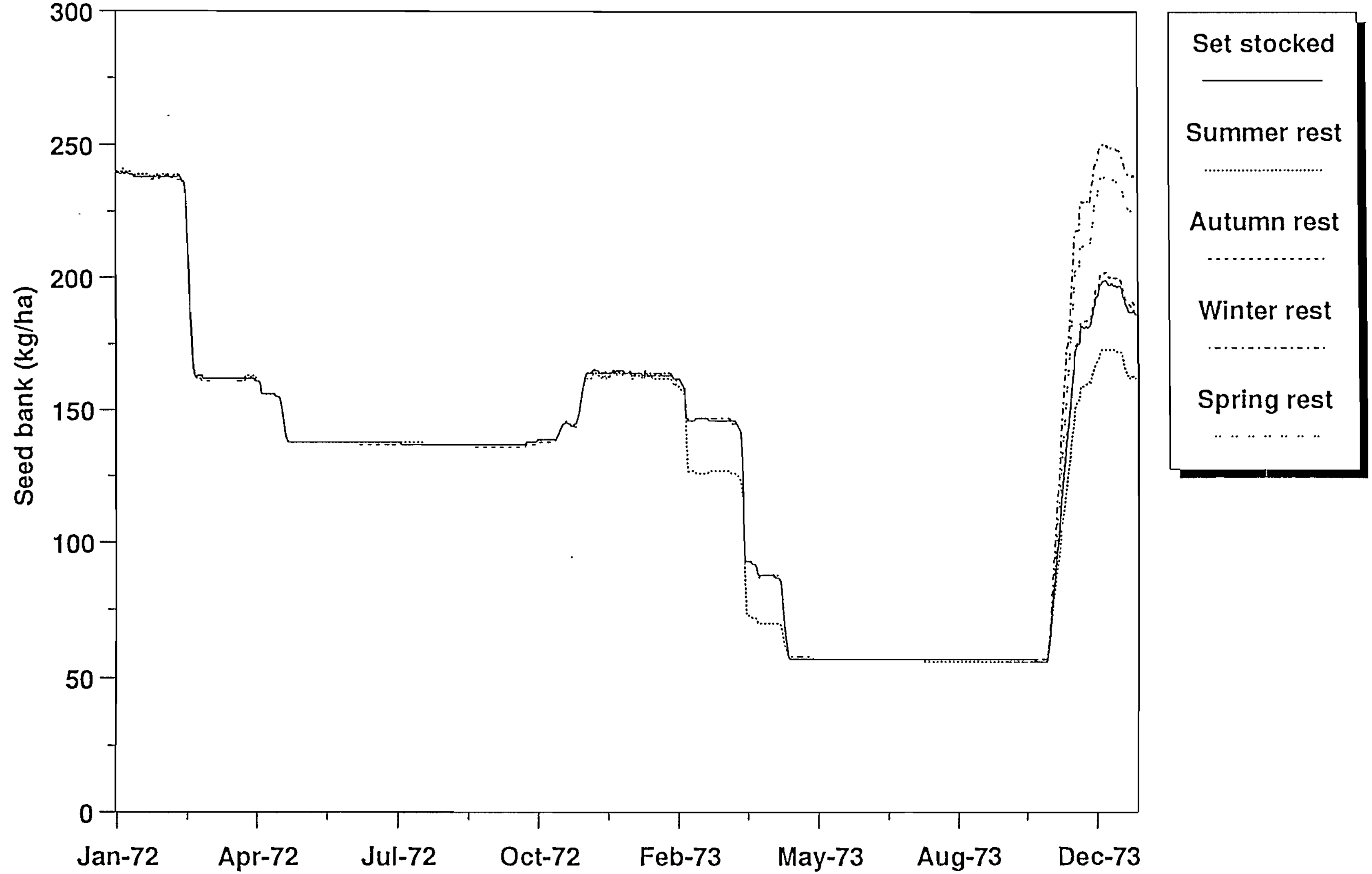


Fig. 14

Sub clover proportion of total green pasture DM in mid November each year

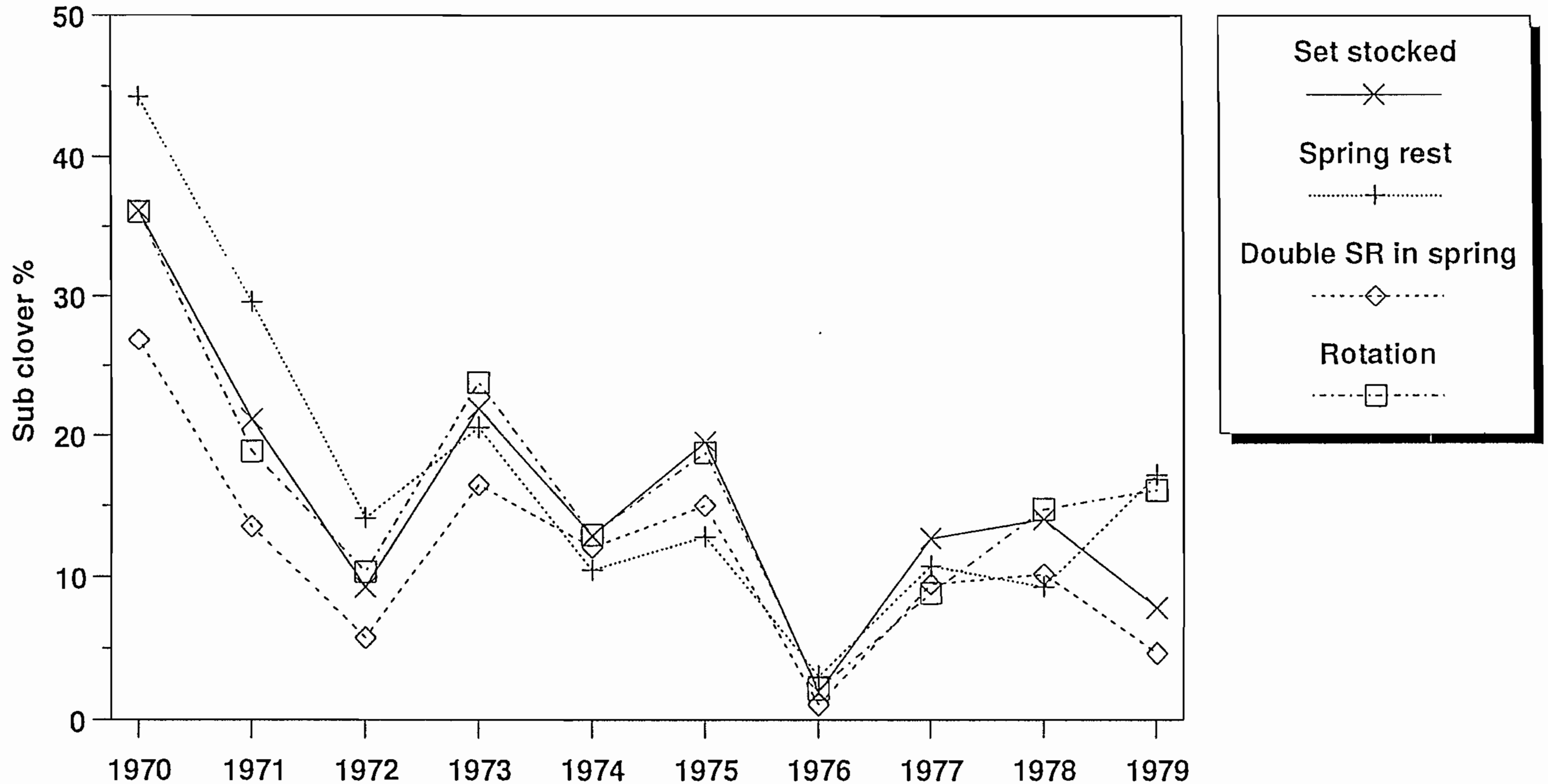


Fig. 15 Effect of treatment on proportion of live sub clover in sward in spring

(A ratio of 1 means the treatment had no effect on sub clover content from one year to the next)

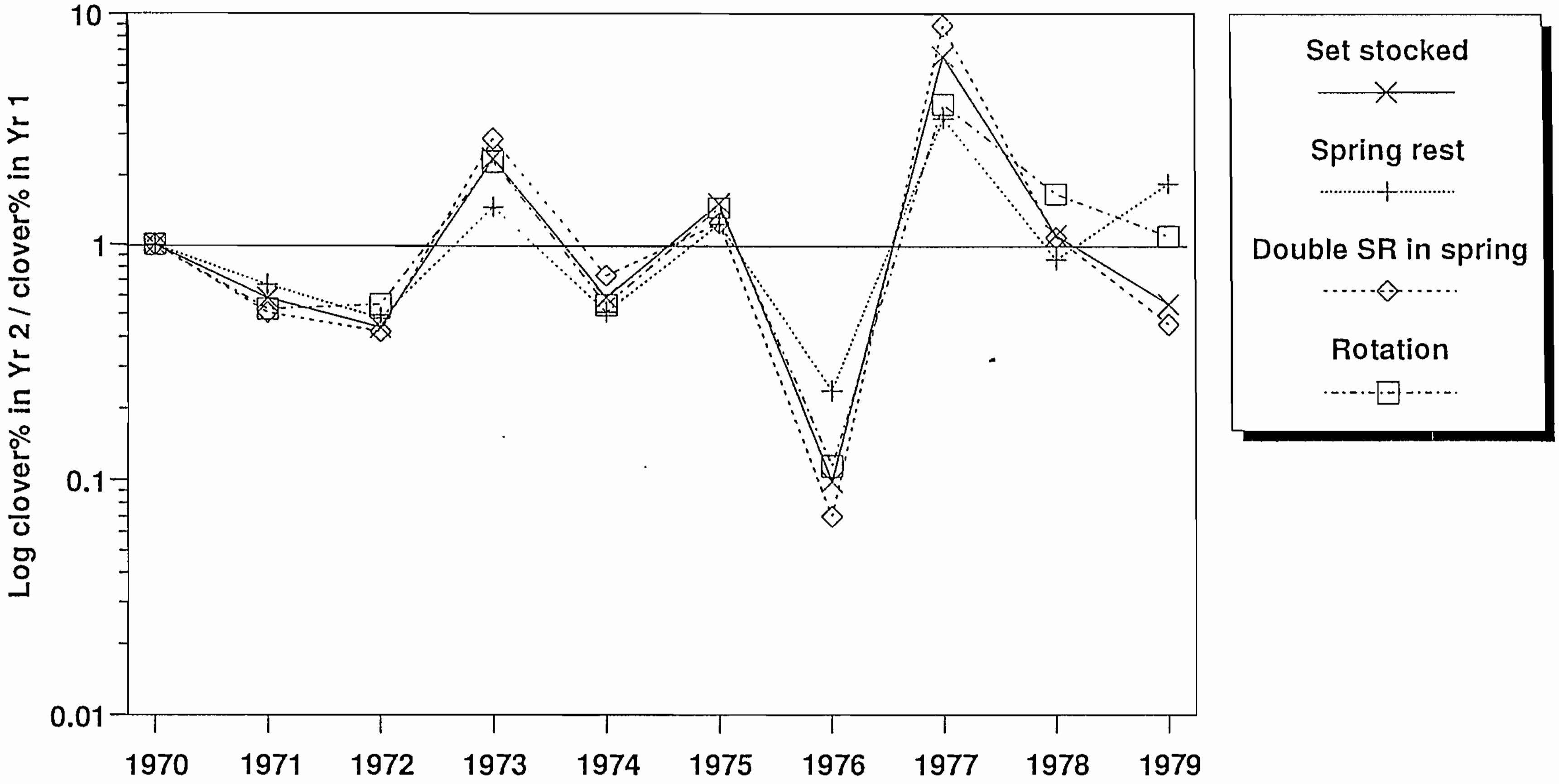


Fig. 16 Effect of grazing management on green sub clover DM

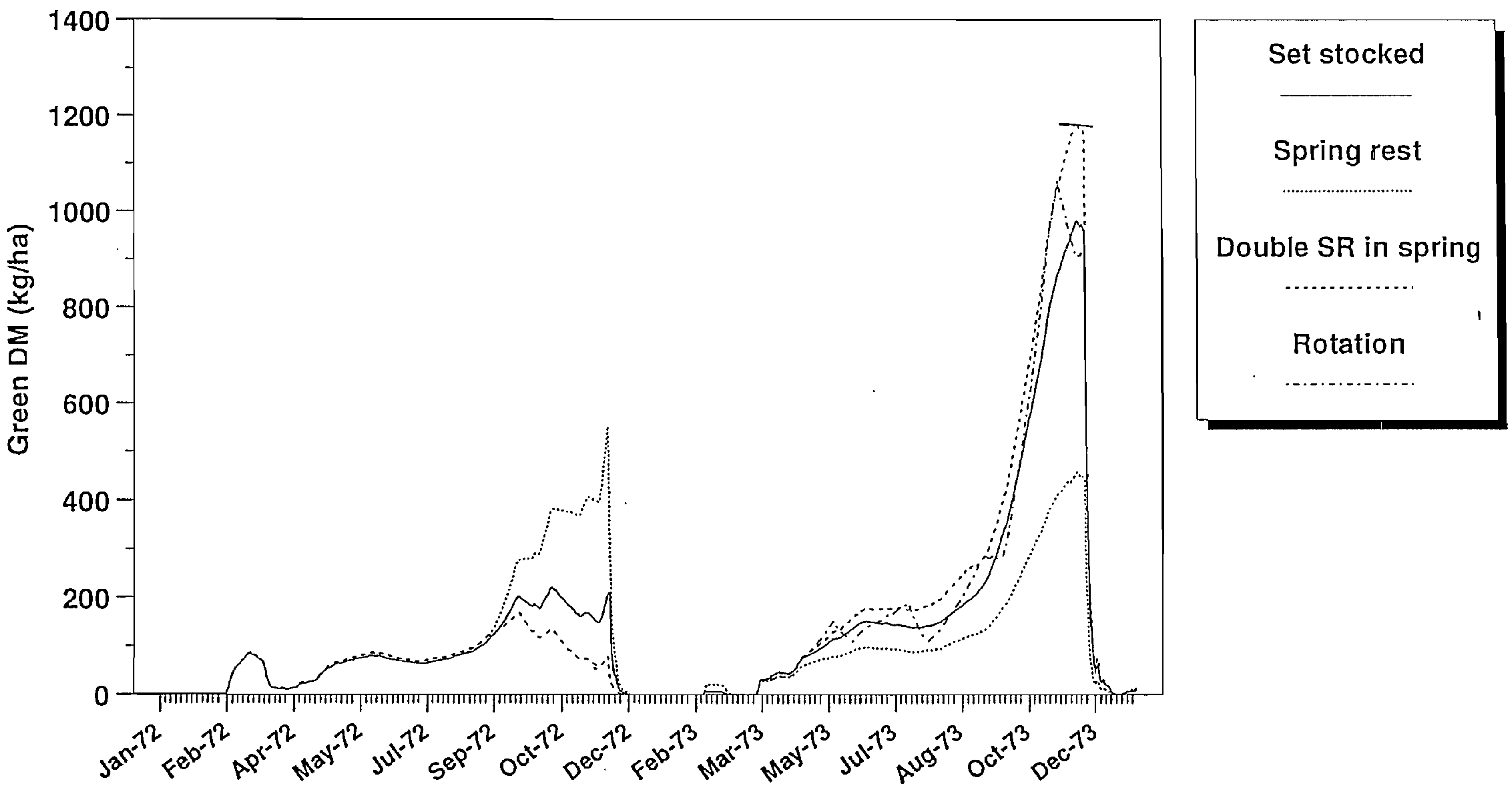


Fig. 17 Effect of grazing management on sub clover seed bank

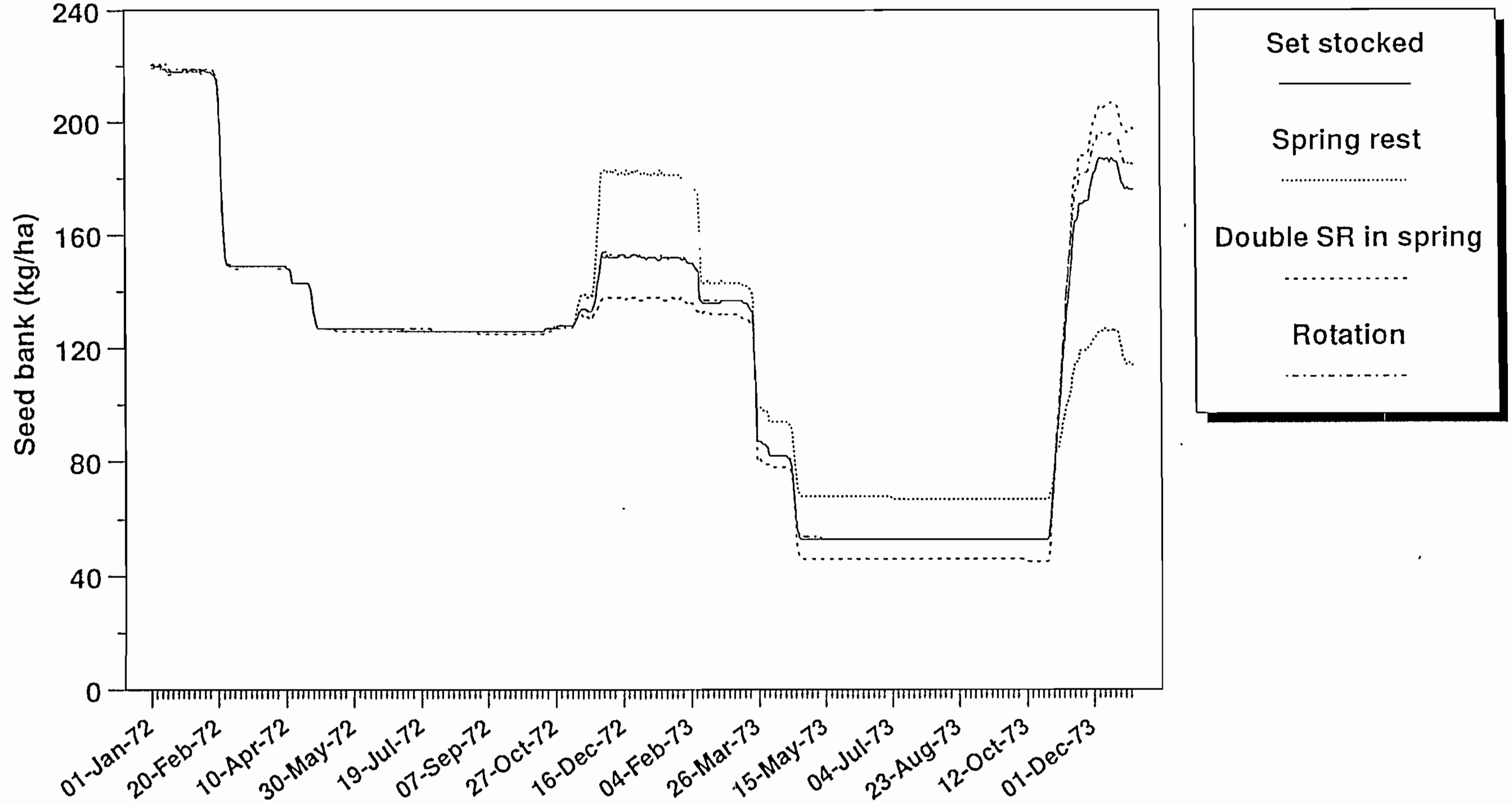


Fig. 18 Effect of grazing management on green annual ryegrass DM

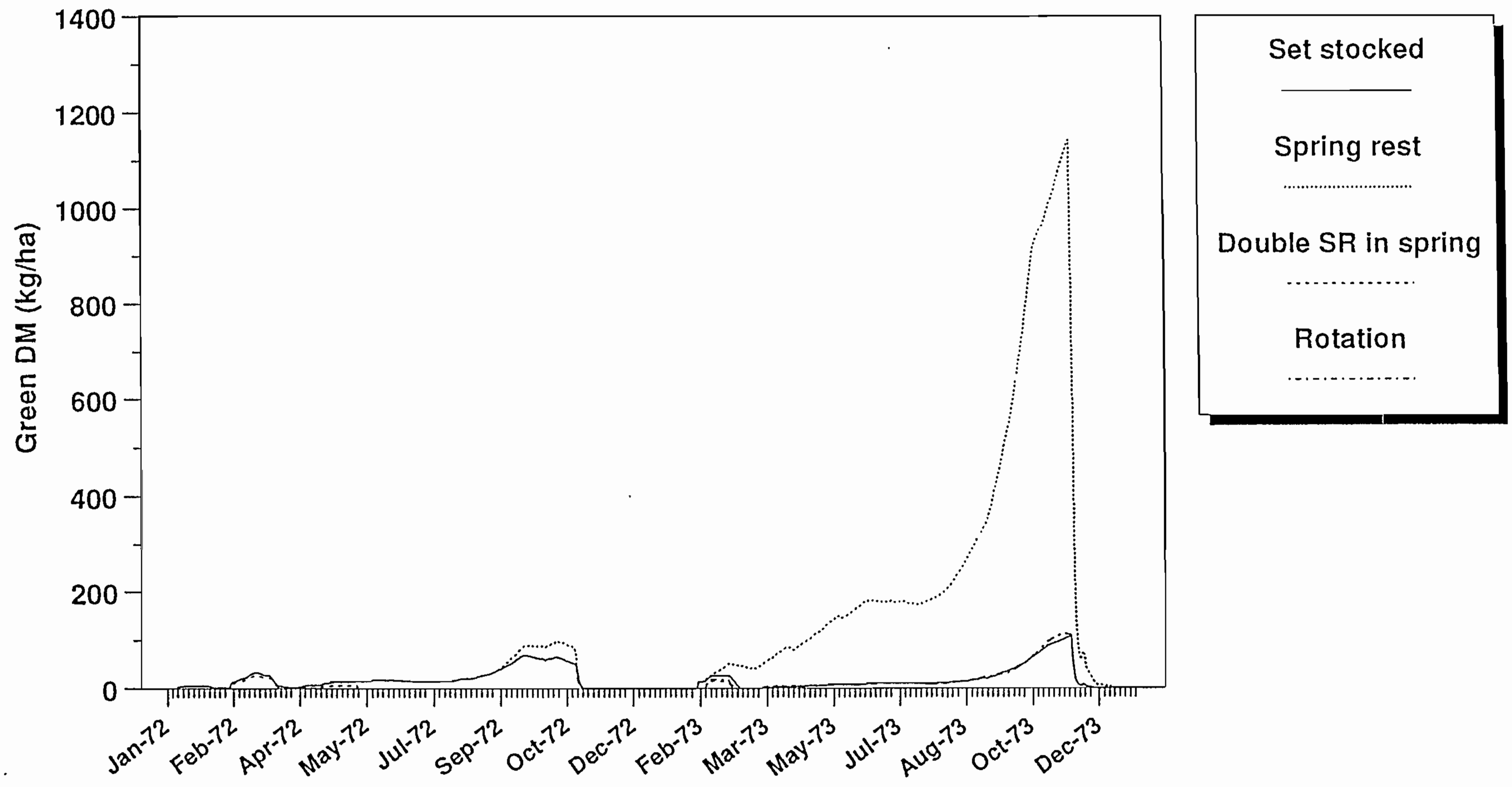
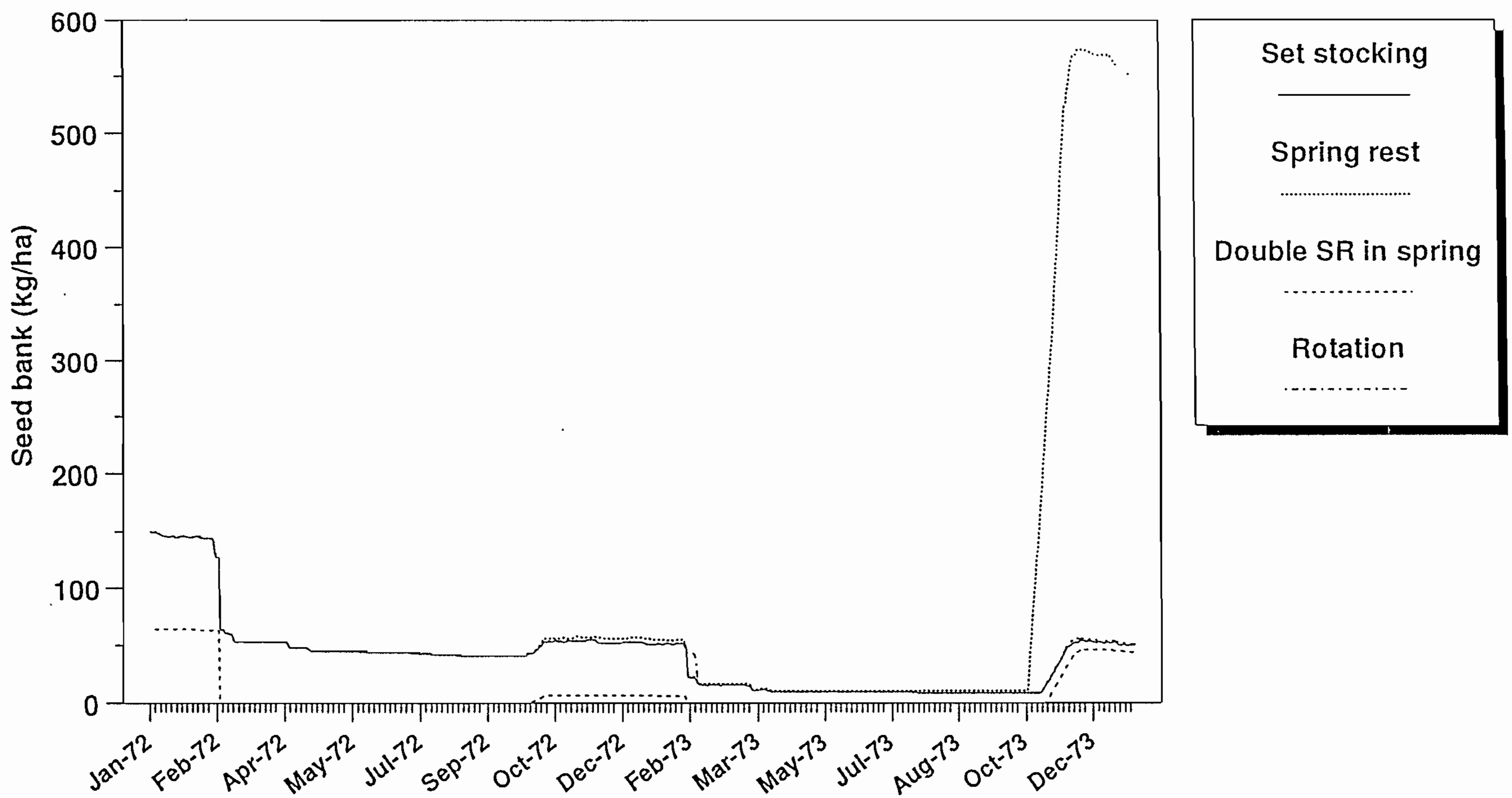


Fig. 19 Effect of grazing management on annual ryegrass seedbank



3.3.2 Delany's Cattle - Hamilton, Victoria

Pasture and animal production from the TPSKP grazing management site - Delany's cattle - was successfully simulated using GrassGro for Windows ver 1.3.0a in September 1996.

