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CONF

Commercial Pilot Demonstration Of Tasmanian Greenhouse Capsicum Production Opportunities, Incorporating World's Best Practice Production Techniques.

Dr Jason Dennis
Field Fresh Tasmania

FINAL REPORT
TO
HORTICULTURE AUSTRALIA LIMITED

Project No. VG00062

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Purpose:

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Glen Graham, for providing guidance and leadership for this very challenging project.

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Disclaimer:

Contents:

MEDIA SUMMARY:

Tasmania's cool temperate climate and relatively low pest and disease incidence is ideal for greenhouse capsicum production. In 1996, Japan granted Tasmania area freedom from Tobacco Blue Mould; offering Tasmania an opportunity to export Solanaceous fruits such as tomatoes and capsicums to Japan.

Initial screening trials and test marketing identified capsicums as the crop with the most export potential. Capsicums therefore became the major focus with an emphasis on production under Tasmanian conditions, for export to Japan. A significant opportunity for developing a greenhouse capsicum market in Australia was also identified.

Previous project results were very encouraging, however trial work was conducted in a very small greenhouse (200m^2), which was too small to be considered to represent a commercial scale operation. Therefore, a pilot commercial scale trial was established to be able to rigorously check the production and market budgets, particularly heating costs, yields, class one pack outs and market prices. The combinations of these will determine the final economic viability of greenhouse capsicum production and all required clarification and verification on a commercial scale.

The financial results from this project produced an unfavourable outcome. A negative gross margin was recorded and after fixed costs are taken into account an overall loss was the final result for this pilot commercial crop. The reason for the poor result is due to the very poor yields achieved. This was due to the plant density being too low, excessive humidity fluctuations and