The site contained a degraded perennial ryegrass pasture. The major species present were perennial ryegrass, fog grass, onion grass, subterranean clover and annual grasses. For the simulations a mixture of perennial ryegrass and subterranean clover was used. The fertility scalar was set to 0.80.

Weaner steers were introduced to the pasture in late January in each of two years - 1994 & 1995. Simulations were run for each of the two years. The first ran from 26th January 1994 to 24 January 1995 and the second from 31st January 1995 to 10th February 1996. Livestock were as follows:

- Hereford, Angus, Beef Shorthorn
- Standard Reference Weight = 500 kg
- Initial stocking rate = 2.0 weaners/ha
- Initial mean liveweight = 245 kg (1994) 249 kg (1995)

Management was as follows:

- No supplementary feeding in 1994.
- 2.5kg/ha/day pasture hay fed between 20th April and 8th May 1995.
- Stocking rate increased to 3.0/ha in mid September (1994 only)

Initial state of soil:

Area of paddock	100 ha
Steepness	Level
SCS curve number I:	75
Stage II soil evapn:	3.8 mm/d½
Fertility scalar	0.80
Initial soil moisture	
Topsoil	30 %
Subsoil	40 %

	Topsoil	Subsoil
Texture	Clay loam	Clay
Cumulative depth	400	1000 mm
Bulk density	1.40	1.35 g/cm3
Water content at F.C.	34	42 %
Water content at W.P.	20	29%
Sat. hyd. conductivity	2.0	0.8 mm/h

Initial state of pastures:

Species	Herbage components (DM kg/ha) Green	Dead	Litter	Root	Seed	Phenological stage
1994						
Perennial ryegrass	0	1000	200	1200	0	Dormant
Subterranean clover	0	200	0	0	400	Senescent
1995						
Perennial ryegrass	500	1000	200	1200	0	Vegetative
Subterranean clover	100	200	200	100	400	Vegetative

1994 simulation results

Figure 20 shows simulated versus actual steer liveweights. Note the change from 2.0 to 3.0 steers per hectare. At this point two simulation runs were spliced together and because of weight range limitations in relation to condition score in GrassGro the weight of the animals at the start of the 3.0 /ha run was slightly higher than that of the animals at the end of the 2.0 /ha run. Note also the fall off in weight of the simulated steers from mid December 1994 compared to the experimental animals.

Figure 21 presents live pasture DM availability - simulated and measured. From the autumn break until mid-spring the simulation predicted the measured availability well. However, the simulated pasture dried off several weeks before the real pasture and the subsequent decrease in pasture quality accounted for the difference in performance of the simulated and experimental steers at this time.

1995 simulation results

Figure 22 shows simulated versus actual steer liveweights. The stocking rate was 2.0/ha for the entire simulation run. As with the 1994 simulation the prediction was excellent until early December. At this time, the simulated steers' weight gain ceased while the experimental steers continued to gain weight for a few more weeks. Figure 23 shows predicted versus actual live pasture DM availability. Although there were insufficient measured points to be sure, it appears that as was the case in 1994, simulated pasture was drying off several weeks earlier than it should have and again this would account for the animal performance differences.

Figure 24 shows daily rainfall events for 1st November to 31st December 1995. There was a period of about 10 days with little or no rain after the 15th November. This lead to severe moisture stress (Figure 25) and in turn to rapid drying off of the pasture (Figure 26). In reality, the pasture survived this period and was able to keep growing on the strength of good rain in late November - mid-December.

Conclusions

In each year the simulation closely matched measured animal and pasture performance. The only serious discrepancy was removed when simulated rooting depths were increased (see 3.5 improvements to GrassGro 3.5.1 Rooting depth). GrassGro can accurately predict the performance of steers in the Hamilton district

Fig. 20

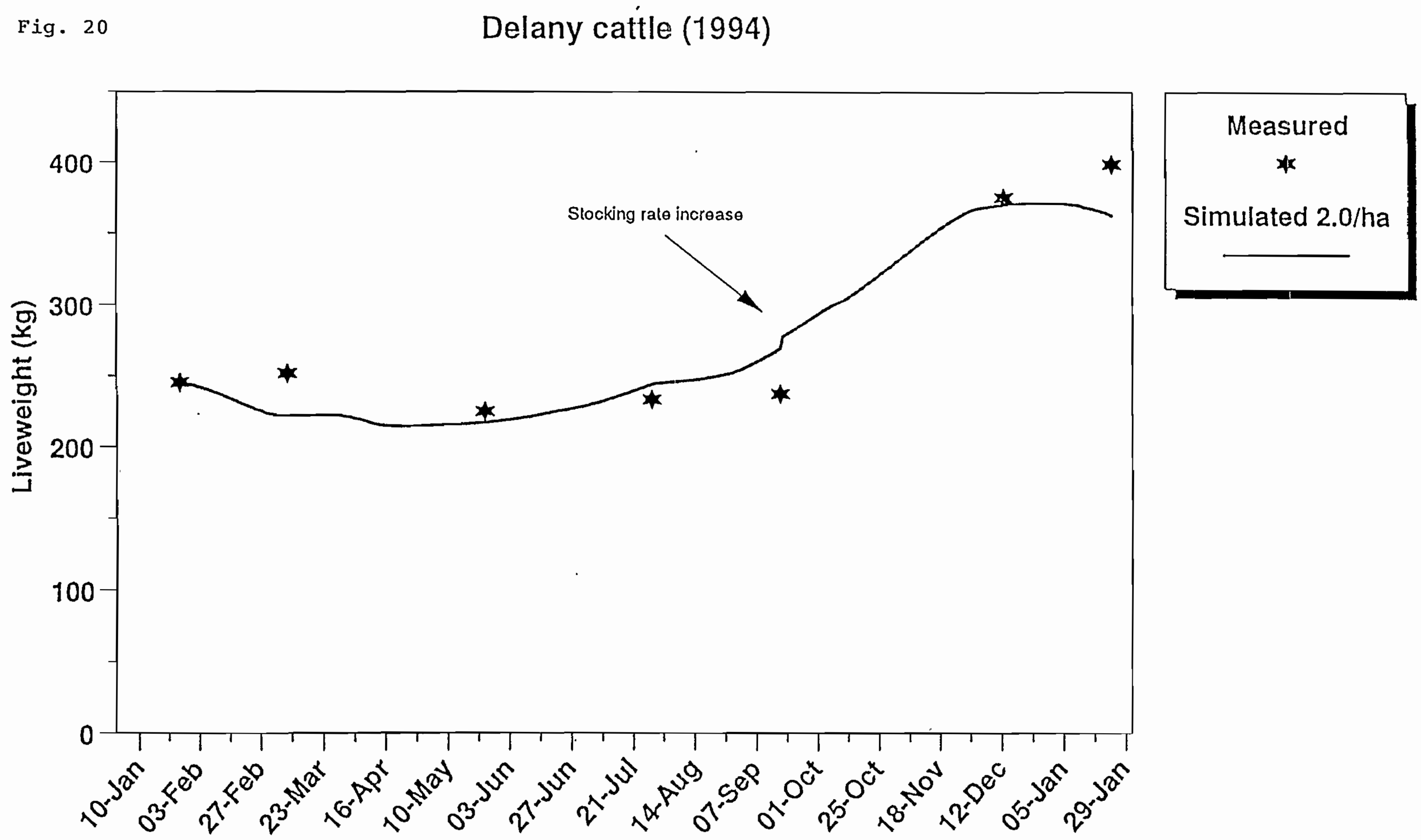
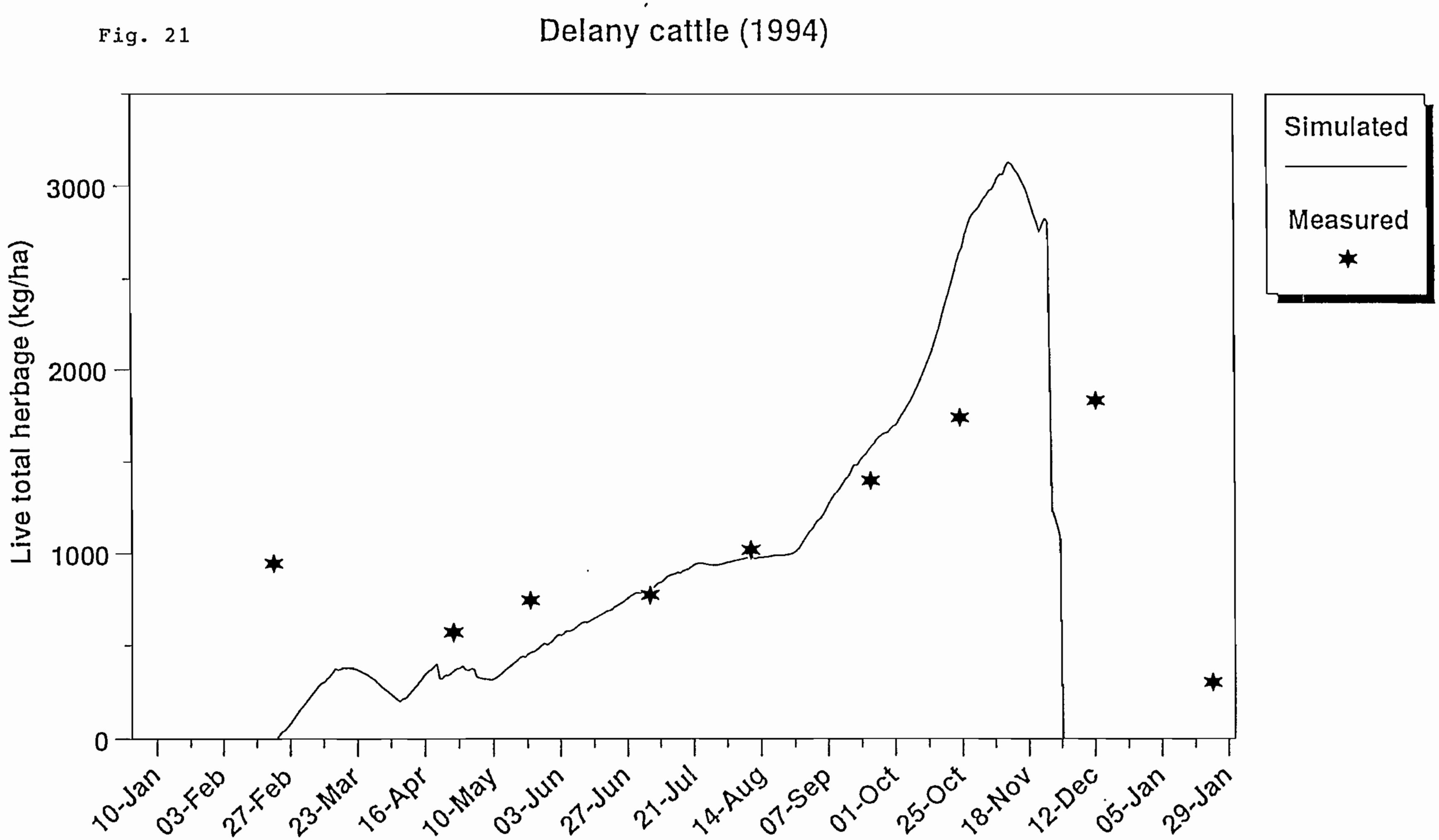

Delany cattle (1994)
Liveweight (kg)
0
100
200
300
400
10-Jan
03-Feb
27-Feb
23-Mar
16-Apr
10-May
03-Jun
27-Jun
21-Jul
14-Aug
07-Sep
01-Oct
25-Oct
18-Nov
12-Dec
05-Jan
29-Jan
Stocking rate increase
Measured
Simulated 2.0/ha

Fig. 21



Delany cattle (1994)
Live total herbage (kg/ha)
0
1000
2000
3000
10-Jan
03-Feb
27-Feb
23-Mar
16-Apr
10-May
03-Jun
27-Jun
21-Jul
14-Aug
07-Sep
01-Oct
25-Oct
18-Nov
12-Dec
05-Jan
29-Jan
Simulated
Measured

Fig. 22

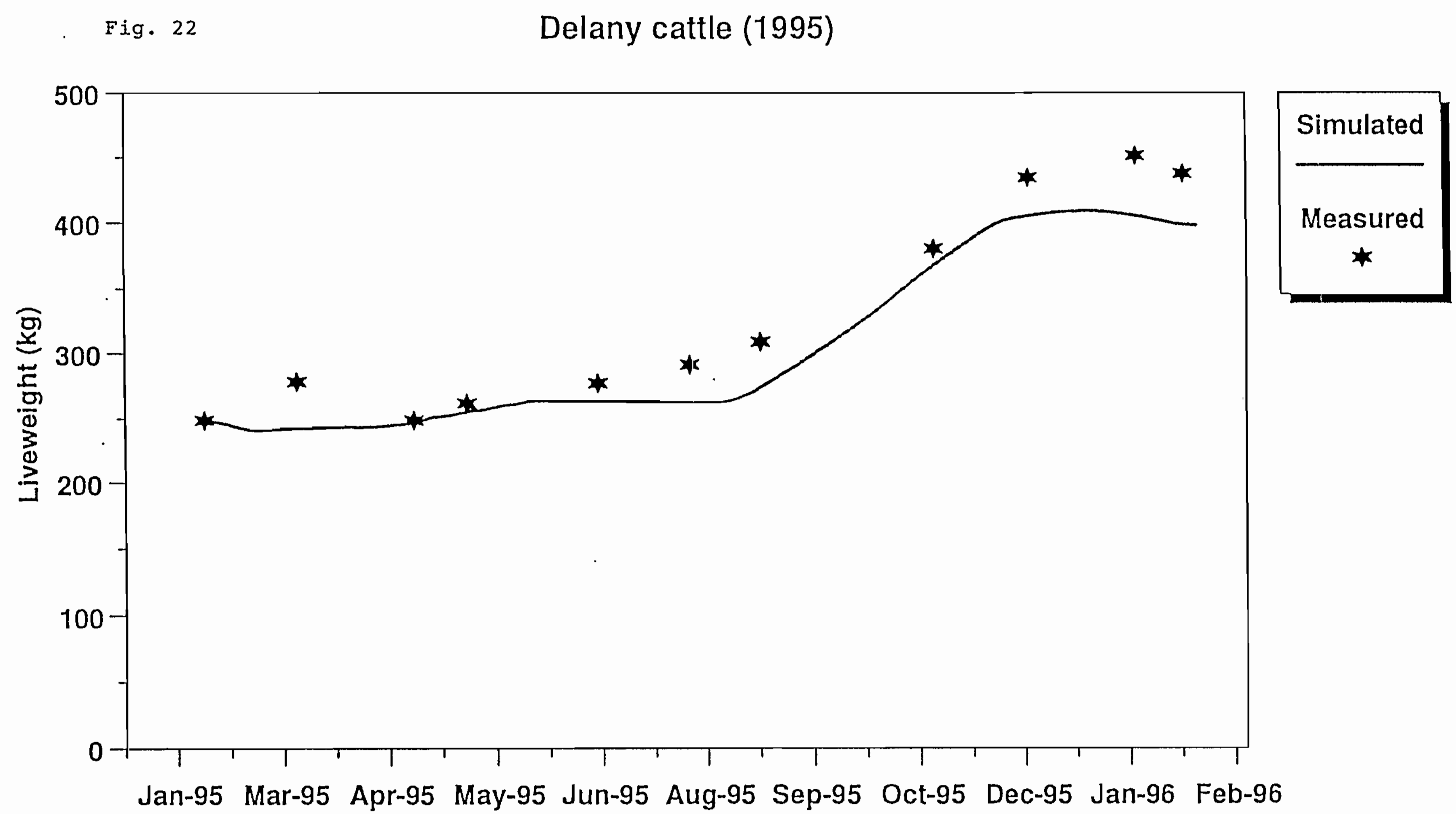
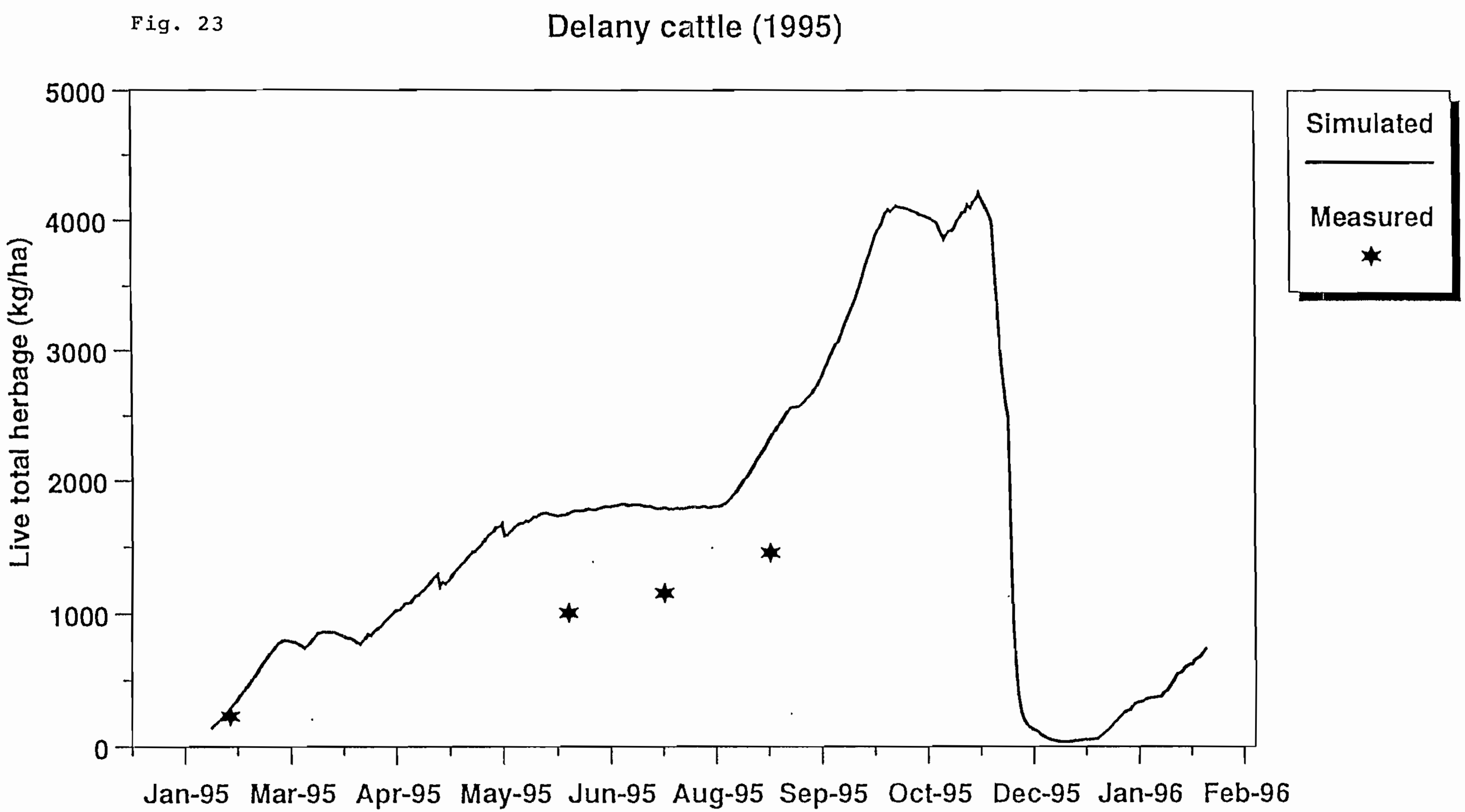

Delany cattle (1995)
Liveweight (kg)
500
400
300
200
100
0
Jan-95
Mar-95
Apr-95
May-95
Jun-95
Aug-95
Sep-95
Oct-95
Dec-95
Jan-96
Feb-96
Simulated
Measured

Fig. 23



Delany cattle (1995)
Live total herbage (kg/ha)
5000
4000
3000
2000
1000
0
Jan-95
Mar-95
Apr-95
May-95
Jun-95
Aug-95
Sep-95
Oct-95
Dec-95
Jan-96
Feb-96
Simulated
Measured

Fig. 24

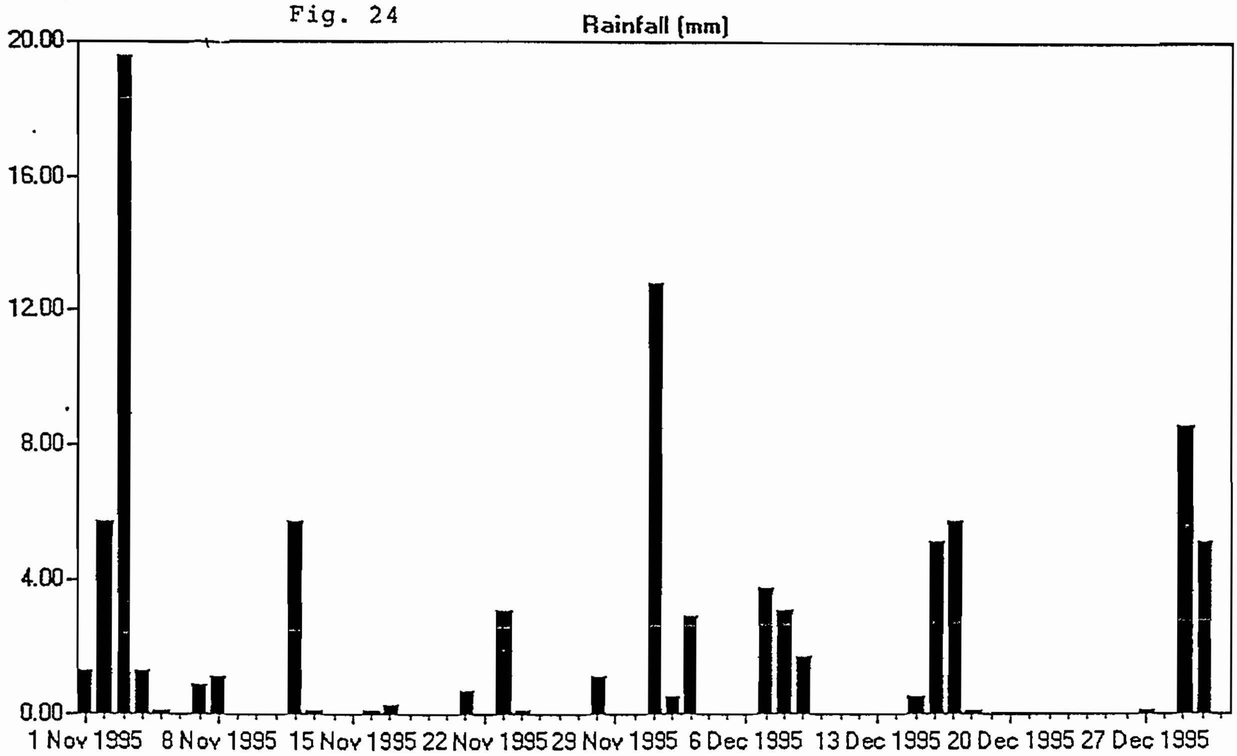
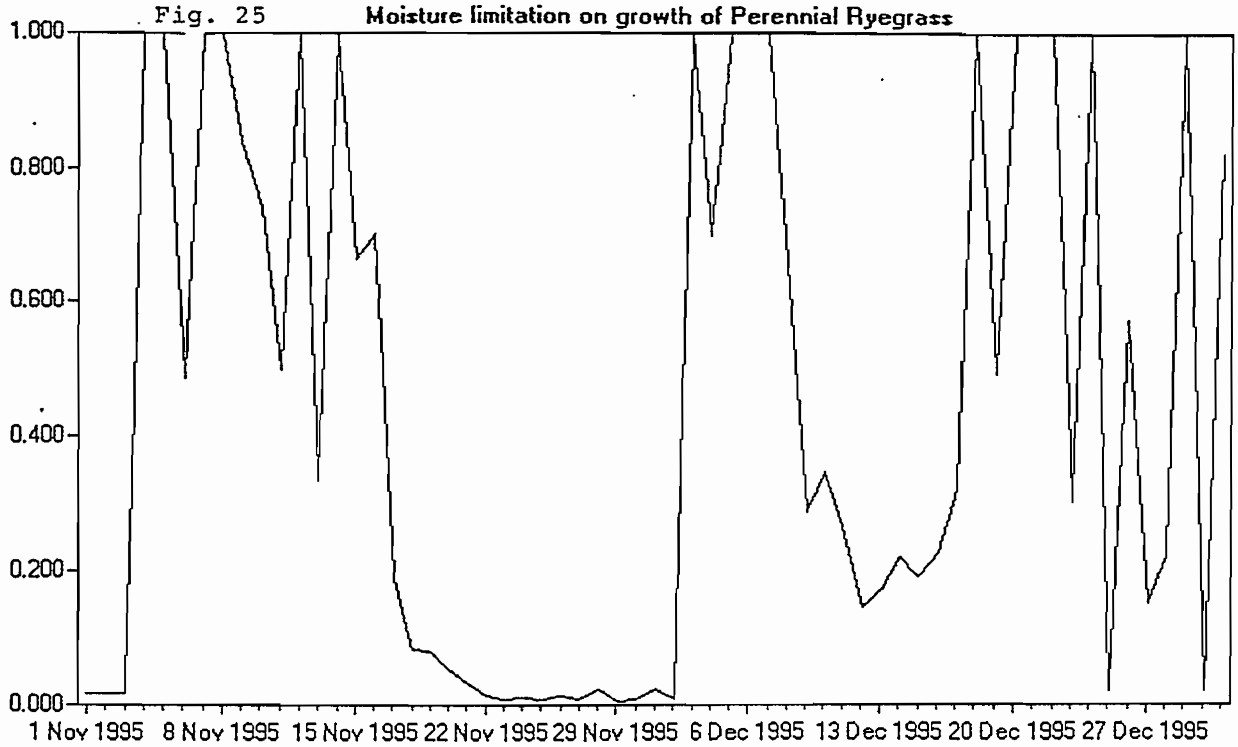

Rainfall (mm)
20.00
16.00
12.00
8.00
4.00
0.00
1 Nov 1995
8 Nov 1995
15 Nov 1995
22 Nov 1995
29 Nov 1995
6 Dec 1995
13 Dec 1995
20 Dec 1995
27 Dec 1995

Fig. 25


Moisture limitation on growth of Perennial Ryegrass
1.000
0.800
0.600
0.400
0.200
0.000
1 Nov 1995
8 Nov 1995
15 Nov 1995
22 Nov 1995
29 Nov 1995
6 Dec 1995
13 Dec 1995
20 Dec 1995
27 Dec 1995

3.3.3 Delamere wethers, S.A.

Pasture and animal production from the TPSKP grazing management site - Delamere, South Australia - were successfully simulated using GrassGro DOS in March 1996. In May 1996 the site manager - Tim Prance and myself spent a day examining a long term simulation run for the site. With Tim's local knowledge it was further improved. Figures 27 to 30 present output from the long term GrassGro run - total live herbage, live clover herbage, animal liveweight and average pasture growth rate respectively. We next discussed a suite of grazing management treatments to test using GrassGro. The aim was to see if any would have beneficial effects on the subterranean clover content of the sward.

The treatments examined were as follows:

Set stocking	}	20 wethers/ha
Summer rest	}	
Autumn rest	}	All have stock removed for 3 calendar months in year 1.
Winter rest	}	Set stocking at 20 wethers/ha otherwise.
Spring rest	}	

High spring utilisation - Set stocked at 20/ha. SR increased in spring to 40/ha until senescence then SR reverts to 20/ha

Rotational grazing - Rotational grazing (5 days on / 35 days off) from mid January to mid July. Set stocked at 20/ha other times.

Late summer/short autumn close - Set stocked at 20/ha except March and April when stock are excluded.

Autumn deferment + high spring utilisation - Stock removed after opening rains until 1000 kg/ha of DM accumulates. Set stocked at 20/ha over winter. SR increases to 40/ha in Spring and reverts back to 20/ha in Summer.

Pasture description

The site contained a recently sown perennial ryegrass, cocksfoot, subterranean clover pasture. For the base simulation, a pasture mixture of perennial ryegrass and subterranean clover was used. On the advice of Tim Prance cocksfoot was omitted from the simulation as it was only a minor contributor in the pasture.

All simulations ran from 1st January 1979 to 31st December 1980.

Livestock description:

- Large merino wethers
- Standard Reference Weight = 60 kg
- Potential greasy fleece weight = 6.0 kg
- Maximum fibre diameter = 22 microns
- Initial stocking rate = 20 wethers/ha
- Initial mean liveweight = 65.8 kg
- Initial mean greasy fleece weight = 1410 g

Basic management:

- Shearing date was 16th November
- Wheat was fed as a supplement if fat score reached 1.5
- 20% of stock replaced each year on 31st December with animals 12 months of age and fat score 2½

Initial state of soil:

Area of paddock	100 ha
Steepness	Level
SCS curve number I:	75
Stage II soil evapn:	4.1 mm/d½
Fertility scalar	0.80
Initial soil moisture	
Topsoil	15 %
Subsoil	24 %

	Topsoil	Subsoil
Texture	Sandy loam	Sandy clay
Cumulative depth	250	950 mm
Porosity	52	42 %
Water content at F.C.	29	31 %
Water content at W.P.	12	21%
Sat. hyd. conductivity	36.0	1.3 mm/h

Initial state of pastures:

Species	Herbage components (DM kg/ha) Green	Dead	Litter	Root	Seed	Phenological stage
Perennial ryegrass	329	895	479	1509	0	Vegetative
Subterranean clover	64	216	96	19	316	Senescent

Figures 31 & 32 show the effect of the 4 seasonal rest treatments on subterranean clover live herbage DM and seed bank.

Consider the second year of the simulation runs. Compared to the set stocked control treatment, autumn closure was detrimental, summer closure had no effect and the winter and spring closures were beneficial.

The grazing management treatments affected the perennial ryegrass component also. The table below presents the subterranean clover proportion of the total live DM in mid Spring 1980:

Management	Clover % in mid spring 1980
Set stocked	26.8
Autumn close	14.9
Winter close	29.4
Spring close	27.2
Summer close	27.5

Figures 33 & 34 show the effect of the 4 remaining treatments on subterranean clover live herbage DM and seed bank and the table below presents the subterranean clover proportion of the total live DM in mid Spring 1980:

Spring high stocking rate greatly reduced the subterranean clover content of the sward in spring of 1980 and subsequently led to a greatly reduced seed bank.

Rotational grazing until mid July led to a reduced seed set in 1980 although the clover content in mid spring 1980 was similar to that of the control treatment.

Late summer/autumn close resulted in increased competition from the perennial ryegrass and clover content in mid spring 1980 and seed set that year were substantially less than with the control treatment.

Autumn defer/high spring pressure led to rapid subterranean clover growth in autumn each year. However the perennial ryegrass grew faster and clover content in spring 1980 was substantially less than with the control treatment. Seed set was also less than the control treatment.

Management	Clover % in mid spring 1980
Set stocked	26.8
Spring high SR	18.7
Rot graze until mid July	24.5
Late sum/autumn close	14.8
Autumn defer/high spring	19.0

The only treatments which led to an increased subterranean clover seed bank in the second year were winter and spring rests - and these increases were quite small. With winter rest the subterranean clover component of the sward is well placed at the start of spring to take advantage of the warmer temperatures for rapid growth. Concerns about GrassGro's competition model mean that one shouldn't place too much reliance on the predicted benefits a spring rest. Winter rest of a paddock or two on a whole farm should generally be feasible despite this being a time when feed is often in short supply - although at this site winter temperatures are mild and pasture growth is less restricted than at other, colder sites.

Fig. 27

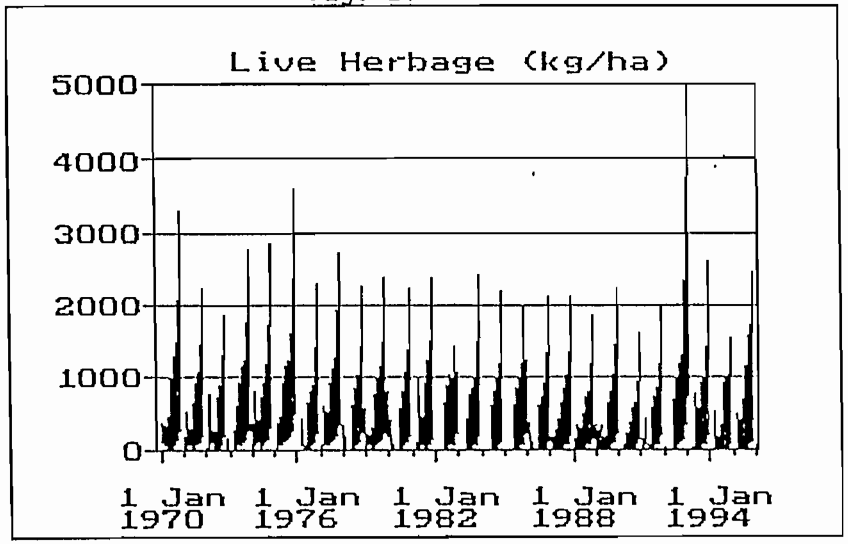


Fig. 28

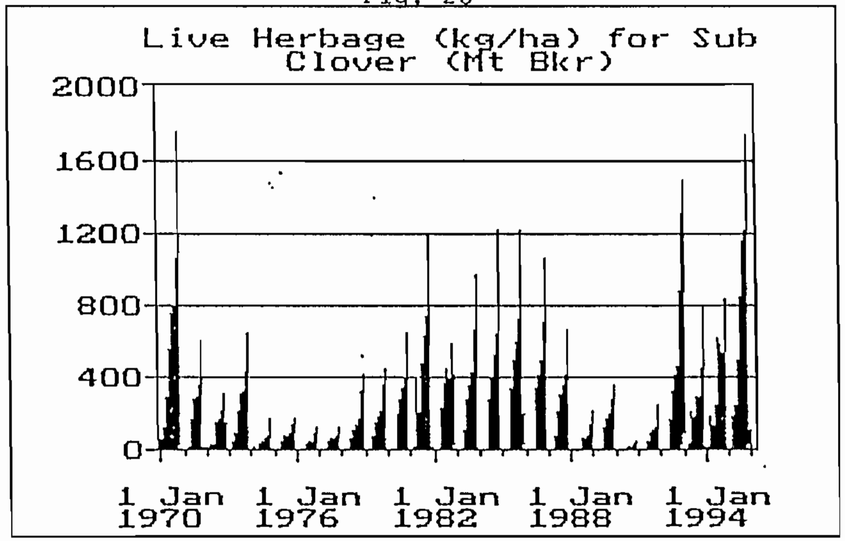


Fig. 29

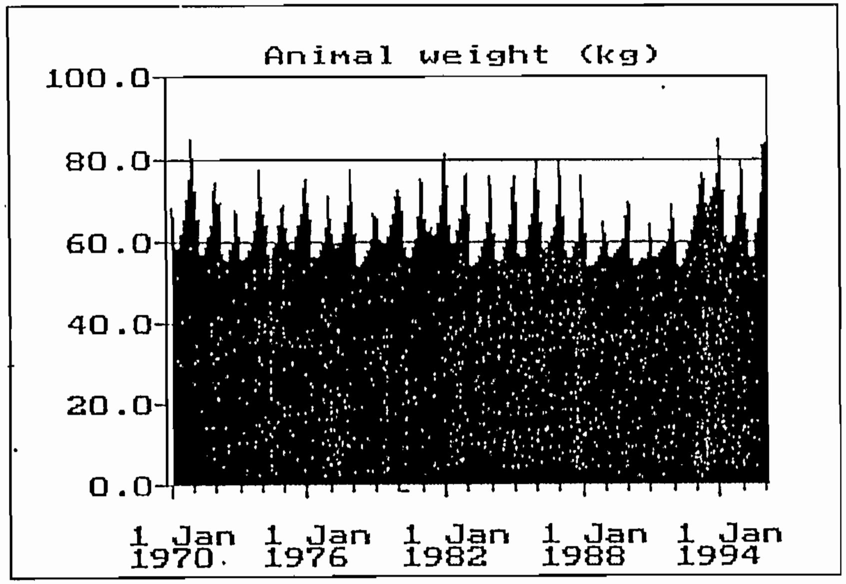


Fig. 30

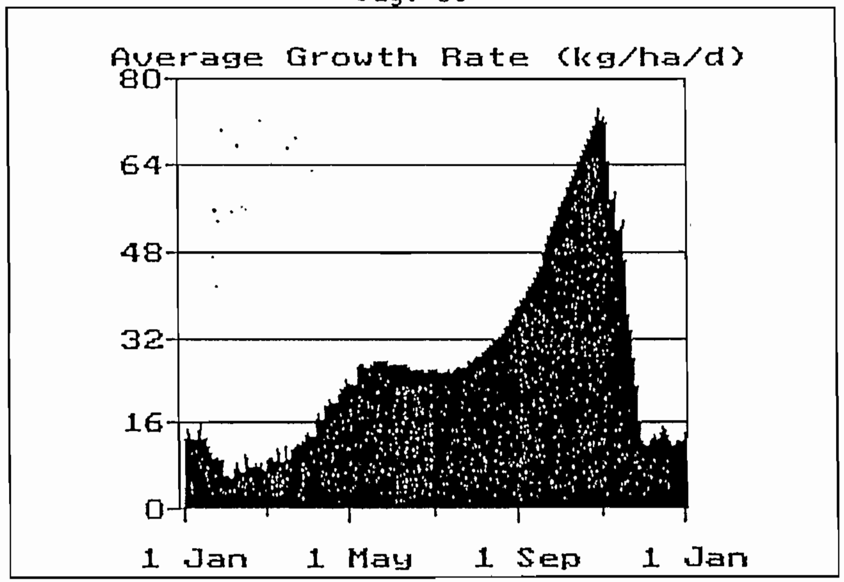
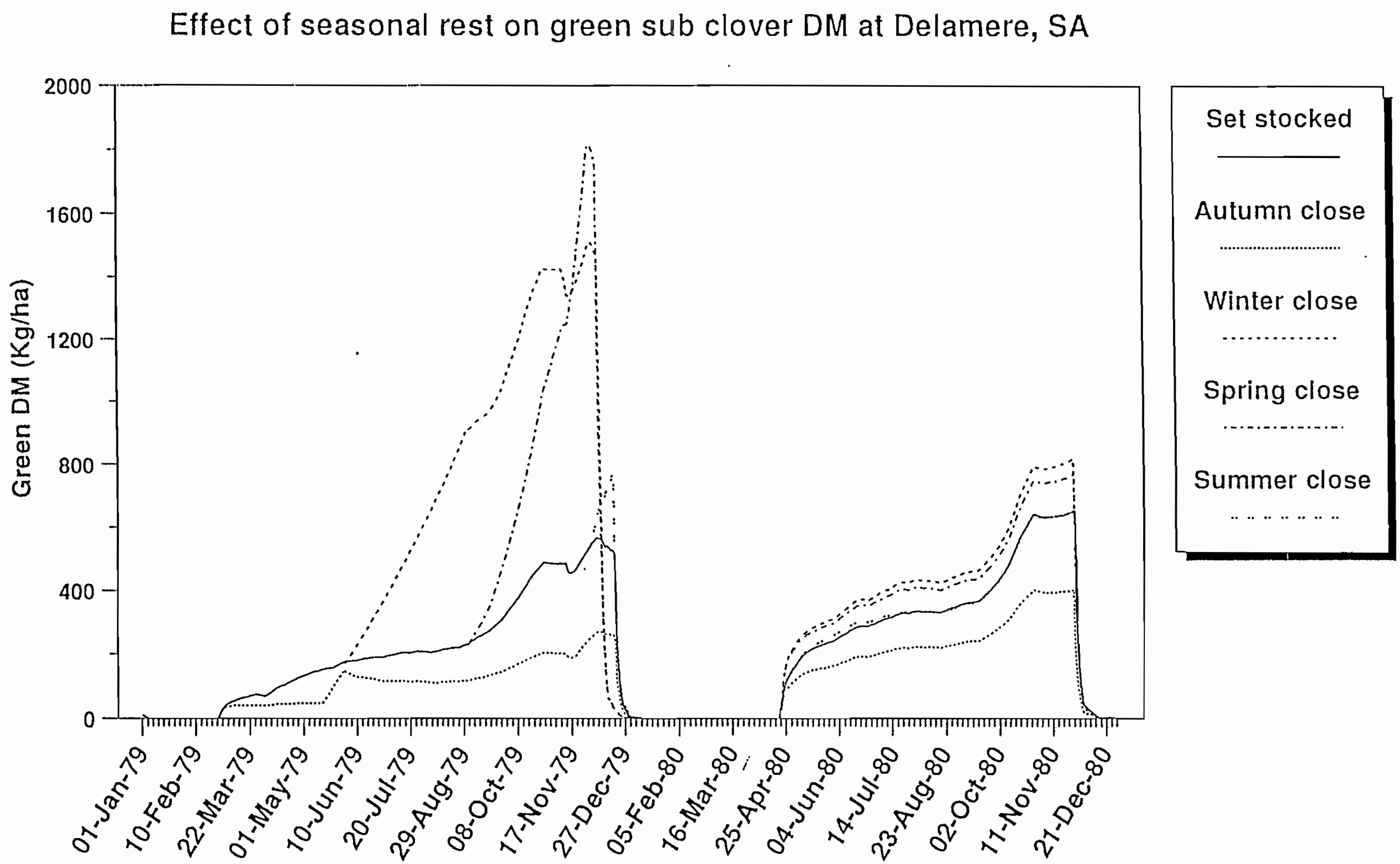


Fig. 31



Effect of seasonal rest on green sub clover DM at Delamere, SA
Green DM (Kg/ha)
2000
1600
1200
800
400
0
01-Jan-79
10-Feb-79
22-Mar-79
01-May-79
10-Jun-79
20-Jul-79
29-Aug-79
08-Oct-79
17-Nov-79
27-Dec-79
05-Feb-80
16-Mar-80
25-Apr-80
04-Jun-80
14-Jul-80
23-Aug-80
02-Oct-80
11-Nov-80
21-Dec-80
Set stocked
Autumn close
Winter close
Spring close
Summer close

Fig. 32

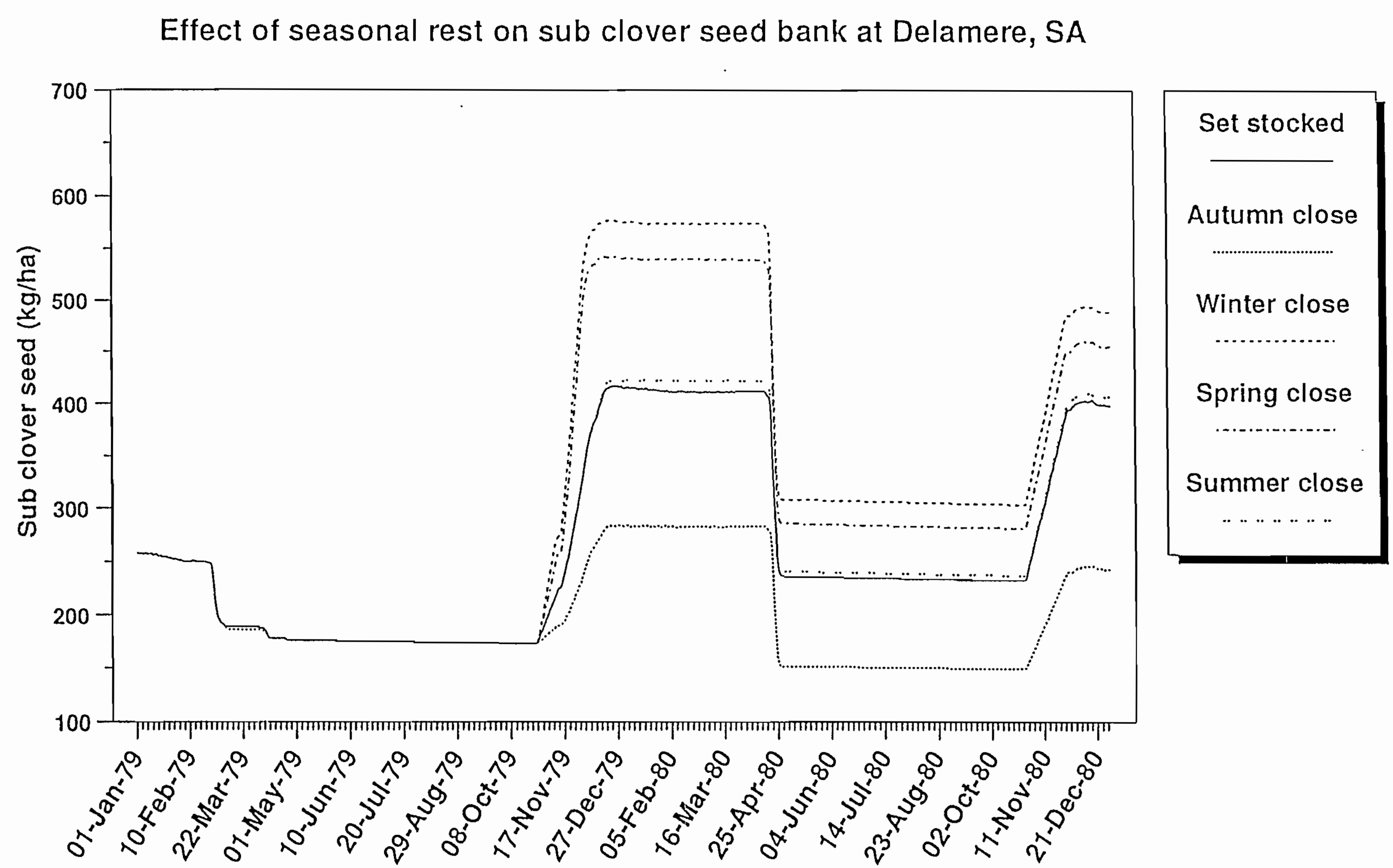

Effect of seasonal rest on sub clover seed bank at Delamere, SA
Sub clover seed (kg/ha)
700
600
500
400
300
200
100
01-Jan-79
10-Feb-79
22-Mar-79
01-May-79
10-Jun-79
20-Jul-79
29-Aug-79
08-Oct-79
17-Nov-79
27-Dec-79
05-Feb-80
16-Mar-80
25-Apr-80
04-Jun-80
14-Jul-80
23-Aug-80
02-Oct-80
11-Nov-80
21-Dec-80
Set stocked
Autumn close
Winter close
Spring close
Summer close

Fig. 33

Effect of grazing management on green sub clover DM at Delamere, SA

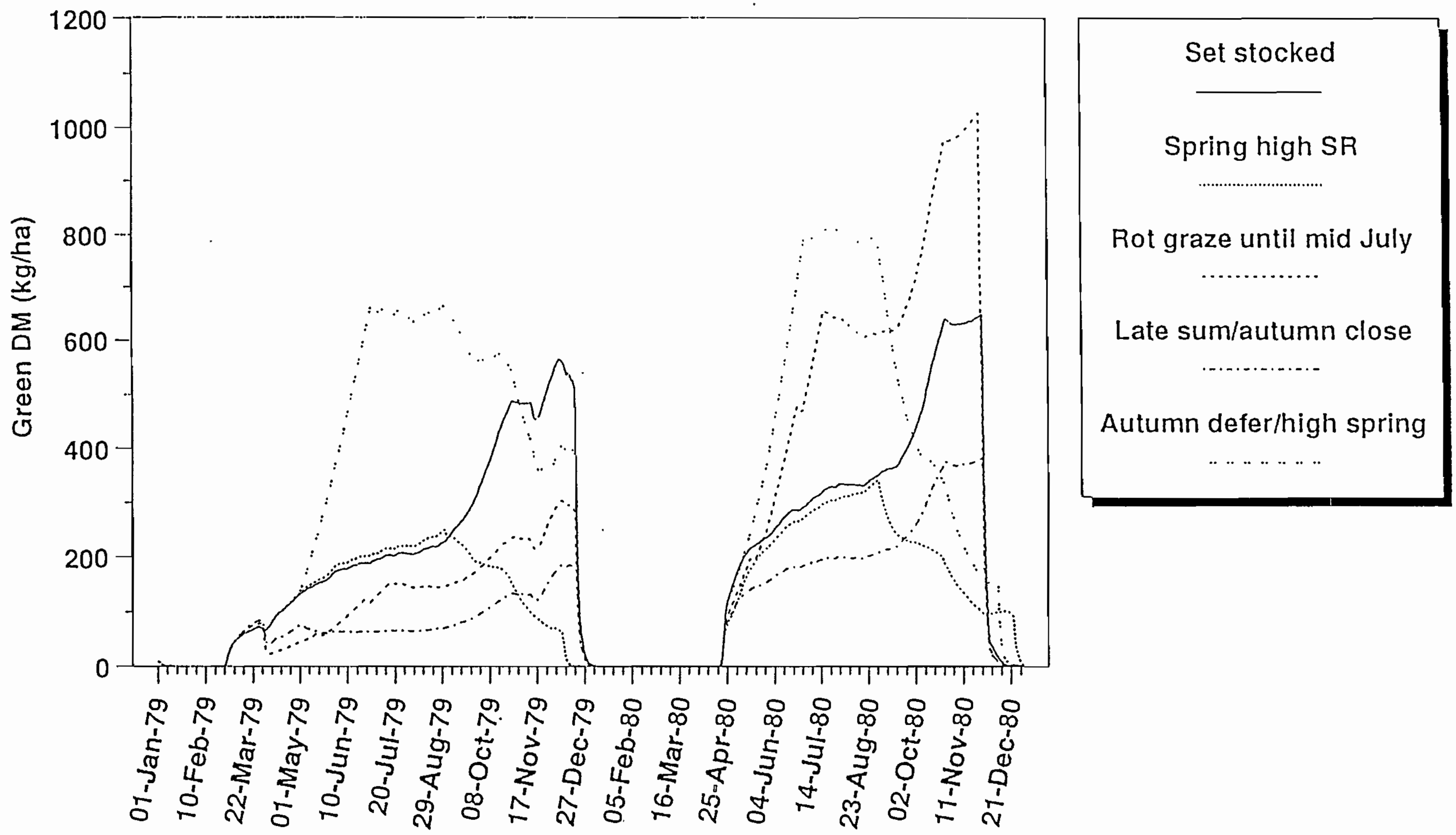
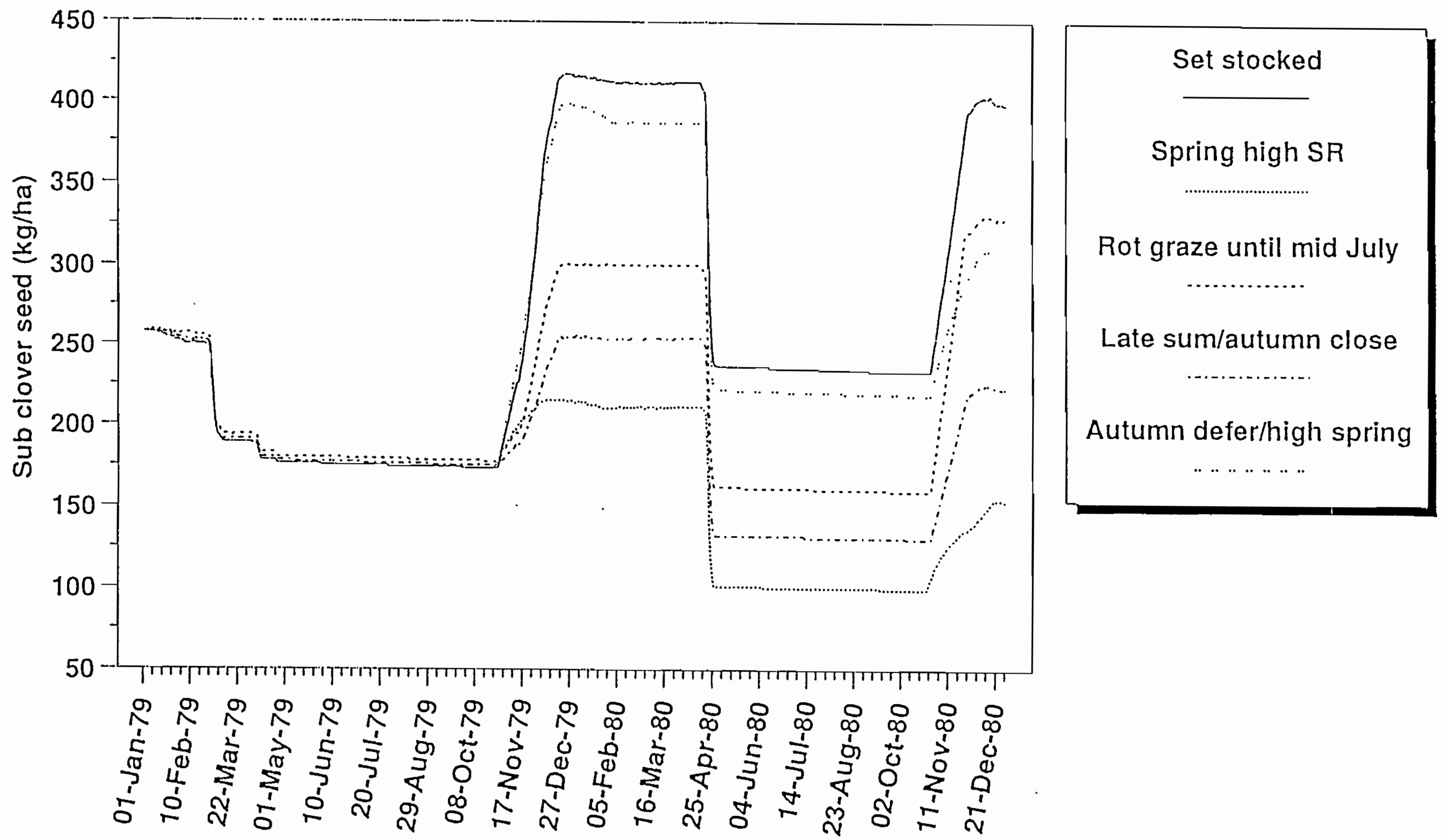


Fig. 34

Effect of grazing management on sub clover seed bank at Delamere, SA



3.3.4 Dundee wethers (newly sown site) - Glen Innes. NSW

A filled weather file (i.e. no missing data) was created based on the weather log from the site and supplemented with Glen Innes Agricultural Research Station weather records. The filled file covers the period 1st November 1993 - 31st August 1995.

The pasture was a recently sown cocksfoot/tall fescue pasture. At the start of the experiment these two species composed 80% of the sward in roughly equal proportions. White clover made up another 5% with the remainder comprising a range of native grasses. The trial site experienced a major drought almost immediately and there was essentially no white clover present for much of the trial period. For the simulation, a mixture of cocksfoot and tall fescue was used.

The simulation ran from 1st November 1993 to 31st August 1995.

Livestock description:

- Medium merino wethers
- Standard Reference Weight = 50 kg
- Potential greasy fleece weight = 5.0 kg
- Maximum fibre diameter = 26 microns
- Initial stocking rate = 7.5 wethers/ha
- Initial mean liveweight = 40 kg
- Initial mean greasy fleece weight = 500 g

Management:

- Shearing date is 23rd August
- No supplementary feeding

Soil details and initial soil moisture levels:

Area of paddock	100 ha
Steepness	Level
SCS curve number I:	75
Stage II soil evapn:	4.5 mm/d½
Fertility scalar	0.70
Initial soil moisture	
Topsoil	20 %
Subsoil	35 %

	Topsoil	Subsoil
Texture	Loam	Clay
Cumulative depth	300	600 mm
Porosity	47	49 %
Water content at F.C.	26	42 %
Water content at W.P.	12	29 %
Sat. hyd. conductivity	13.0	0.8 mm/h

Initial state of pastures:

Species	Herbage components (DM kg/ha)					Phenological stage
	Green	Dead	Litter	Root	Seed	
Tall Fescue	200	150	50	300	0	Reproductive
Cocksfoot	200	150	50	300	0	Reproductive

The overall duration of the simulation was from 1st November 1993 to 31st August 1995. During this period there were stocking rate changes due to severe drought during 1994. Because GrassGro is designed as a single mob program, the period was split into 5 separate simulation runs from 34 days to 216 days in duration. The pasture and animal conditions at the end of one run were used as the starting condition for the next.

Green pasture (simulated versus observed) is presented in Figure 35. There were some marked discrepancies between simulated and observed green pasture. Some of this may have been due to the deficiencies of the parameter sets for cocksfoot and tall fescue (parameter sets for pasture species in GrassGro are constantly evolving). However the overall growth patterns were similar for observed and simulated pastures. Some of the discrepancies in the drought period (mid-late 1994) were most likely to be associated with difficulty in assessing pastures when availability is extremely low. The errors in assessing low availability pastures would be at least as large as the actual amount of pasture present.

The pattern in change in wether liveweight is presented in Figure 36. Initially the predicted weights corresponded well with those of the experimental sheep. At the height of the drought in June 1994 the stocking rate was reduced from 5.0/ha to 1.4/ha until the end of January 1995 when the stocking rate was restored to 5.0/ha. The experimental sheep gained 10 kg but the simulated sheep lost approximately 9kg initially and then put on weight towards the end of the period. The overall difference at the end of January 1995 was some 20 kg. A large weight difference was maintained for the remainder of the simulation (i.e. until August 1995).

During the period of severest drought (June 1994 - January 1995) pasture availability was low on the plots. The table below presents total pasture yield and % green for this period (supplied by Des FitzGerald, site Manager, NSW Agriculture).

Date	Total DM (kg/ha)[1]	Green %[2]
15th June 1994	666	9.2
27th July 1994	1234	2.0
22nd September	1397	7.8
26th October 1994	899	7.0
12th December 1994	235	38.9

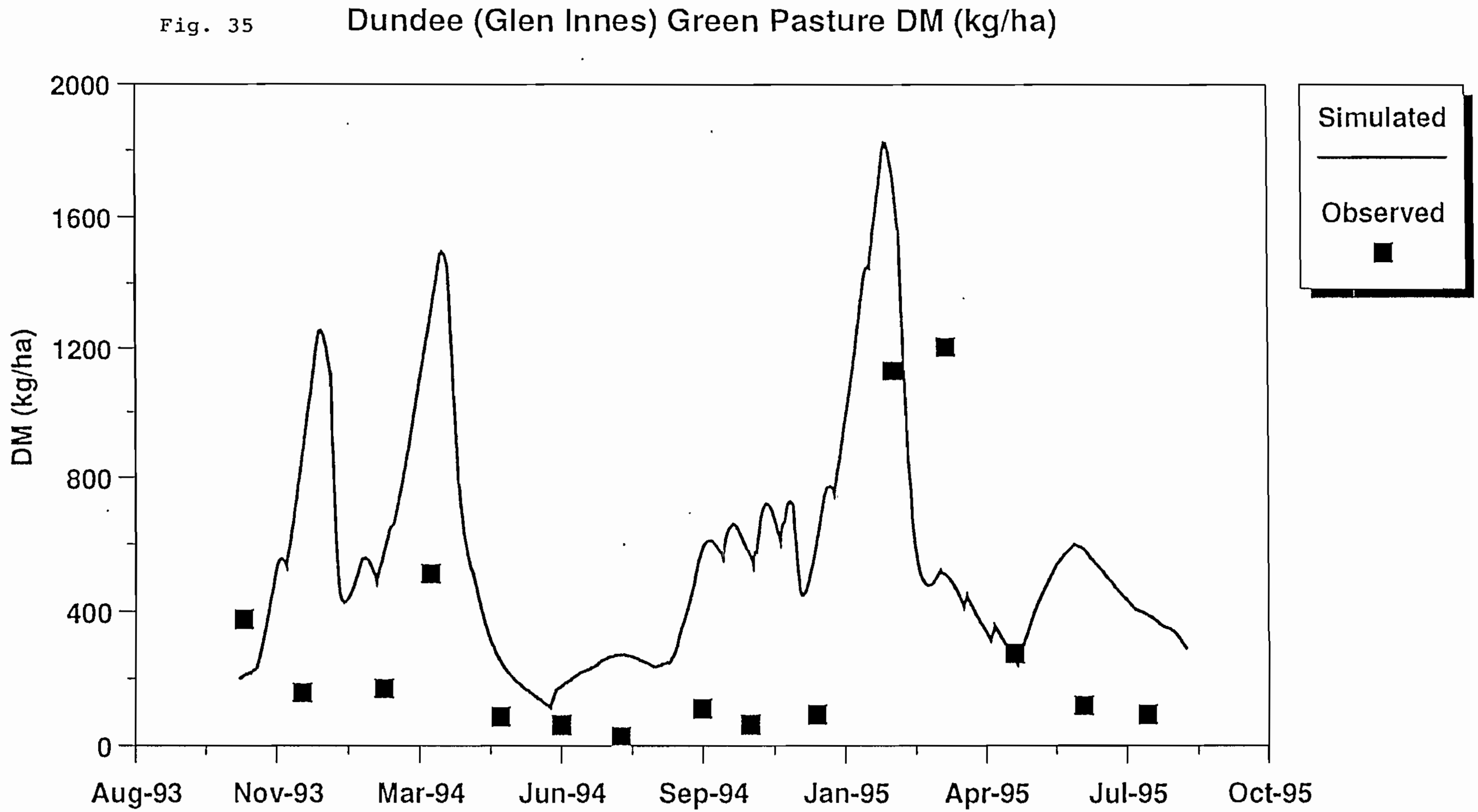
[1]Measured with a falling plate meter [2]Determined by hand sorting

For most of the period the observed availability and quality of the pasture seemed insufficient to promote animal liveweight gain even at 1.4 wethers/ha. Des FitzGerald suggested that although the pasture was of poor quality the animals at the greatly reduced stocking rate were able to select a diet which was of much higher quality than that of the total feed on offer. However there may be a pasture sampling problem here because even 1 sheep/ha cannot select a diet of sufficient quantity or quality to maintain liveweight at the claimed levels of availability. Although GrassGro predicted there would be more feed available and allows animals to select higher quality diets than the feed on offer, simulated weight gains were less than those observed. Consequently we conclude that GrassGro is insufficiently sensitive at such low availabilities and quality levels - probably because it doesn't allow for clumpiness of pasture. Analysis with GrazFeed similarly suggests that sheep would lose weight on the pasture described in the table above - even when pasture height is increased to increase its availability to the animals. Even casual analysis indicates that these pasture estimates were too low to support the liveweight gains that were measured.

In a second series of simulations, the mean liveweight for the wethers when the stocking rate was increased in January 1995 was set to 60kg. From this point on the simulated sheep closely matched the experimental sheep (Figure 37).

These analyses draw attention to some of the difficulties that are inherent in making observations on pasture availability and animal performance under extreme conditions such as drought. The measured animal performance during the drought at this site could not have resulted from the available pasture as measured. Sheep are highly efficient in choosing a diet of higher quality than the feed on offer but at low availabilities their total intake will be limited by the length of time they are willing to graze. The data and analyses presented here strongly suggest that it may be worthwhile reconsidering procedures for estimating yield when the pasture is sparse or clumpy in structure.

Fig. 35



Dundee (Glen Innes) Green Pasture DM (kg/ha)
DM (kg/ha)
2000
1600
1200
800
400
0
Aug-93
Nov-93
Mar-94
Jun-94
Sep-94
Jan-95
Apr-95
Jul-95
Oct-95
Simulated
Observed

Fig. 36 Dundee (Glen Innes) Wether liveweight (kg)

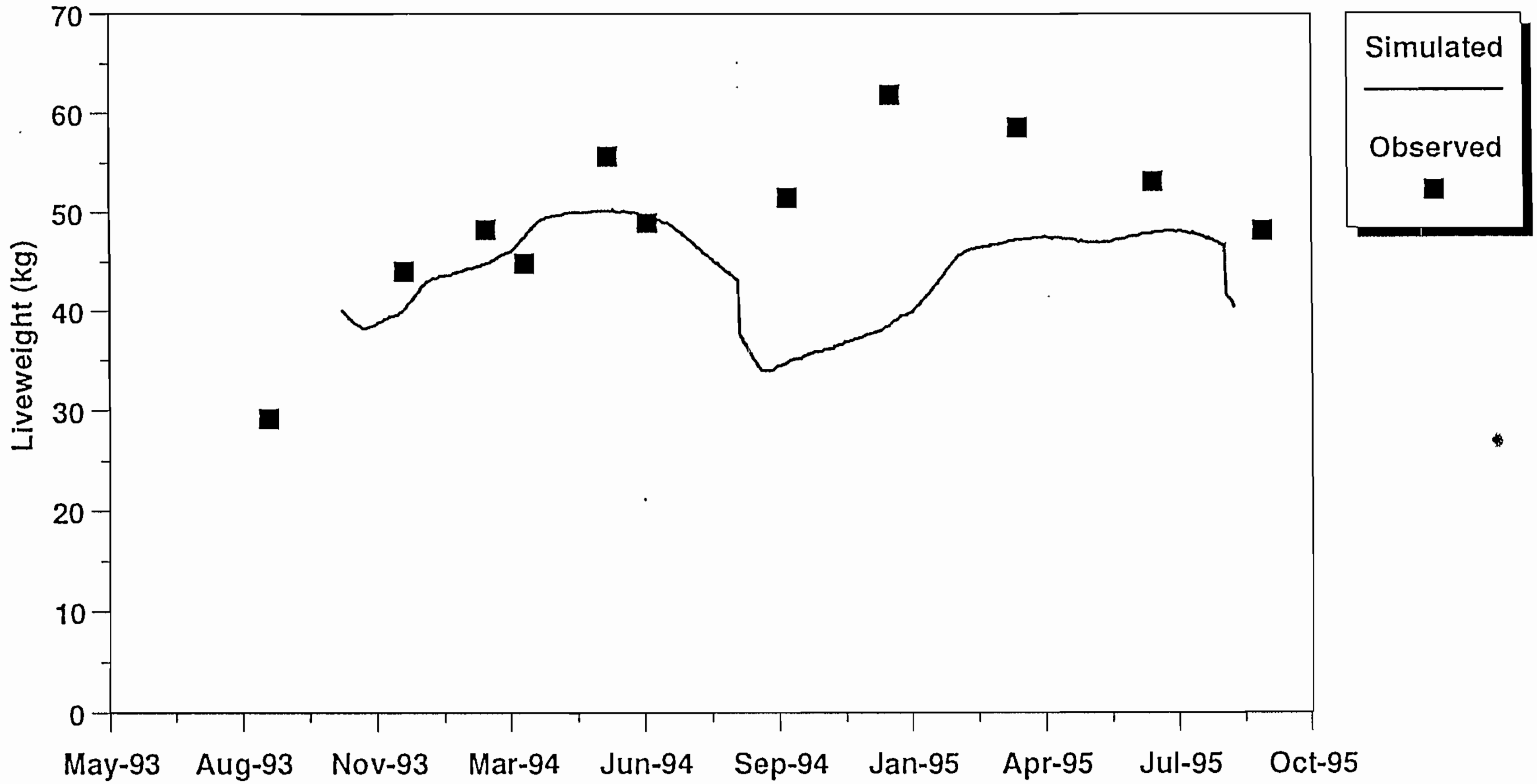
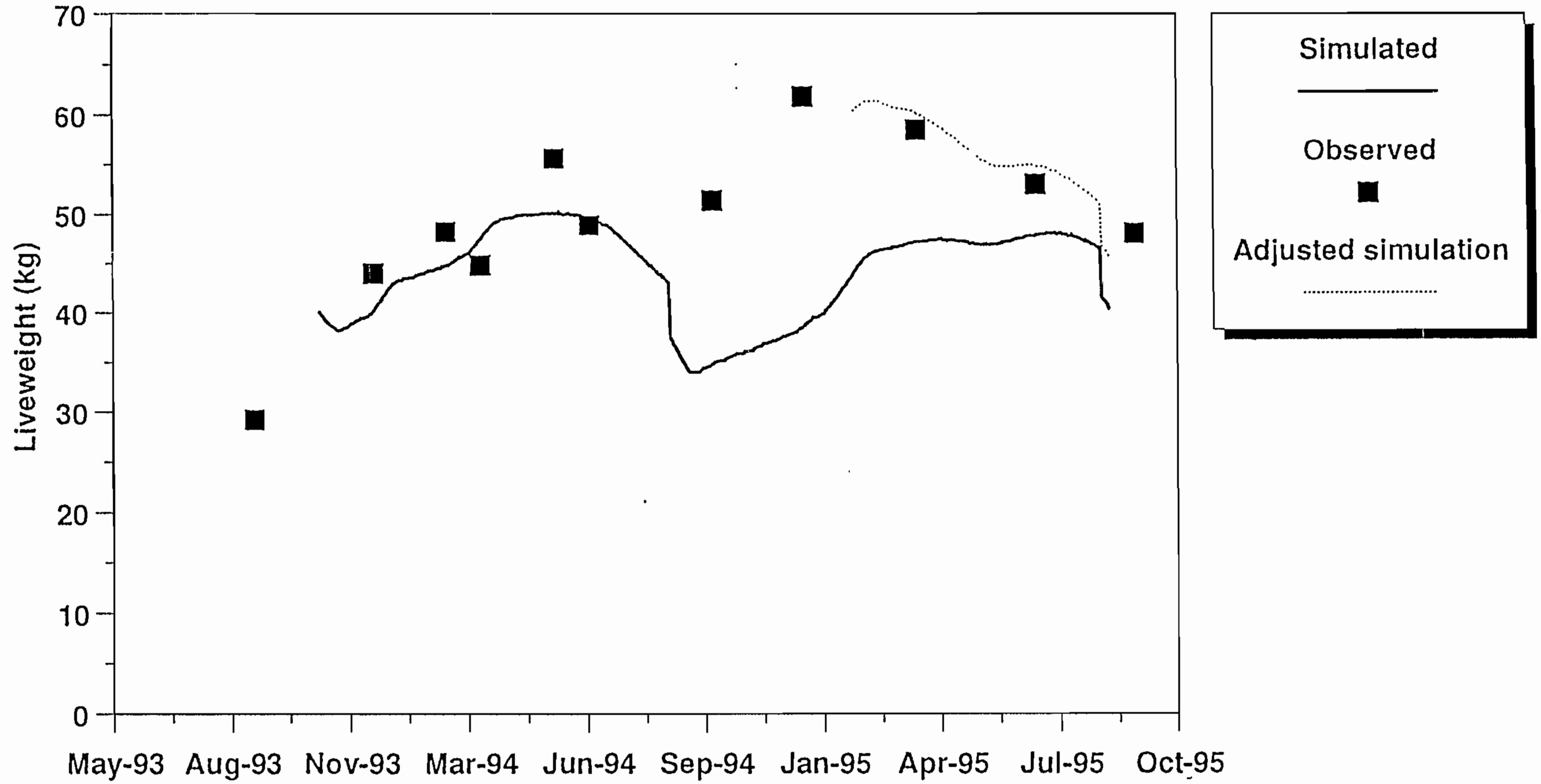


Fig. 37 Dundee (Glen Innes) Wether liveweight (kg)



3.3.5 Hall wethers, NSW

Pasture and animal production from the TPSKP grazing management site - "Yeumville" near Hall, ACT - was successfully simulated using GrassGro in April 1996. This site is a native pasture with *Microlaena* and *Danthonia* as the dominant species.

A GrassGro pasture parameter set for *Microlaena* was developed. Consultation with David Eddy and Denys Garden (NSW Agriculture) indicated that the quality of *Microlaena* was higher than that of tall fescue and it was thought that this was because *Microlaena* leaves decline in digestibility more slowly than tall fescue leaves. Experimenting with the tall fescue parameter set led to a new set which simulated the native pasture at Hall successfully. The new parameter set has only one value different to that of the tall fescue set. It is designated K(M,1,I,lf) - decline rate of 60% DMD live leaf (shoot) with no water stress. The value was changed from 0.20 for tall fescue to 0.10 for *Microlaena*.

The pasture growth pattern for the period of the experiment is presented in Figure 38. It closely matched herbage availability data from the experiment except that the peak in summer 1994-95 was considerably higher than really occurred. During this period the stocking rate was only 2.0 wethers/ha and the extra simulated feed would not have affected animal production.

Figure 39 presents simulated versus experimental animal production. There was a close fit until the onset of the drought about August 1994. At this point the stocking rate was reduced to 2.0 wethers/ha. The simulated animals lost weight until November 1994 when conditions improved and pasture growth began. The experimental animals increased in weight throughout this period and by the time the stocking rate was increased to 6.0 wethers/ha the simulated animals were over 10 kg lighter than the experimental animals. This difference was maintained for the rest of the simulation although the pattern of weight gain and loss were closely similar.

The discrepancy between the simulated and experimental animals in late winter-early spring 1994 is almost identical to the situation which occurred at the Dundee (Glen Innes) site. In both cases, the measured pasture availability during the critical period would have been unable to support the animal growth rates observed. Photographs of the Yeumville site during the drought demonstrates that the pasture was extremely clumpy. Discussion with Carol Harris (Glen Innes) indicate that the same was the case at the Dundee site.

These findings point to two issues. The first is the inability of the pasture sampling techniques to provide accurate data when pasture availability is low. The techniques need to be revised for Phase 2 sites. The second is the approach used in GrassGro to model herbage mass and only a limited capacity to simulate clumpiness.

The *Microlaena* parameter set is preliminary and has a number of limitations; in particular the control of flowering and seedling recruitment (Dr. Terry Bolger, CSIRO Plant Industry is studying these and other issues. His work will be invaluable in improving GrassGro and our understanding of the dynamics of pastures).

The parameter set for *Microlaena* has been based on tall fescue but needs refinement. Nevertheless, a first approximation to achieving reasonable simulations of this important native grass is now possible and will help to increase GrassGro's usefulness over a wider area of temperate pastures.

Fig. 38 Simulated green Microlaena DM (kg/ha) at Yeumville

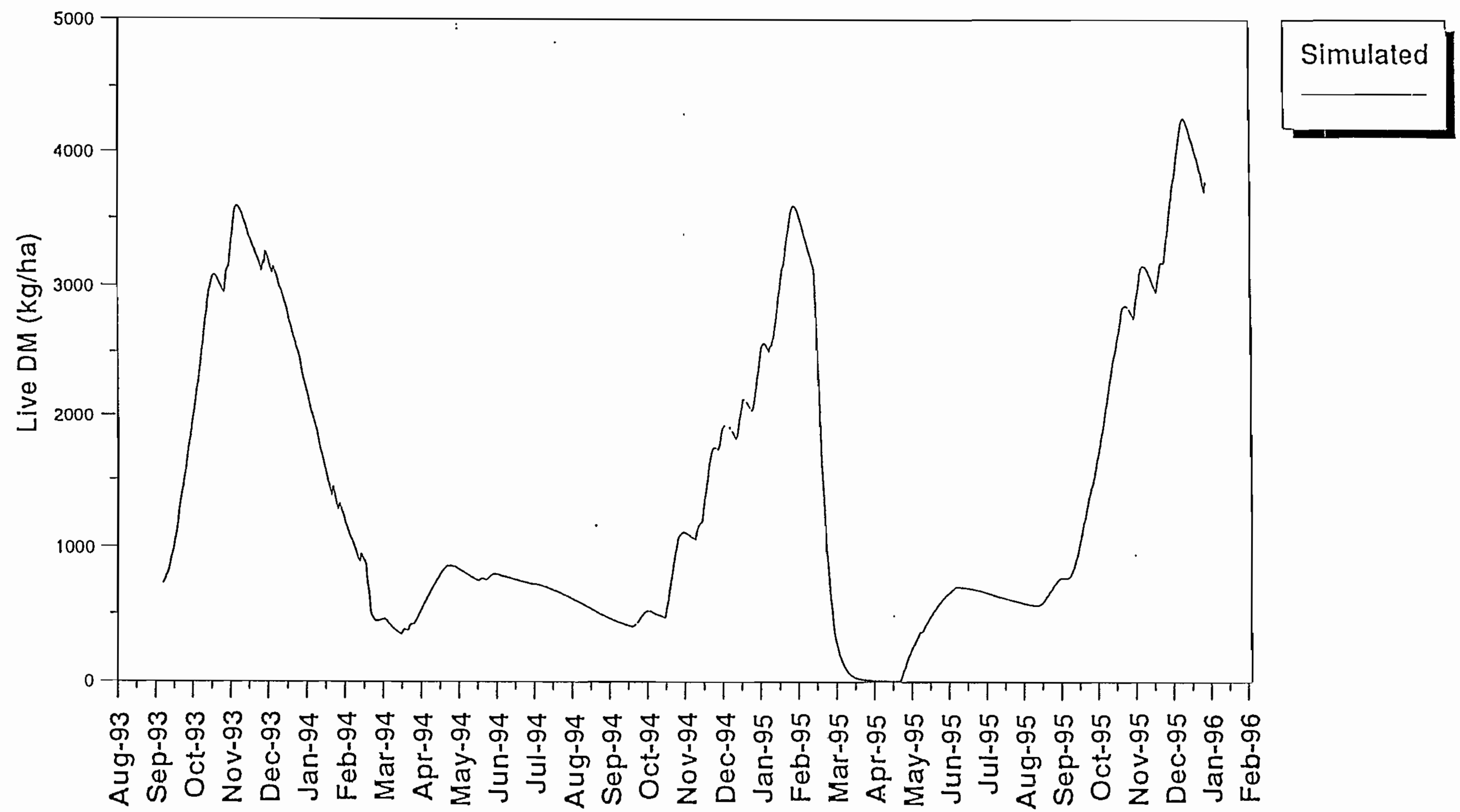
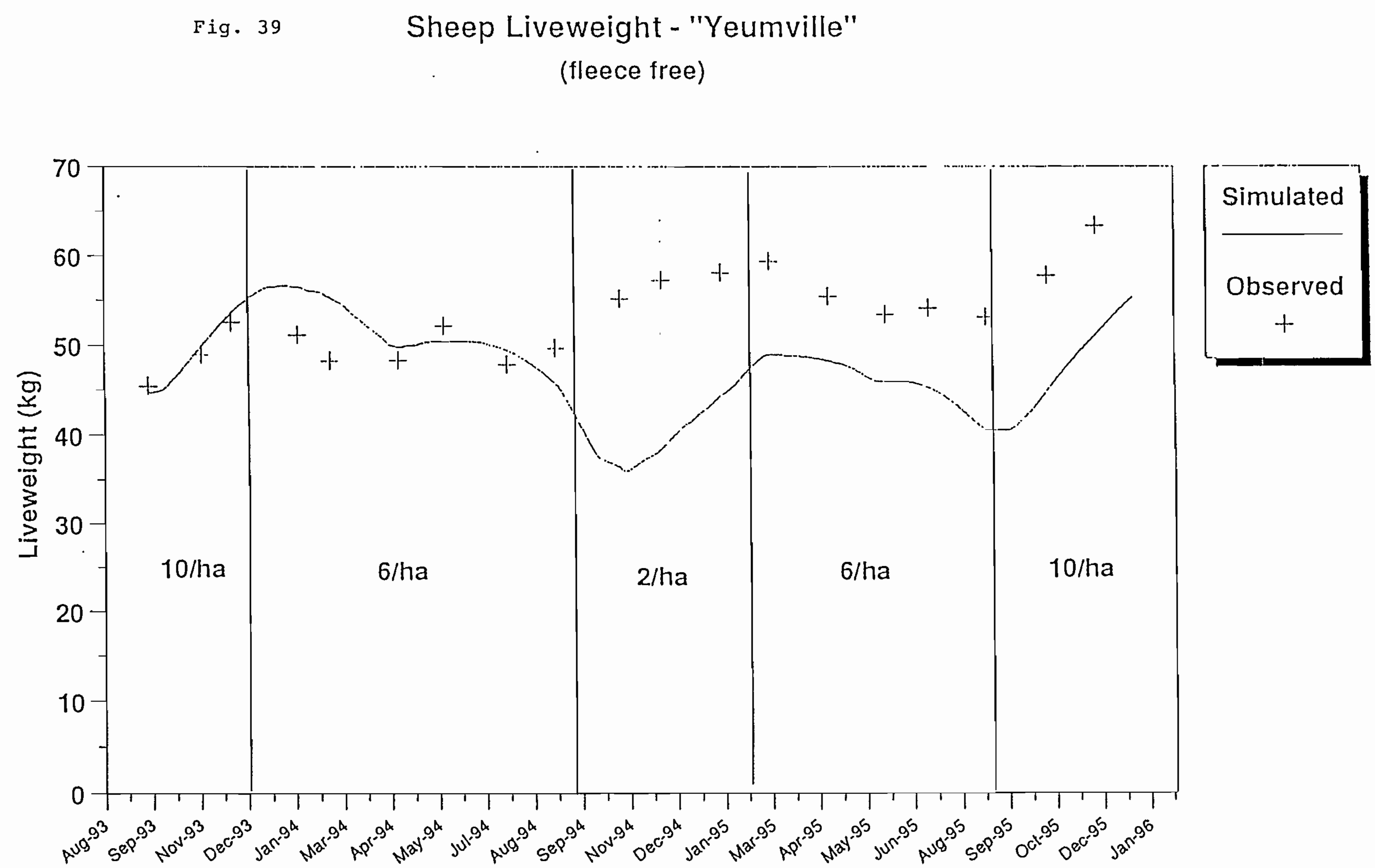


Fig. 39



Sheep Liveweight - "Yeumville"
(fleece free)
Liveweight (kg)
70
60
50
40
30
20
10
0
10/ha
6/ha
2/ha
6/ha
10/ha
Aug-93
Sep-93
Nov-93
Dec-93
Jan-94
Mar-94
Apr-94
May-94
Jul-94
Aug-94
Sep-94
Nov-94
Dec-94
Jan-95
Mar-95
Apr-95
May-95
Jun-95
Aug-95
Sep-95
Oct-95
Dec-95
Jan-96
Simulated
Observed

3.3.6 Cootamundra wethers. NSW

In mid July 1996 I received a disk with weather files from the Cootamundra sites. The files consisted of raw data logger output and some processed data. A week previously I had received by email two spreadsheet files containing each sites' pasture and animal data.

It was quickly apparent that the weather files would be of no use in constructing a GrassGro compatible weather file. There were many large gaps and a substantial proportion of the data was nonsense (e.g. a period of 10 days where daily rainfall exceeded 100mm).

Previous simulation studies at Wagga Wagga and Cootamundra had proven successful so it was decided to conduct a long run simulation (1957-1993) with wethers grazing a pasture composed of phalaris, subterranean clover and capeweed.

Figures 40 to 42 present some of the output from the simulation run. With Jim Virgona's (site manager, NSW Agriculture) input it should have been possible to assess the effects of a range of grazing management treatments on pasture composition.

This information was passed on to Jim Virgona on 22nd July 1996 with a request for an appointment. No reply was forthcoming.

Fig. 40

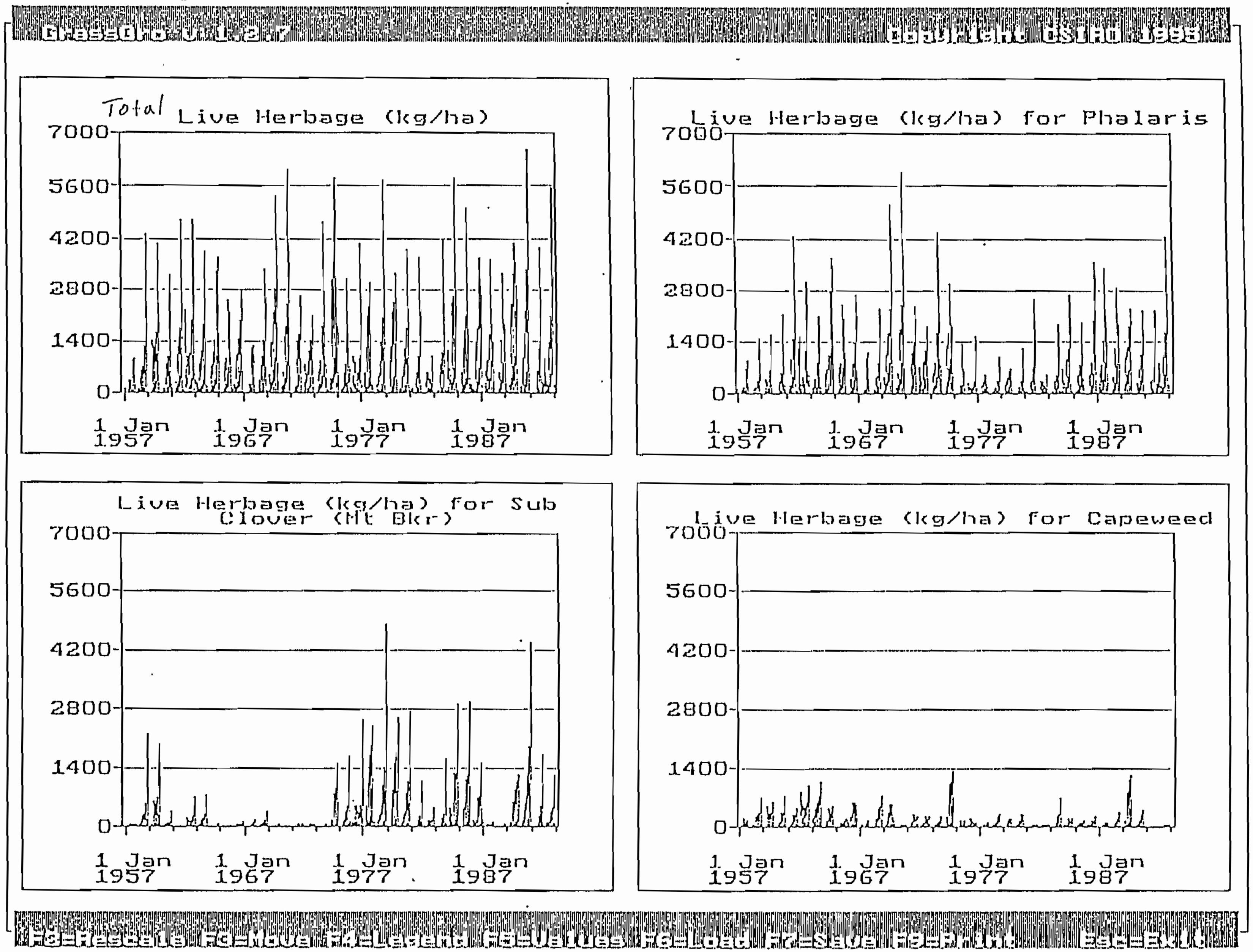

Total Live Herbage (kg/ha)
7000
5600
4200
2800
1400
0
1 Jan 1957
1 Jan 1967
1 Jan 1977
1 Jan 1987
Live Herbage (kg/ha) for Phalaris
Live Herbage (kg/ha) for Sub Clover (Mt Bkr)
Live Herbage (kg/ha) for Capeweed

Fig. 41

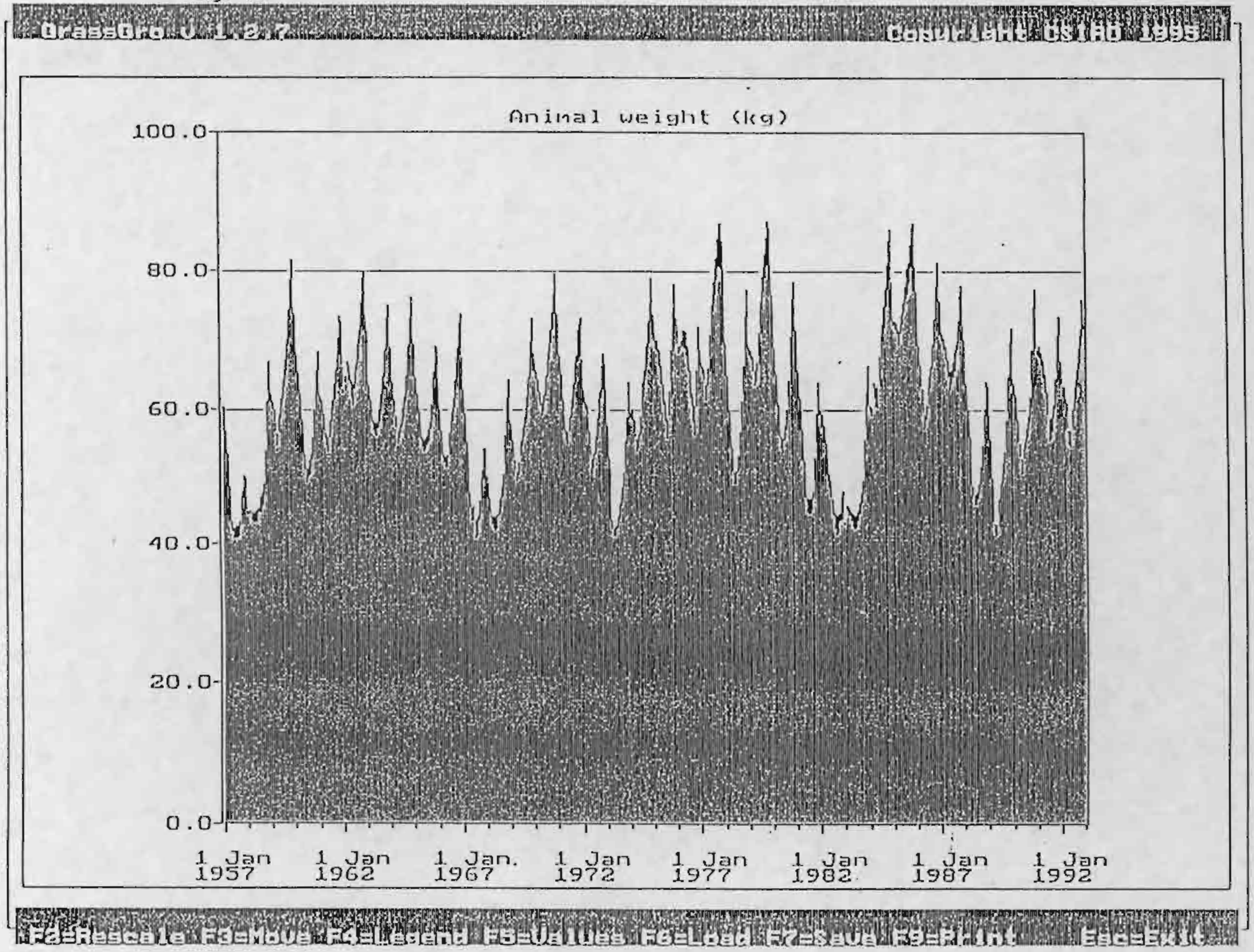
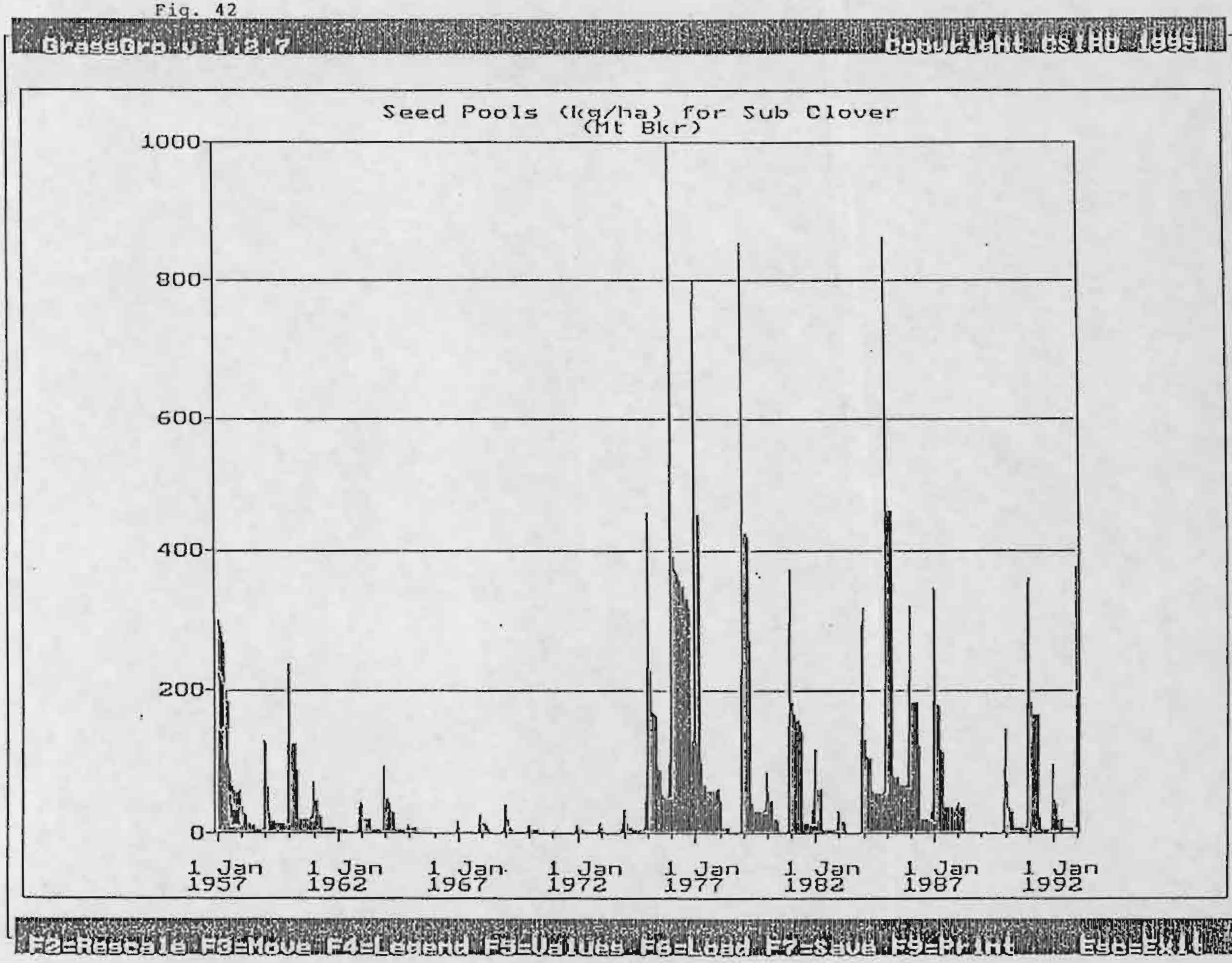

GrassGro V 1.2.7
Copyright CSIRO 1995
Animal weight (kg)
100.0
80.0
60.0
40.0
20.0
0.0
1 Jan 1957
1 Jan 1962
1 Jan. 1967
1 Jan 1972
1 Jan 1977
1 Jan 1982
1 Jan 1987
1 Jan 1992
F2=Rescale F3=Move F4=Legend F5=Values F6=Load F7=Save F9=Print Esc=Exit

Fig. 42


GrassGro v 1.2.7
Copyright CSIRO 1995
Seed Pools (kg/ha) for Sub Clover
(Mt Bkr)
1000
800
600
400
200
0
1 Jan 1957
1 Jan 1962
1 Jan 1967
1 Jan 1972
1 Jan 1977
1 Jan 1982
1 Jan 1987
1 Jan 1992
F2=Rescale F3=Move F4=Legend F5=Values F6=Load F7=Save F9=Print
Esc=Exit

3.3.7 Springhurst wethers, Victoria

Pasture and animal production from the TPSKP grazing management site - Springhurst wethers - were simulated using GrassGro for Windows ver 1.3.0a in September 1996.

The site was newly sown to phalaris cv. Sirosa, cocksfoot cv. Porto and subterranean clover cvv. Trikkala and Karridale and also contained onion grass and a range of annual grass species. For the simulations a mixture of cocksfoot and phalaris was used. The fertility scalar was set to 1.0 (non-limiting).

Small merino weaners were introduced to the experiment at the end of August 1993. Because of frequent stocking rate changes eight separate simulations were run and spliced together to produce the accompanying graphs. The simulated period ran until the end of December 1995 which was the last date in the weather file.

Livestock description:

- Small merino weaners
- Standard Reference Weight = 40 kg
- Potential fleece weight = 4.0 kg
- Maximum fibre diameter = 22 microns
- Initial stocking rate = 10.0 weaners/ha
- Initial mean liveweight = 31.2 kg
- Initial mean fleece weight = 300g

Basic management:

- Shearing dates were 22nd September 1994 and 12th September 1995
- No supplementary feeding
- The same animals were kept for the duration of the simulation.

Initial state of soil:

Area of paddock	100 ha
Steepness	Level
SCS curve number I:	75
Stage II soil evapn:	3.8 mm/d½
Fertility scalar	1.0
Initial soil moisture	
Topsoil	25 %
Subsoil	38 %

	Topsoil	Subsoil
Texture	Sandy clay loam	Clay
Cumulative depth	140	1000 mm
Bulk density	1.54	1.35 g/cm3
Water content at F.C.	27	42 %
Water content at W.P.	17	29%
Sat. hyd. conductivity	10.0	6.0 mm/h

Initial state of pasture:

Species	Herbage components (DM kg/ha)				Phenological
	Green	Dead	Litter	Root	stage
Phalaris	500	200	100	500	Reproductive
Cocksfoot	700	200	100	700	Reproductive

Simulated live total and available herbage DM for the period of the experiment is presented in Figure 43. Note the spring peaks predicted by GrassGro in 1993 and 1995. These either did not occur in reality or were not picked up because of the sampling interval. In a graph presented by Angela Avery (Figure 44) there were large peaks in dead DM in summer 1994-95 and autumn 1996. This accumulation of dead herbage must have occurred because of an earlier live herbage peak in spring 1995 which was apparently not measured.

During the drought period of spring 1994 GrassGro predicts a modest spring peak of live herbage. Again this was not recorded in the data supplied to us but Figure 44 shows a buildup of over three tonnes of dead herbage DM in the months following, indicating that more green herbage must have been present than was measured.

Figure 45 presents simulated versus measured animal liveweight. At two points the animal weights in GrassGro were reset to the actual weights. The first was after the second period of stock removal (July 1994). The second was when the stocking rate was increased to 7.5/ha after a long period at 1.0/ha (June 1995). These alterations were necessary and were justified as during both periods the pastures were destocked and animals removed were growing under different (and unknown) conditions to those on the experimental area. Apart from these two periods, the simulation predicts the experimental sheep performance well.

Allowing for the possibility that spring peaks were not measured due to the frequency of sampling, GrassGro has predicted the phalaris/cocksfoot pasture reasonably accurately. The parameter set for cocksfoot has not been validated to the same extent as the phalaris parameter set so it is encouraging to see the predicted performance of these two species was close to reality.

Animal production was also predicted well. The only serious deviation was autumn 1995. At this time the stocking rate had been reduced to 1.0/ha and pasture availability was low. This appears to be another situation (similar to the simulation exercises at the Hall and Dundee sites) where GrassGro has trouble predicting animal performance with low pasture availability. This is possibly related to the spatial arrangement of plants modifying availability to the grazing animal.

Figure 43. Springhurst (Vic) TPSKP site - live pasture DM

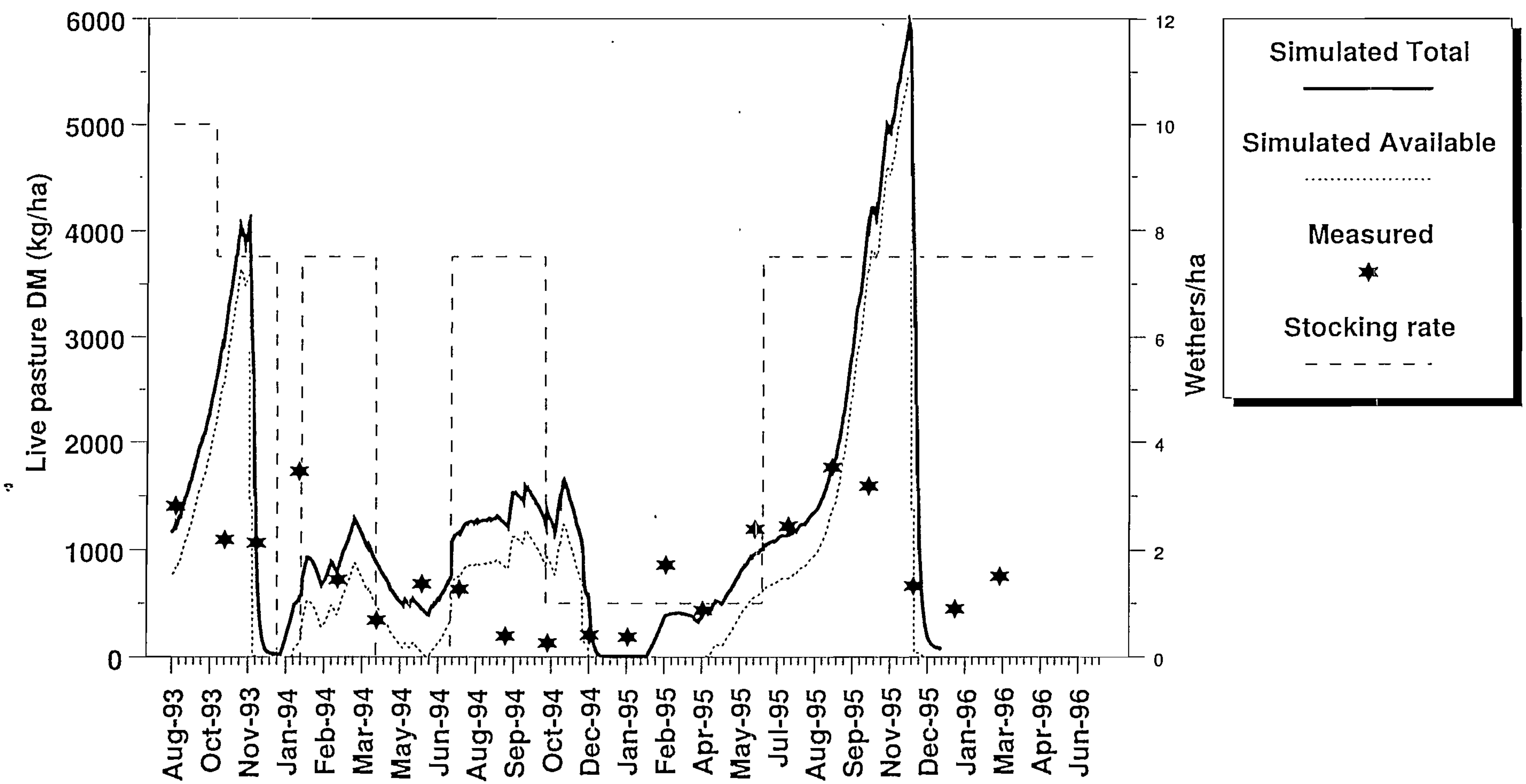
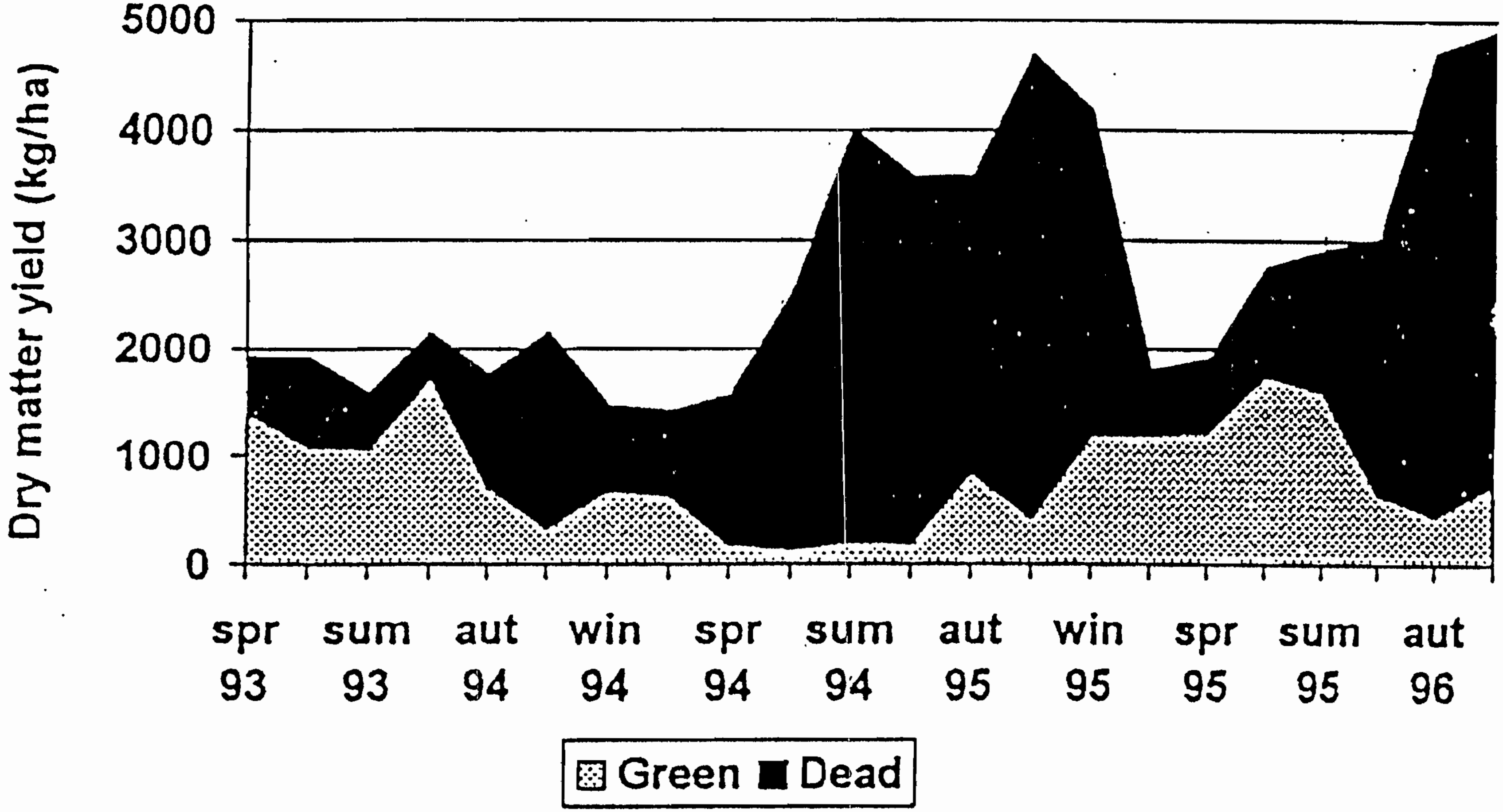


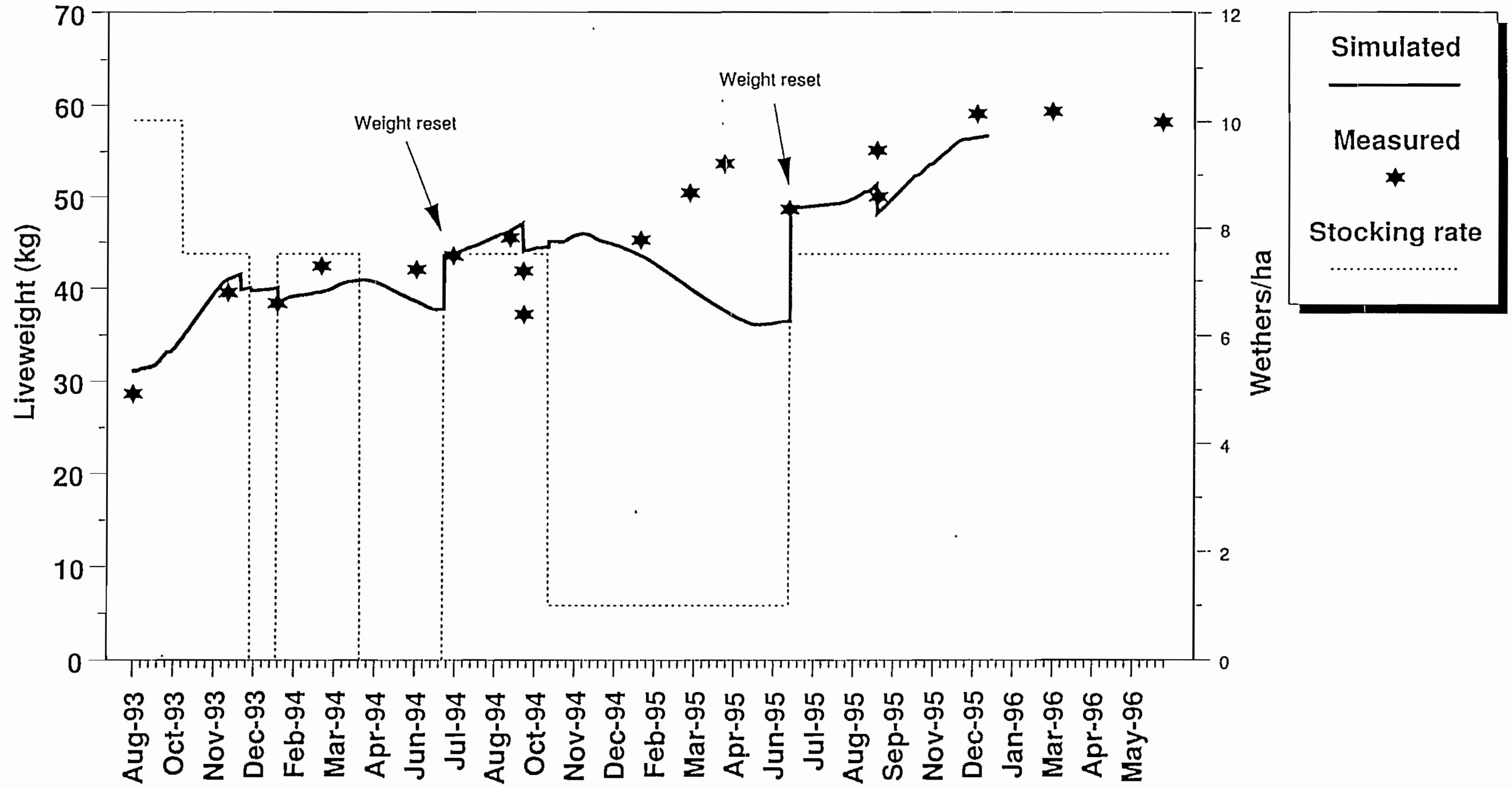
Fig. 44

Herbage Mass (control)



TPSKP:Springhurst site

Figure 45. Springhurst (Vic) TPSKP site - wether liveweight



3.4 Related work

As my expertise with GrassGro grew I was occasionally asked to conduct specific simulation exercises:

3.4.1 Evaluation of plant breeding goals

The tall fescue breeder at the PVI, Hamilton (Shoba Venkatanagappa) was interested in evaluating the likely value of a cultivar with increased winter activity relative to the standard cultivar - Demeter. By changing some of the existing parameters for tall fescue I was able to produce a set which described a more winter-active cultivar. A cow-calf system was simulated using each tall fescue with sub clover at Hamilton from 1985-1994. Long term average graphs were produced for pasture production, cow liveweight, milk production, supplement fed and calf liveweight (Figures 46-50).

The overall conclusion was that the extra fescue growth in winter led to higher milk production, bigger calves and a lower requirement for supplementary feeding. The following table indicates the increased profitability from the winter-active fescue:

Gross margin	Demeter	Winter-active
Mean	$139	$168
Std. Dev.	$84	$61
Minimum	-$2	$74
Maximum	$279	$287

The predictions from GrassGro were used in the development of a successful MRC breeding project.

Fig. 46

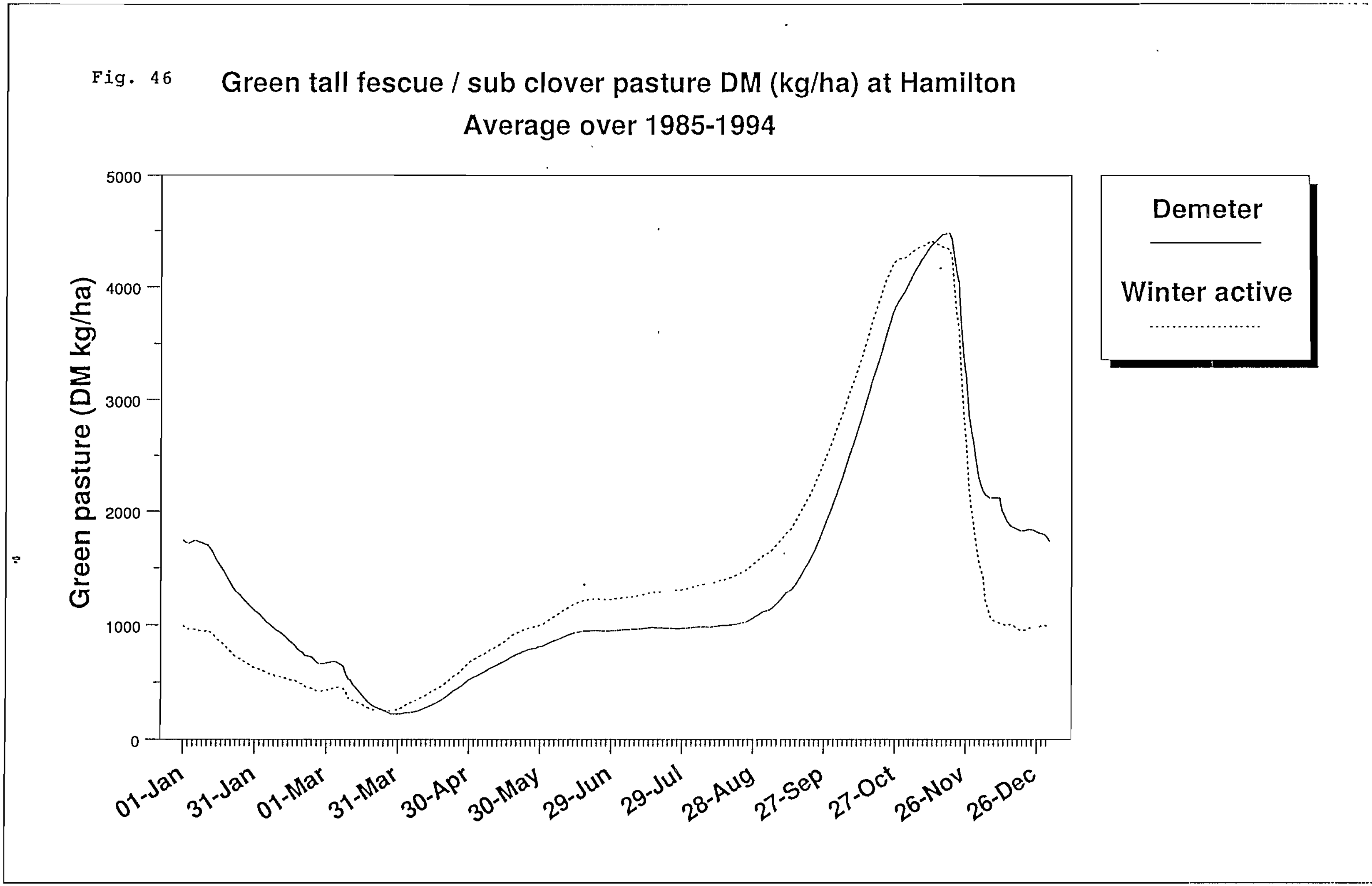

Green tall fescue / sub clover pasture DM (kg/ha) at Hamilton
Average over 1985-1994
Green pasture (DM kg/ha)
5000
4000
3000
2000
1000
0
01-Jan
31-Jan
01-Mar
31-Mar
30-Apr
30-May
29-Jun
29-Jul
28-Aug
27-Sep
27-Oct
26-Nov
26-Dec
Demeter
Winter active

Fig. 47 Cow liveweight (kg) on tall fescue / sub clover pasture at Hamilton
Average over 1985-1994

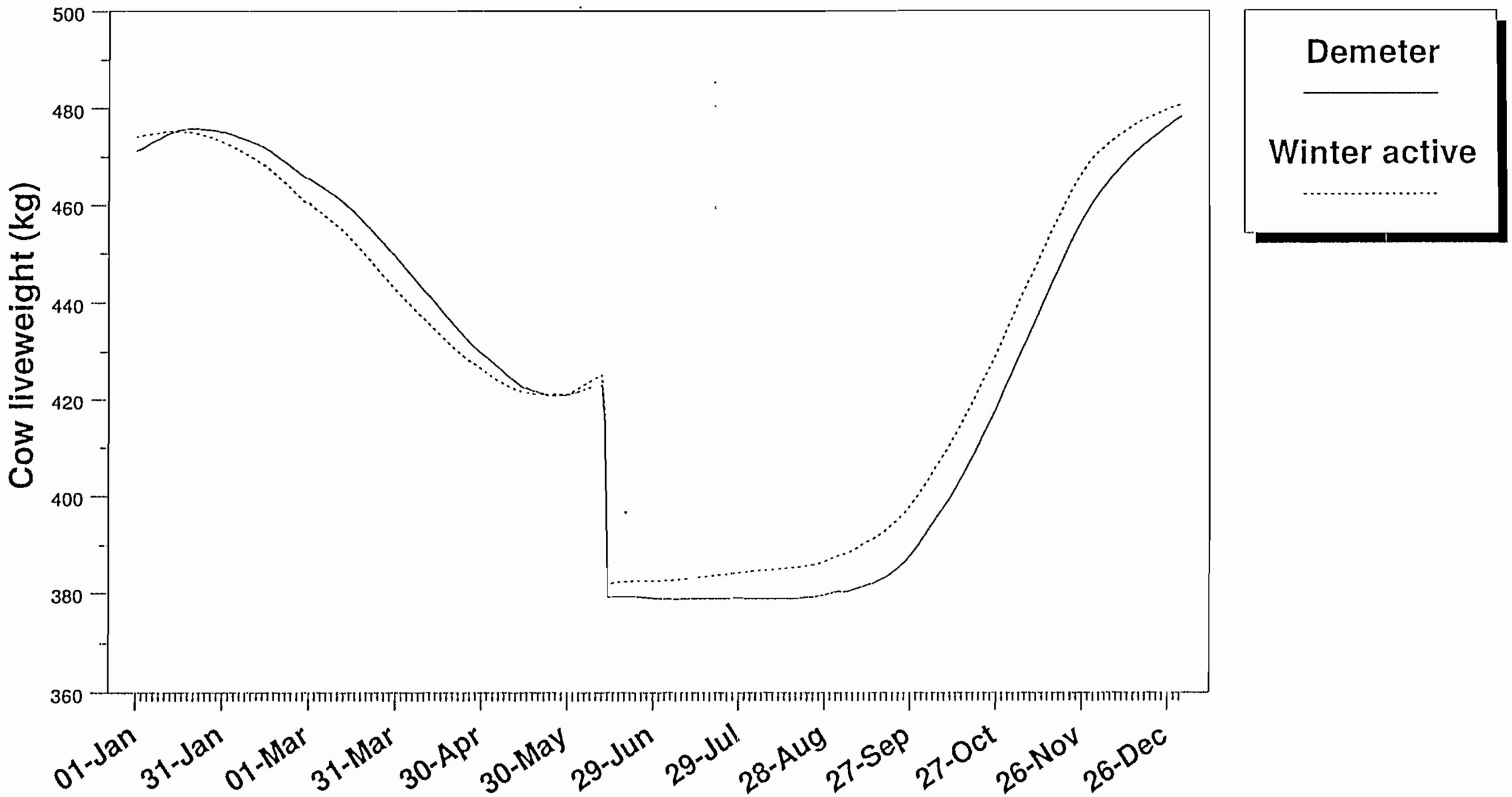


Fig. 48 Milk production (kg) on tall fescue / sub clover pasture at Hamilton
Average over 1985-1994

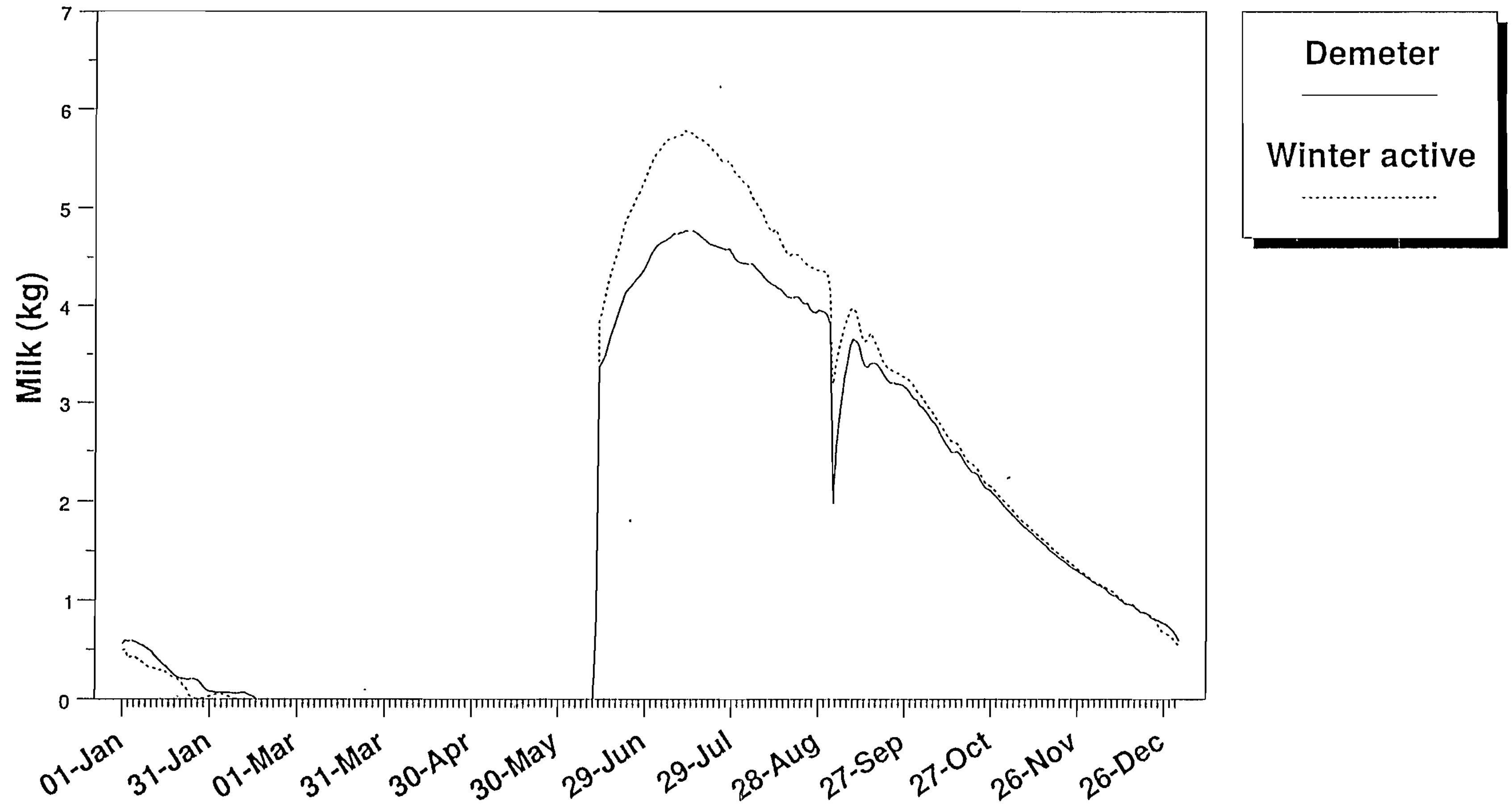


Fig. 49 Supplement intake of cows on tall fescue / sub clover pasture at Hamilton
Average over 1985-1994

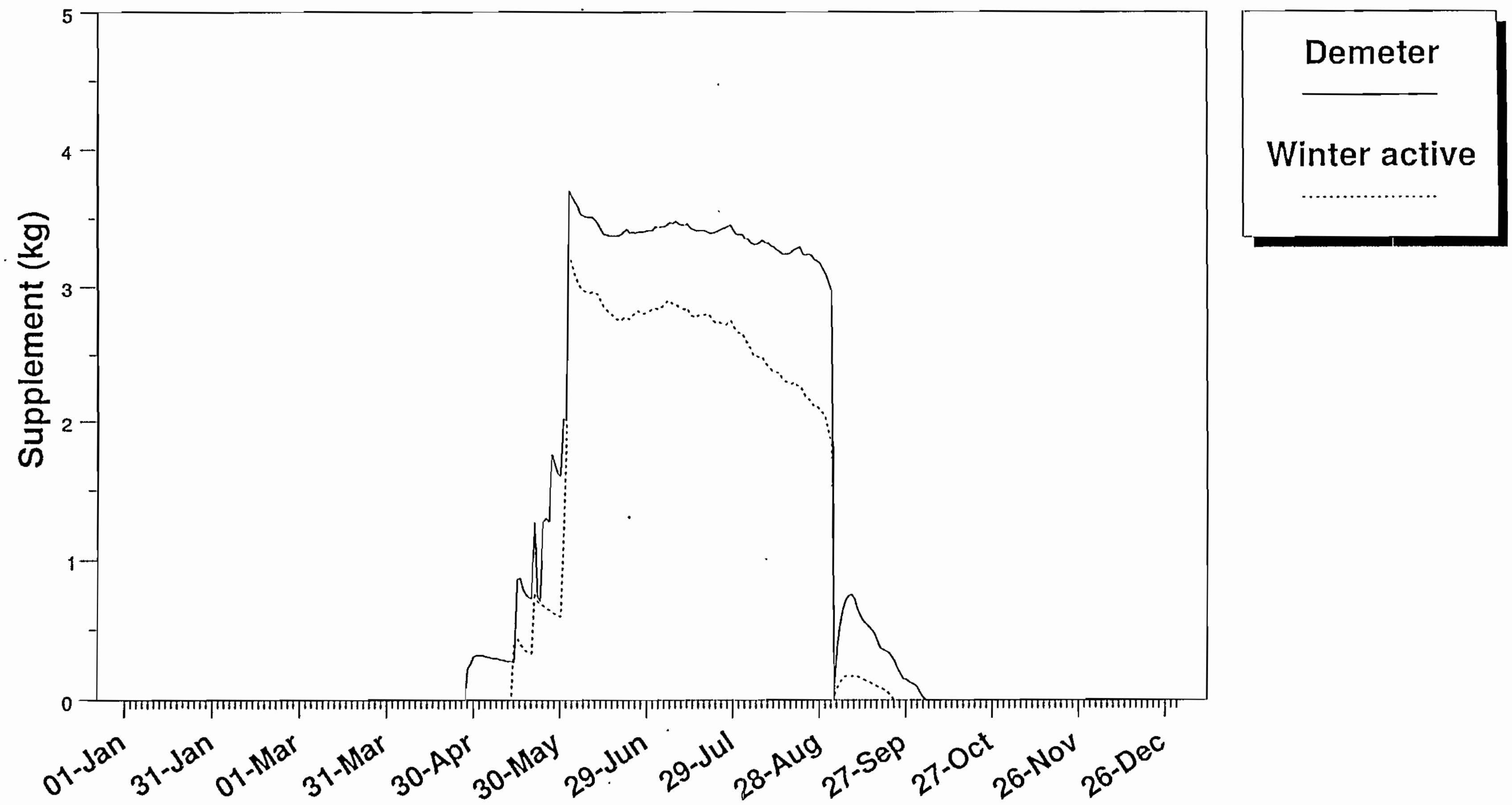
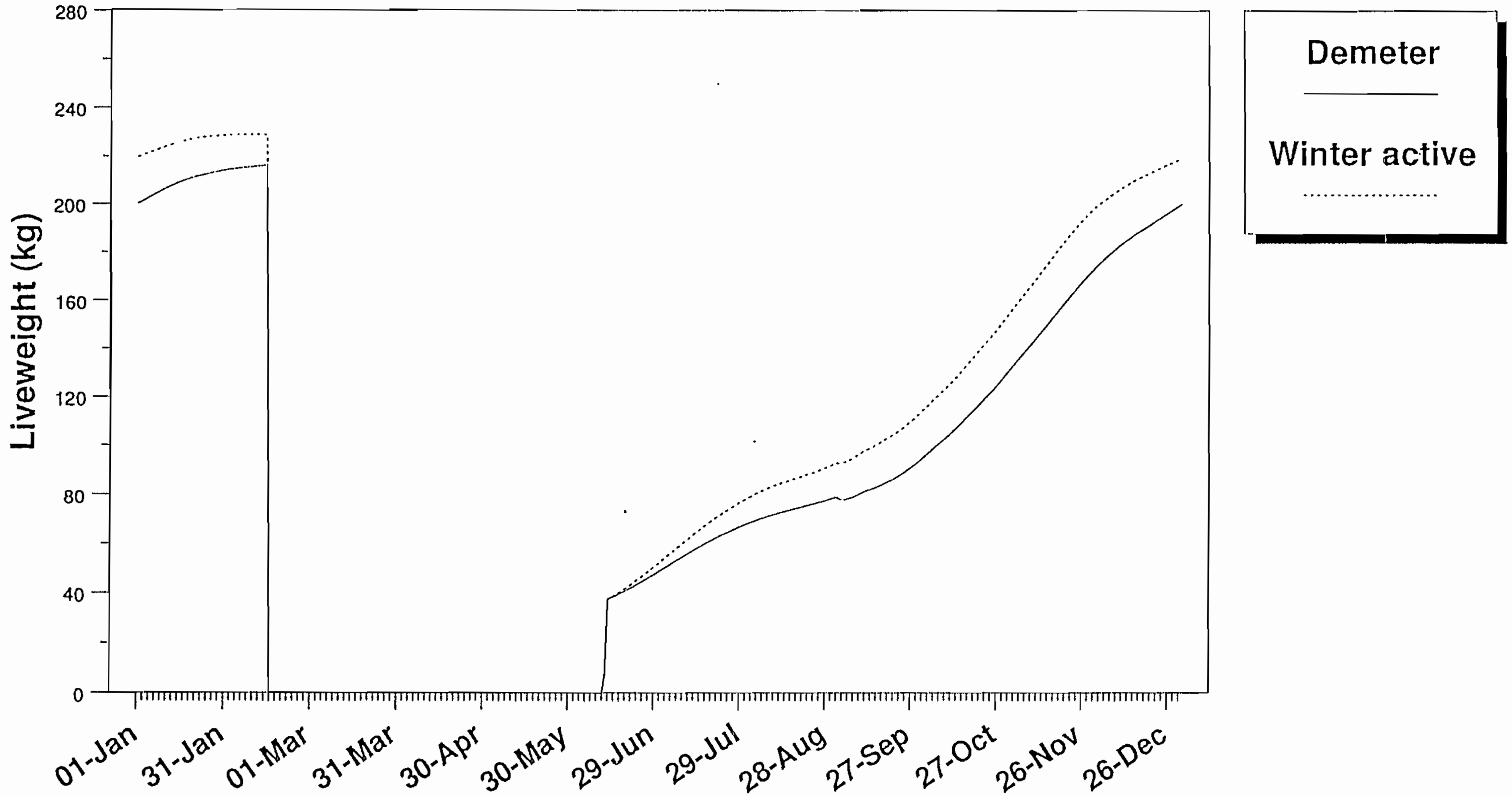


Fig. 50 Calf liveweight (kg) on tall fescue / sub clover pasture at Hamilton
Birth to weaning at 8 months - average over 1985-1994



3.4.2 Analysis of pasture management options

For a paper on plant physiology and grazing management[1] a series of GrassGro simulations were conducted to investigate the effects of changing pasture type and stocking rates. A ewe/lamb system was simulated at Hamilton, Victoria from 1964 to 1993. The pasture type was either annual grass/sub clover or perennial ryegrass/sub clover and the stocking rate was 7, 10, 12 or 15 ewes/ha. Everything else was the same.

GrassGro predicted that it is probably reasonable to operate at stocking rates up to 12 ewes/ha on both pasture types. At this stocking rate the perennial pasture returned an extra $34/ha in gross margin. This is mainly due to a longer period of spring growth from the perennial pasture and heavier lambs for sale.

[1]Simpson, R., Clark, S., Alcock, D., Freer, M., Donnelly, J. and Moore, A. (1996). How plant physiology can help us to achieve better grazing management. *Proceedings of the 11th Conference of the Grasslands Society of NSW*, 1996, pp 57-64.

3.5 Improvements to GrassGro

3.5.1 Rooting depth

The Delany's cattle simulations (page 14) deviated from reality towards the end of spring. Simulated pasture died off several weeks earlier than the real pasture and steers at this time did not perform as well in the simulation.

An examination of the predicted soil moisture available to plants (Figure 51) indicated that the dry period in mid-November led to a depletion of moisture in the soil. From the initial data inputs GrassGro had calculated that perennial ryegrass on this soil would have an effective rooting depth of 410mm. That is the maximum depth its roots could ever reach. Therefore even if this potential depth had been reached by the ryegrass in mid-late November predicted soil moisture would be insufficient for growth. In reality either the ryegrass roots were reaching deeper water or the soil was not drying out to the extent seen in the simulation. These two possibilities were tested.

1. Reducing soil moisture depletion

The weather file used for the simulations was altered so that on each of four days (16, 17, 24 and 25th November) 8mm of rainfall was added to the file - giving 32 mm of "extra" November rain (Figure 52). Figure 53 shows that this reduced the moisture limitation on ryegrass growth and allowed it to remain green for approximately an extra week (Figure 54). Figure 55 indicates that this extra rain had a small effect on plant available water and Figure 56 shows that the extra few days pasture growth had only a small effect on steer weight gain.

It was concluded that unrealistic soil water depletion was not the cause of the discrepancy between the simulated and observed results described above.

2. Increasing the effective rooting depth of perennial ryegrass.

A basic plant parameter for perennial ryegrass was modified to allow a potential rooting depth of 860mm. This had a dramatic effect. Moisture was non-limiting until the second week in December (Figure 57), the pasture remained green for an extra 3-4 weeks (Figure 58) and the performance of the simulated steers more closely predicted the experimental steers (Figure 59). The prediction was better not only at the end of the growing season but also at other times of the year.

The opportunity was taken to examine the actual root distribution in the Delany's wether paddock. Five cores (40 mm x 1.5m) were taken on 13 December 1996. The cores were cut into 10cm pieces and roots were measured in each piece. Figures 60, 61 and 62 show mean root length, cumulative root length and root density respectively. It is clear that roots (most likely of perennial ryegrass) reach depths of 800-900 mm. Below this few roots are found. This depth matches well with the depth required for GrassGro to predict accurately pasture and animal production late in the season (860 mm).

In conclusion, apart from the last few weeks these two simulations fit the measured animal and pasture data well. The early drying off of pasture in December was also a factor with the simulations conducted for the adjacent wether experiment. Further investigation indicated that the simulated rooting depth of perennial ryegrass in this soil was too shallow. Increasing the rooting depth of the ryegrass gave a much better fit with measured animal performance throughout the year. Measurements of real roots indicate that increasing the rooting depth in the simulations was justified.

As a direct result of this work, an attempt to improve the rooting depth characteristics of pasture species has been included in the latest version of GrassGro.

Fig. 51

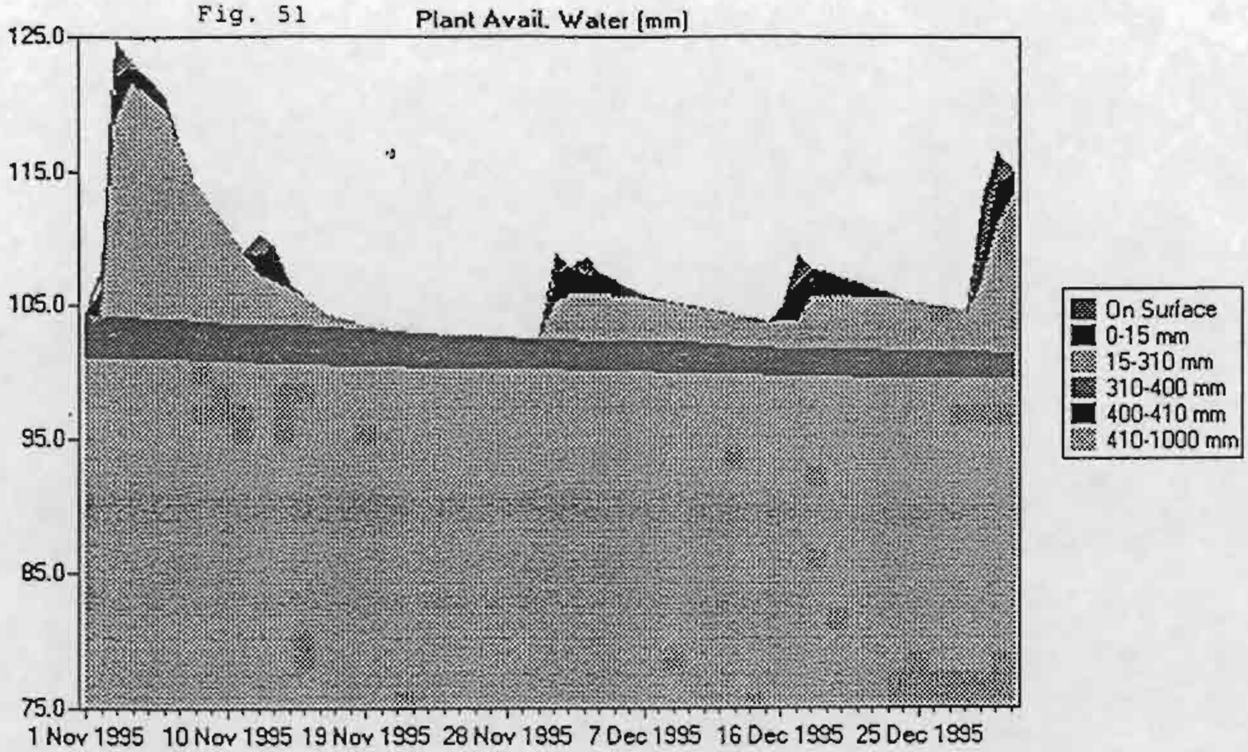
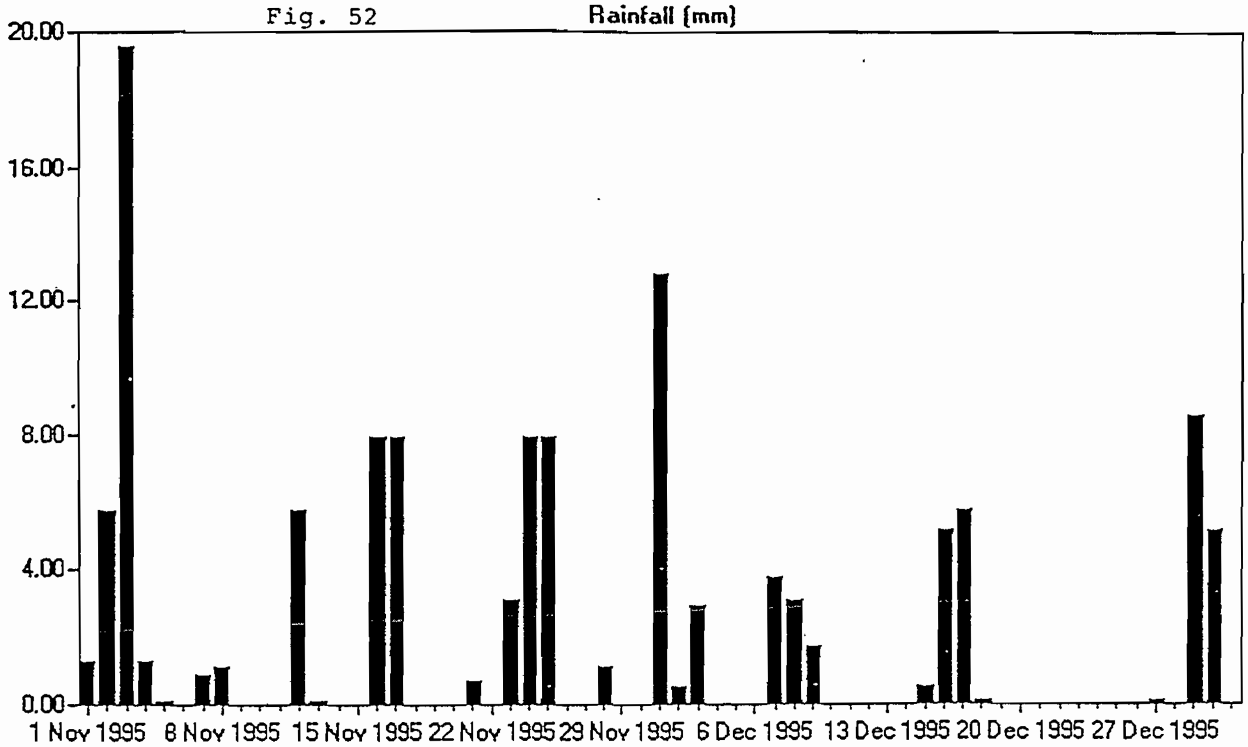

Plant Avail. Water (mm)
125.0
115.0
105.0
95.0
85.0
75.0
1 Nov 1995
10 Nov 1995
19 Nov 1995
28 Nov 1995
7 Dec 1995
16 Dec 1995
25 Dec 1995
On Surface
0-15 mm
15-310 mm
310-400 mm
400-410 mm
410-1000 mm

Fig. 52



Rainfall (mm)
20.00
16.00
12.00
8.00
4.00
0.00
1 Nov 1995
8 Nov 1995
15 Nov 1995
22 Nov 1995
29 Nov 1995
6 Dec 1995
13 Dec 1995
20 Dec 1995
27 Dec 1995

Fig. 53 Moisture limitation on growth of Perennial Ryegrass

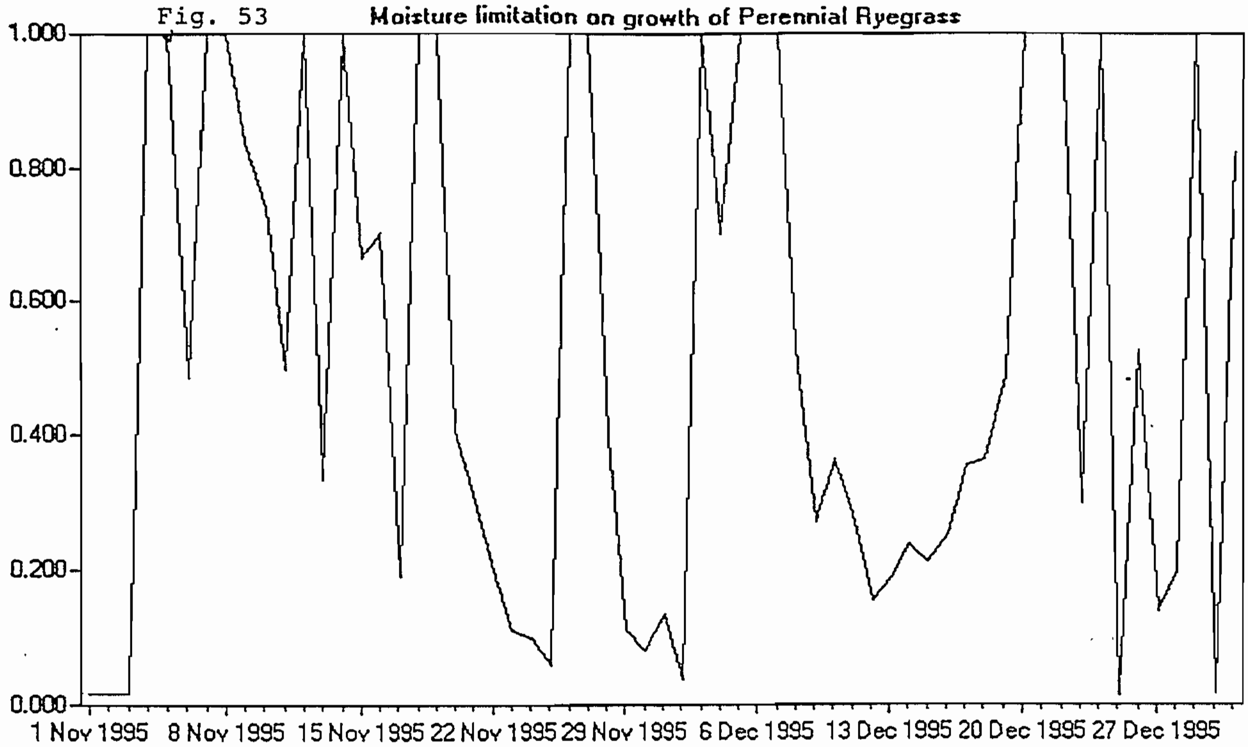


Fig. 54 Live total herbage for Perennial Ryegrass (kg/ha)

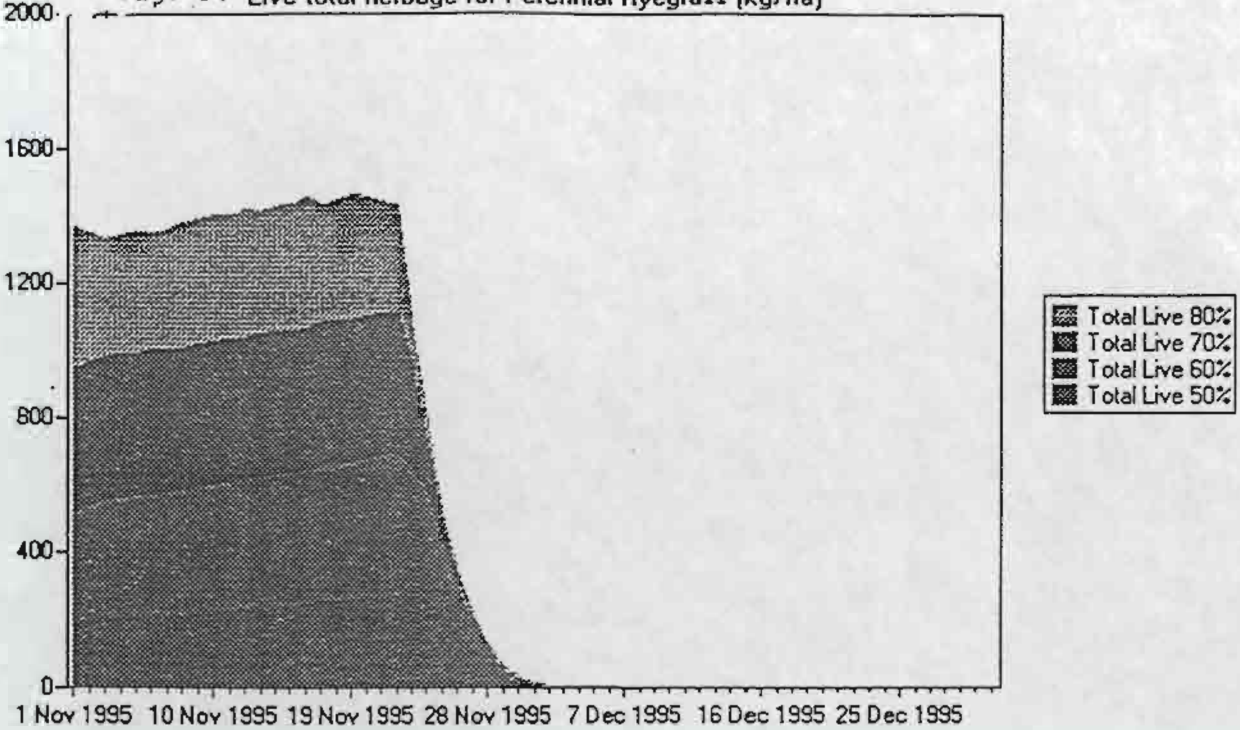


Fig. 55

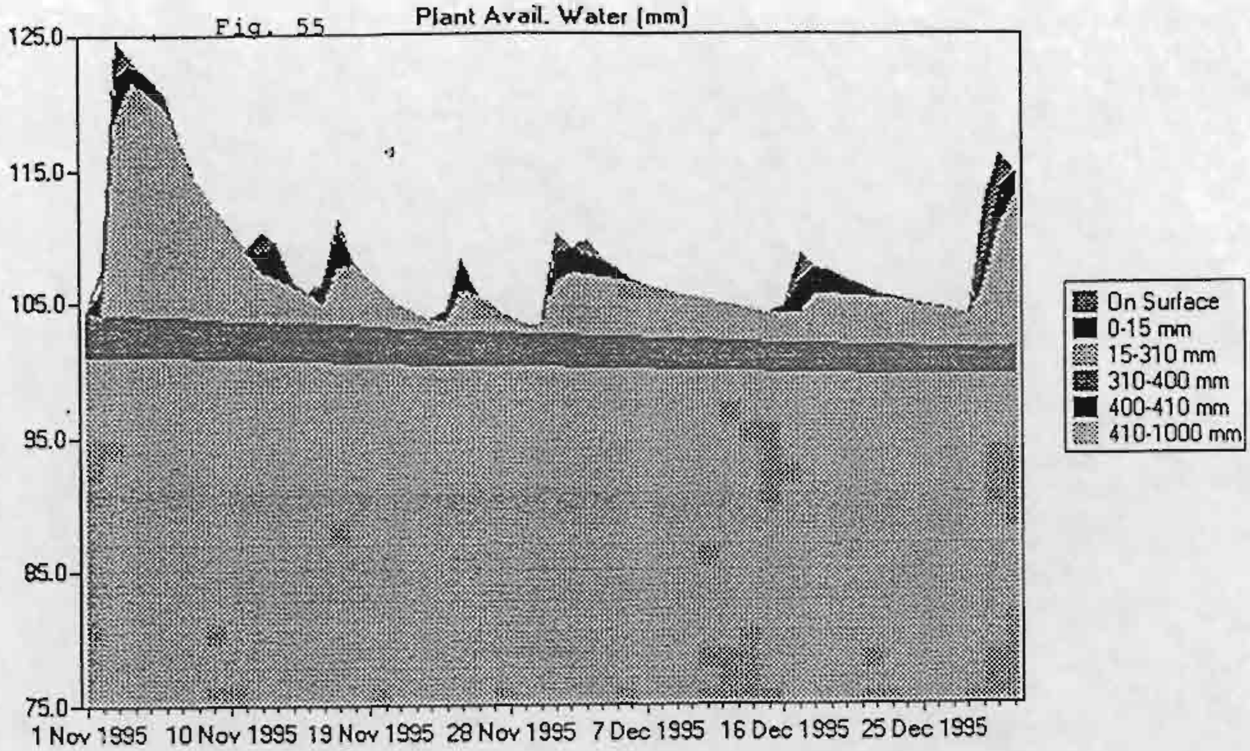

Plant Avail. Water (mm)
125.0
115.0
105.0
95.0
85.0
75.0
1 Nov 1995
10 Nov 1995
19 Nov 1995
28 Nov 1995
7 Dec 1995
16 Dec 1995
25 Dec 1995
On Surface
0-15 mm
15-310 mm
310-400 mm
400-410 mm
410-1000 mm

Fig. 56

(extra rain in late November)

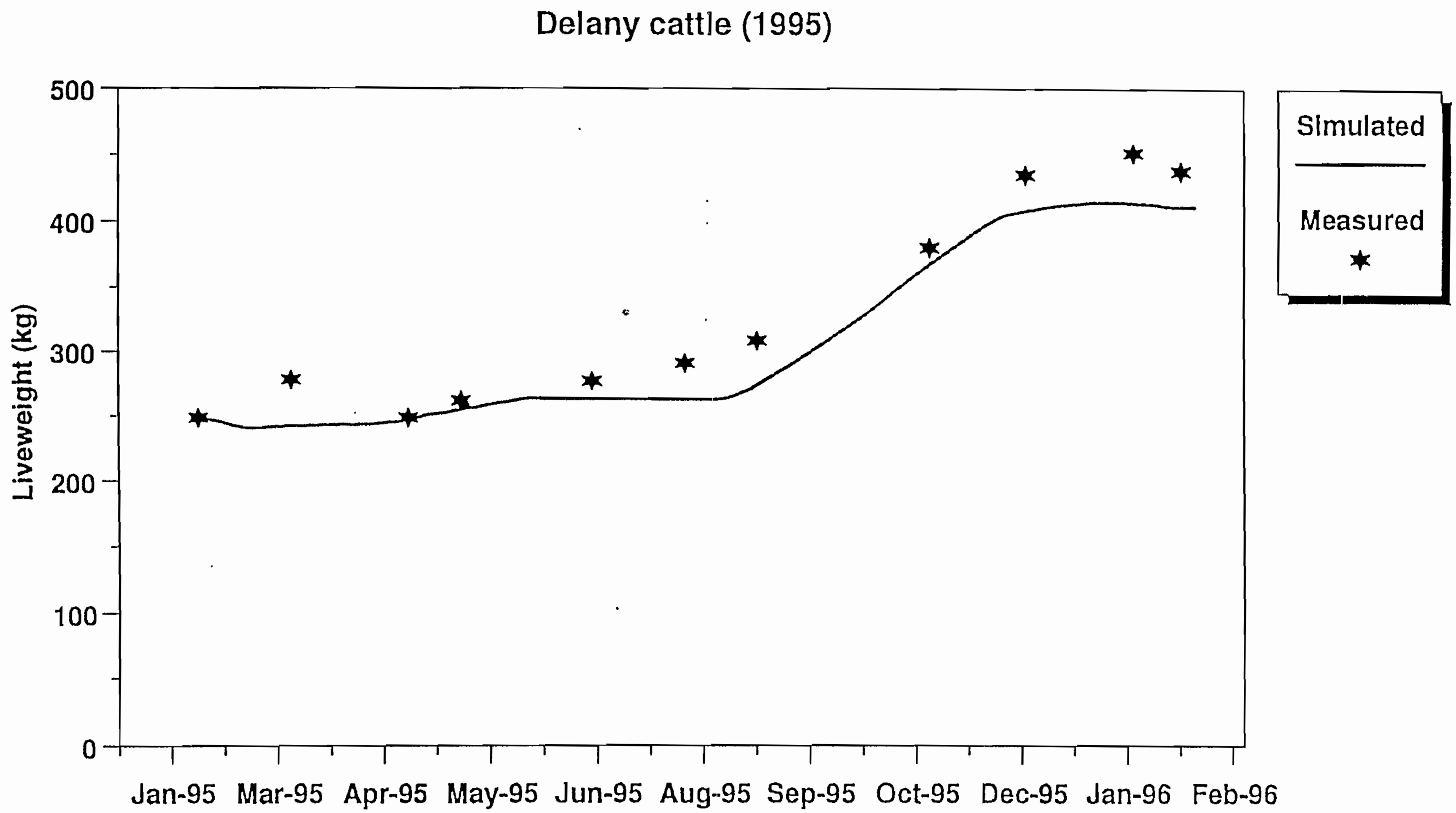


Fig. 57 Moisture limitation on growth of Perennial Ryegrass

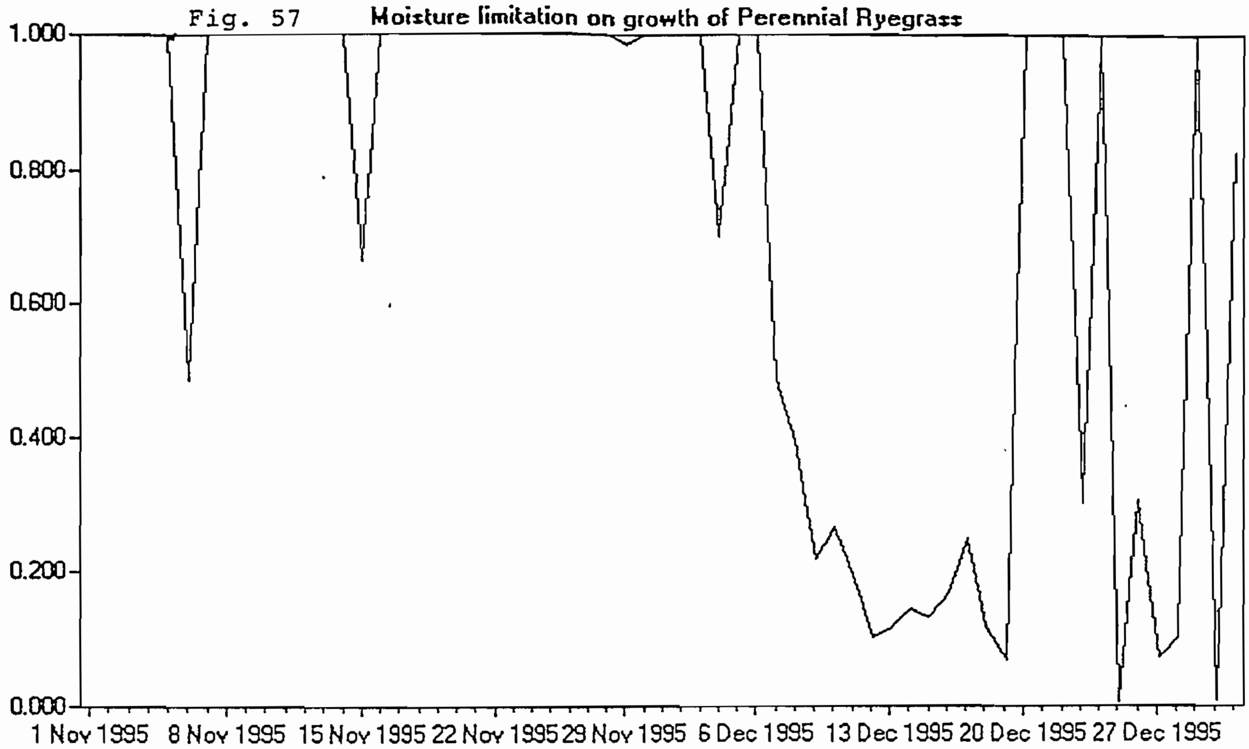


Fig. 58 Live total herbage for Perennial Ryegrass (kg/ha)

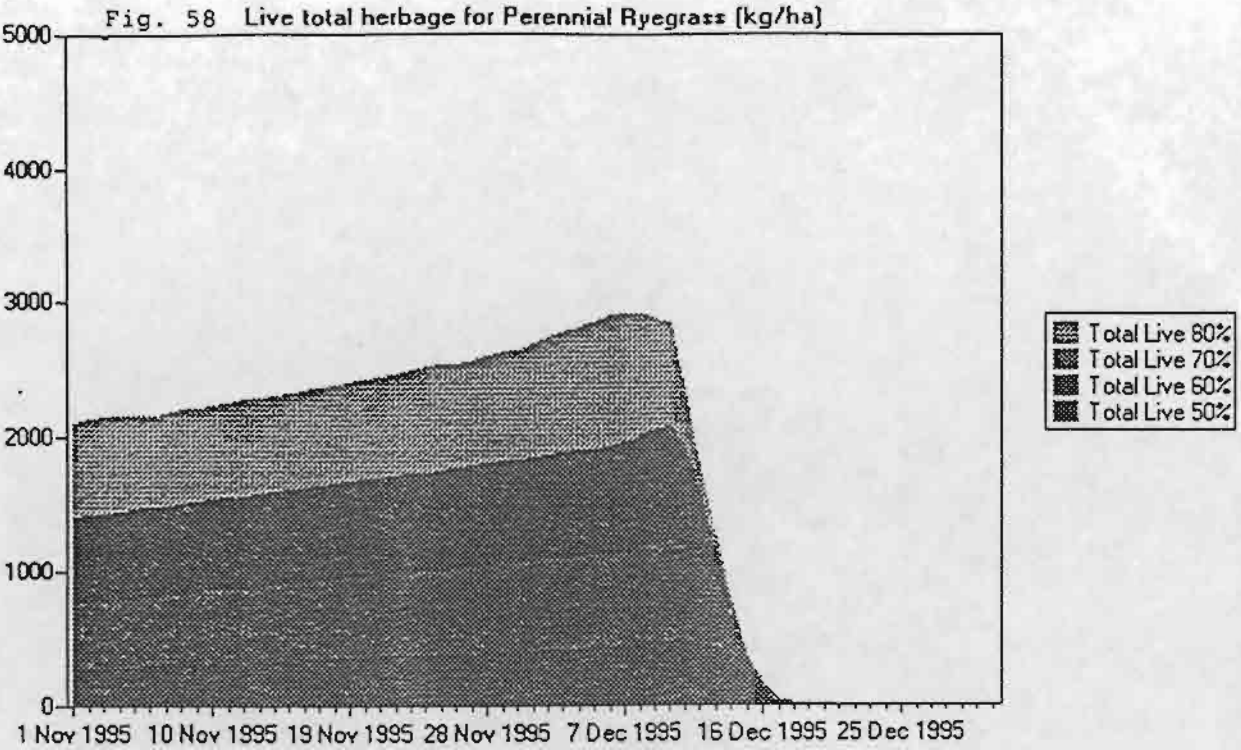


Fig. 59

Increased rooting depth of perennial ryegrass

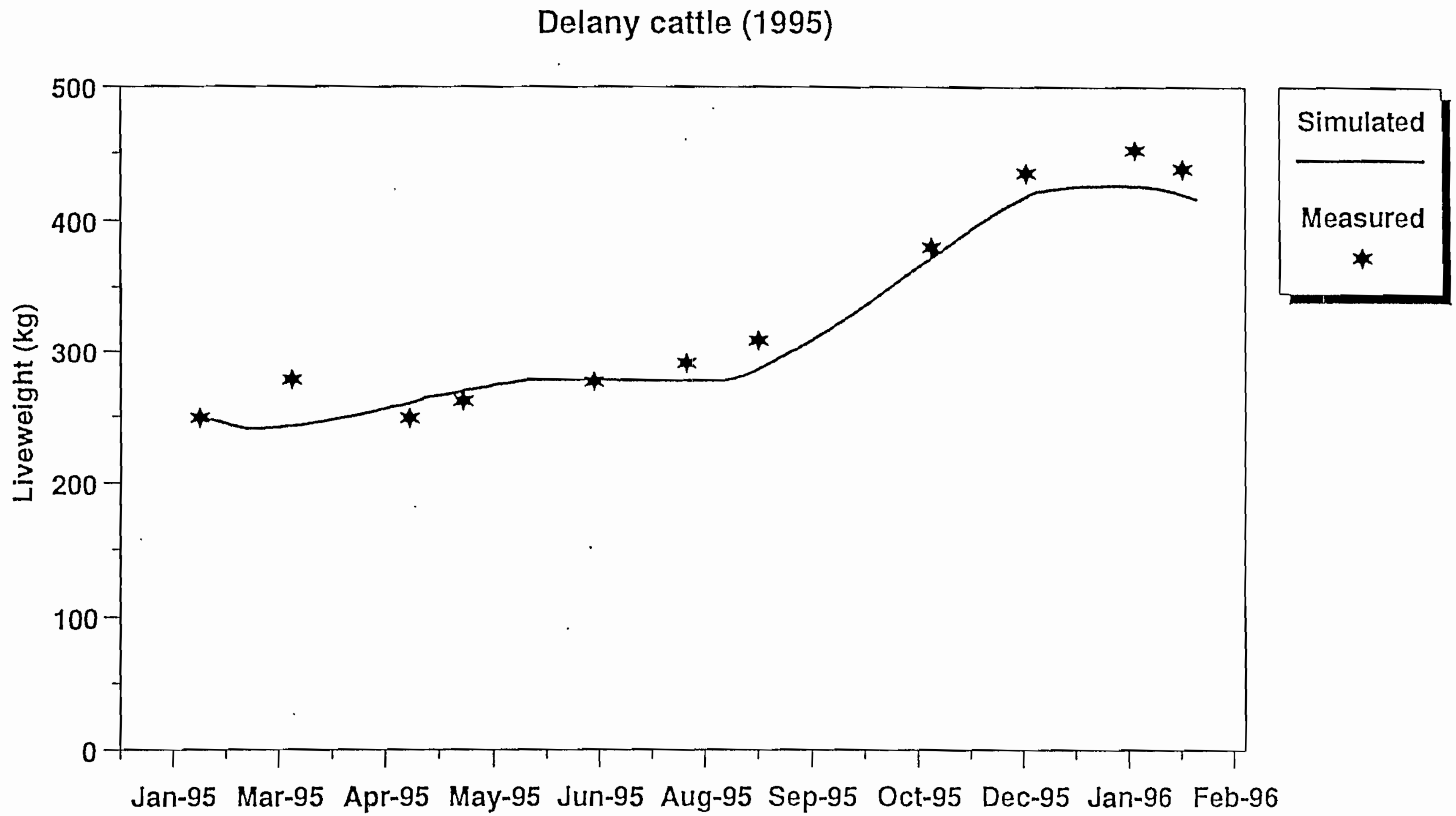


Fig. 60

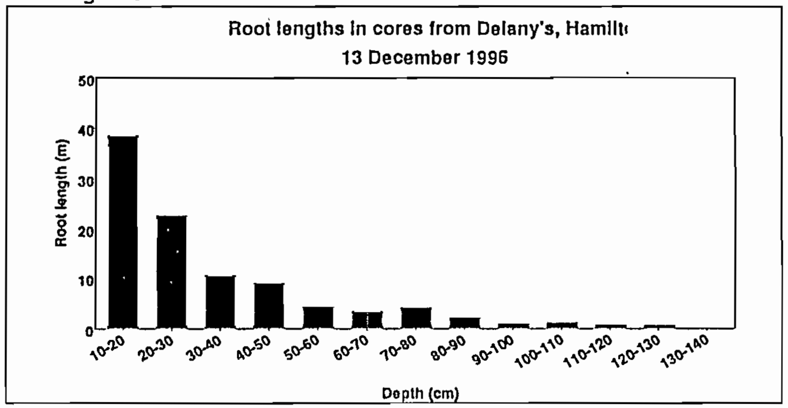


Fig. 61

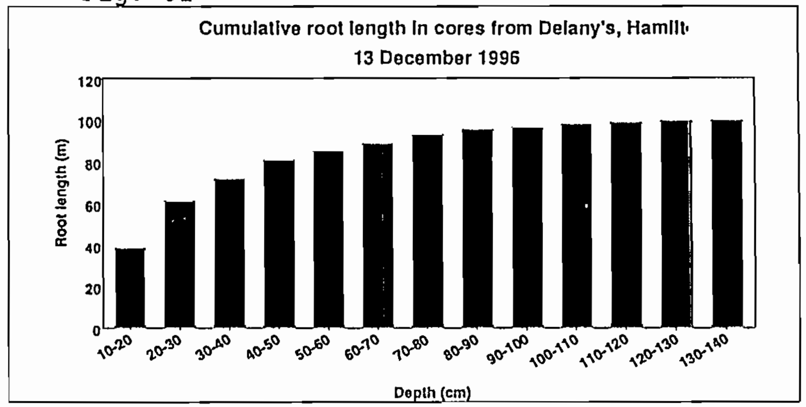
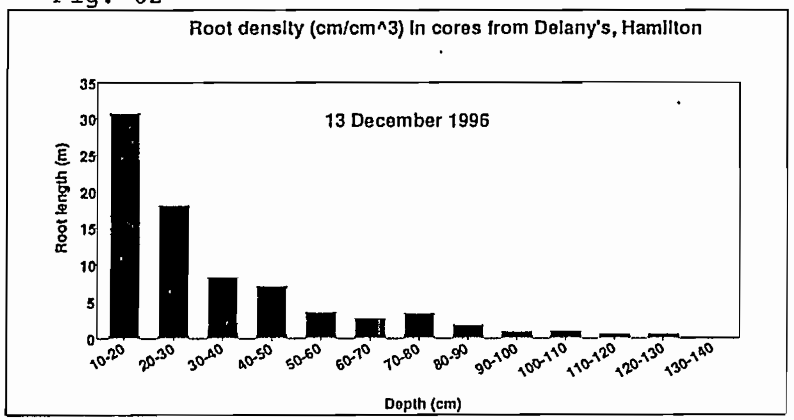


Fig. 62



3.5.2 Summer Annual Grass Parameter Set

Summer active annual grasses play an important role in pasture on the Northern Tablelands of NSW. They often dominate the pasture during the summer months when other species such as phalaris are dormant. In order to simulate the pasture and animal production from the four Tamworth sites it was necessary to develop a parameter set for an annual grass which grows over the summer months.

Dr. Terry Bolger's assistance was sought. We experimented with the phenological pattern, seed dynamics, temperature responses and the factors causing cessation of growth in autumn testing the parameter set after each change.

A long-term simulation run was conducted at Tamworth (1973-1992) on a loam over a clay loam soil with wethers at 10/ha. The pasture consisted of the summer annual grass only. Figure 63 presents the live total herbage over this period demonstrating the ability of the simulated annual grass to persist through time - at least when grown alone.

Figure 64 presents the long-term average of live total herbage (over the period 1973-1992). Note that on average germination occurs in mid-late October, growth peaks in mid-February and ceases with frosts in late May. Note also the spike corresponding to Feb 29th. This is an aberration due to calculating an average based on relatively few data points and has been removed from more recent GrassGro versions.

Figure 65 presents long term average seed dynamics (again with the Feb 29th spike).

At this stage the simulated summer annual grass appeared to behave quite reasonably. A report on this work including graphs was sent to Greg Lodge (NSW Agriculture - Tamworth) in August 1996 asking for his comments on the behaviour of the parameter set. No comments were forthcoming.

Fig. 63

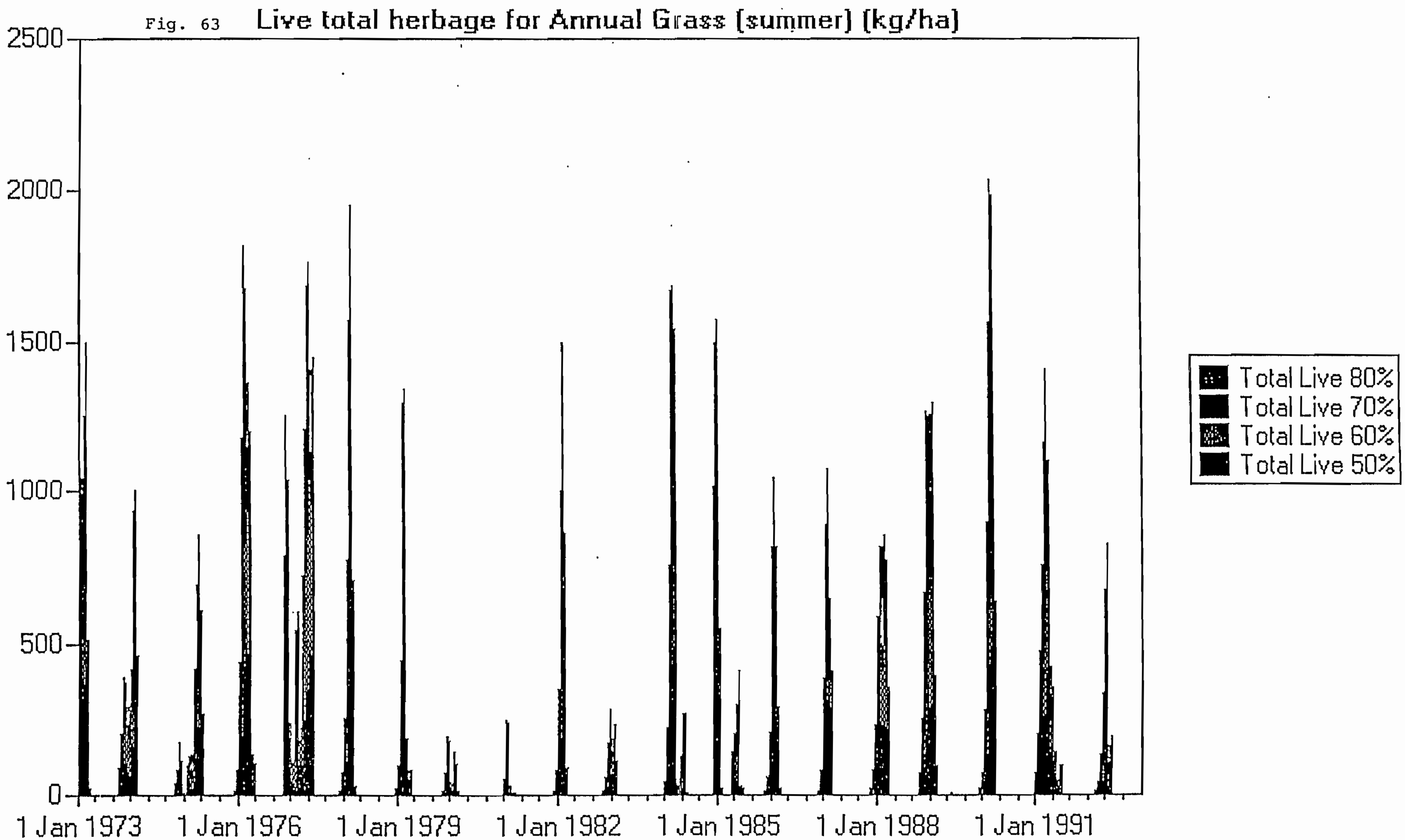

Live total herbage for Annual Grass (summer) (kg/ha)
2500
2000
1500
1000
500
0
1 Jan 1973
1 Jan 1976
1 Jan 1979
1 Jan 1982
1 Jan 1985
1 Jan 1988
1 Jan 1991
Total Live 80%
Total Live 70%
Total Live 60%
Total Live 50%

Fig. 64

Live total herbage for Annual Grass (summer) (kg/ha)

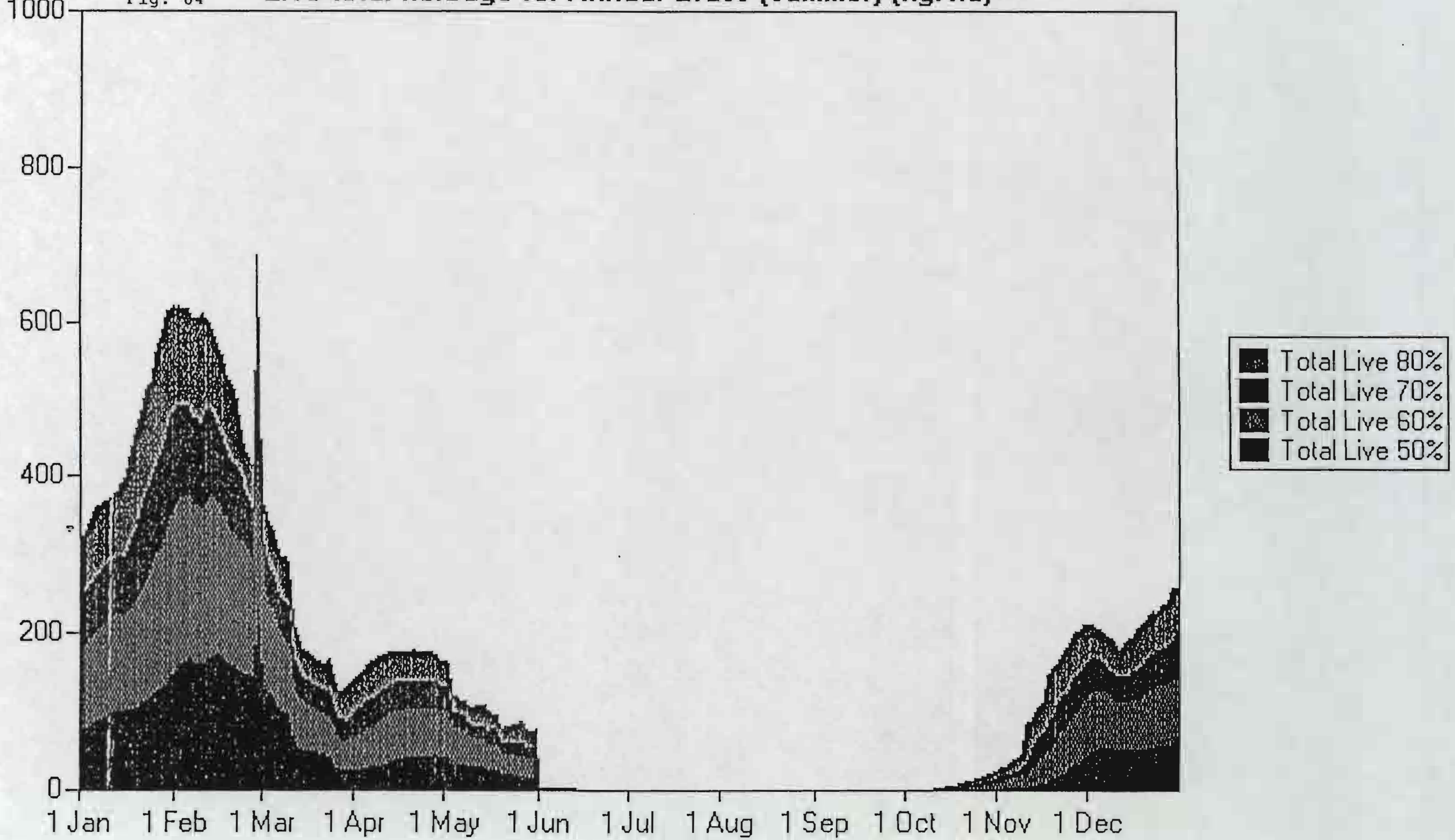
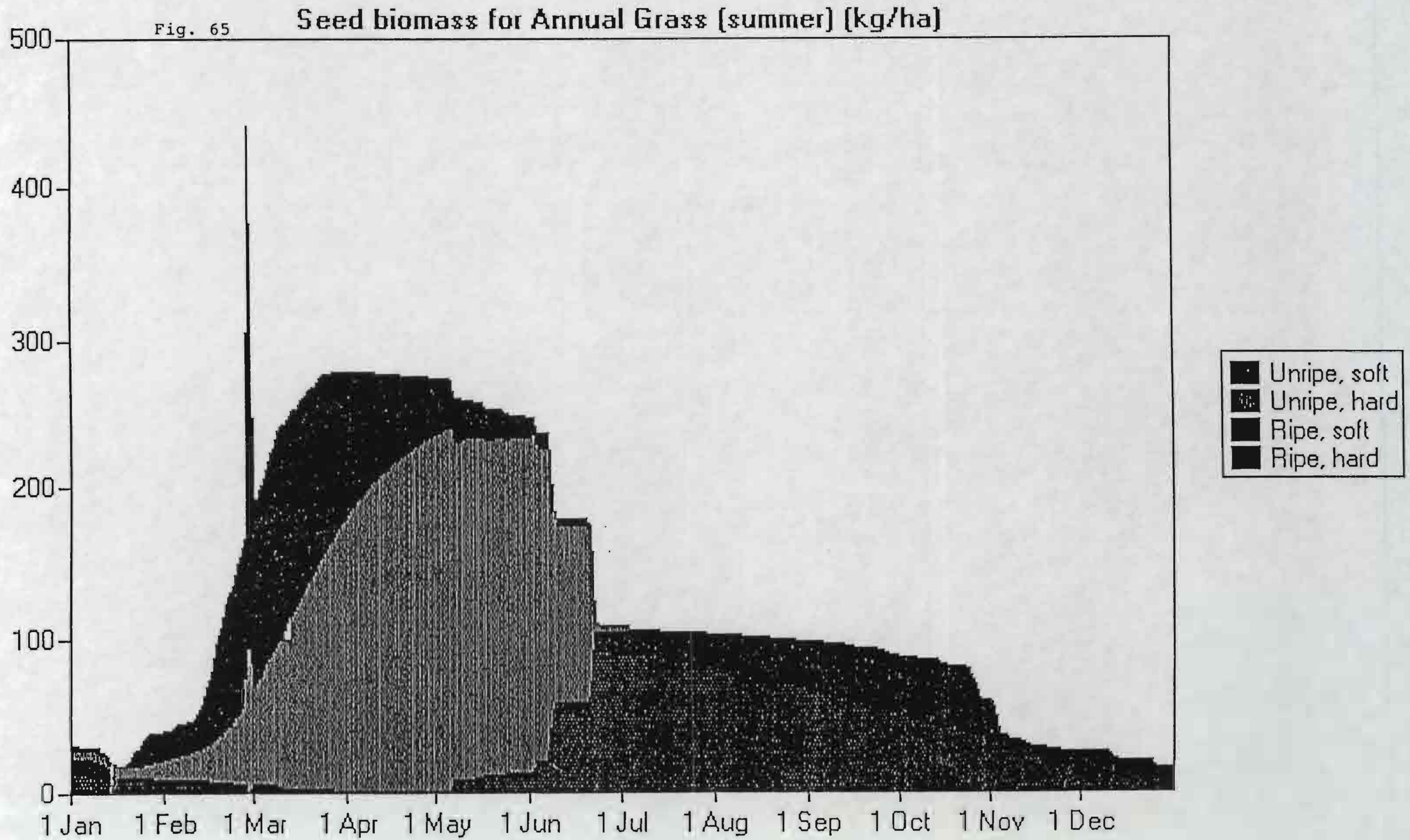


Fig. 65



Seed biomass for Annual Grass (summer) (kg/ha)
500
400
300
200
100
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
Unripe, soft
Unripe, hard
Ripe, soft
Ripe, hard

3.6 Beta-testing of MetAccess and GrassGro for Windows

For most of 1996 MetAccess and GrassGro were being developed as Windows applications for public release in 1997. As one of the few people using both applications on a regular basis I was able to significantly contribute to their development. Both initially contained many bugs and inconsistencies which I helped to remove or improve. I was able to make suggestions which led to improved operation and consistent "look and feel" between the two products.

GrassGro in particular benefited from the work carried out in this project. Improvements have been made to the pasture parameter sets, new species/cultivars have been parameterised and studies are underway to improve the behaviour of annual species (seed dynamics) and the presentation of herbage to animals during periods of low availability.

library

Summary of Final Project Report

28-Apr-1997
1:16:46 PM

Not Confidential (green)

Project No: CS.224
Sector No: 04.03.01
Project Title: Integration and extrapolation of regional grazing management sites, sub-program 5.1 TPSKP.

Project Trigger: Overhead for TPSKP.
Performance Status:
Organisation: CSIRO Australia

Commenced:	01-Aug-1994	**Total Corporation Funding:**	$94,466.00
Completed:	31-Jan-1997	**Corporation Manager:**	IJ
Final Report Due:	31-Jan-1997	**Final Report Received:**	06-Mar-1997
Final Revision Due:	31-Jan-1997	**Final Report Approved:**	21-Apr-1997

Investigator	Phone No.	Fax No.
Mr S Clark		

Project Objectives

By 31 August 1995:
1. To validate the GRAZPLAN pasture dynamics model with data from the Temperate Pasture Sustainability Key Program (TPSKP), including the grazing management (DAN.074, DAV.092, DAS.032, DAT.016), drought (M.401) and sustainability sites (M.405, M.417),

By June 1996:
2. To extrapolate information collected at TPSKP grazing management sites to other locations and seasons, by simulation with the validated model;

3. To use the AusFarm DSS to tailor optimum management strategies identified in TPSKP so that TPSKP findings benefit the meat producers at any specified location;

4. To work with the Program Coordinator to specify production systems for testing in Phase 2 of TPSKP;

5. To link an existing nutrient cycling model (McCaskill-Blair) to the GRAZPLAN pasture model that is used in GrassGro.

Corporation Assessment

ABSTRACT
=========
This project seconded a scientist from Agriculture Victoria for two years to learn how to use the GRAZPLAN decision support system, particularly GrassGro and MetAccess. Data from the Temperate Pasture Sustainability Key Program (TPSKP) research sites was used to validate the model and simulations were done to assess the impact of grazing management practices.

Data was validated for 5 of the 22 TPSKP research sites and simulations were done at 2 sites only. At each site further developmental work was required to get the GrassGro model to give meaningful results. This included adjustments to rooting depth, and adding and altering pasture species parameter sets. Deficiencies in the model in the areas of pasture competition in partiuclar limited the results that could be produced. Seed dynamics and pasture clumpiness were also identified as areas requiring improvement. Extra work on evaluating the benefit of extra pasture growth in winter for plant breeding and analysis of pasture mangement options was done.

BRIEF COMMENTS
================

This project was commissioned to address the deficiencies in coverage of trials in TPSKP. That is, to extrapolate from 22 research sites to other locations and seasons that may be found in the high rainfall zone (30m ha). This project has not met this overall objective. In hindsight the complexity of the models probably means that it will not be able to met this objective in the short term. To date CSIRO have spent $17m in developing the GRAZPLAN models.

RESEARCH SUCCESS/FAILURE
=========================

Objective 1: partly achieved
Objective 2: partly achieved. Only extrapolated to 2 other seasons. Did not extrapolated to other sites.
Objectives 3 & 4: not achieved
Objective 5: achieved, although not reported in final report

INDUSTRY IMPACT
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There is no current and likely to be little potential industry impact. The project has not been able to extrapolate research findings across sites, and has only had limited success in extrapolating across seasons.

FOLLOW-UP ACTION
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CSIRO will be asked to comment on how well they achieved the project objectives and the feasability of the objectives. The broader question of dealing with the variability of the high rainfall zone, and the role of models in helping with this in being addressed in the design of research in the Sustainable Grazing Systems Key Program.

Administration Details

Future Support of Researchers: Area Yes, Researcher Yes, Res Org Yes
Total MRC Funds Spent: No Problem
Financial Return to MRC Arranged?: Not applicable

Commercialisation

How can the results be Commercialised/Implemented?: Not Applicable

Circulation

On request (Free of charge)
5.Other

Signed By:...**(PM)** 28/4/97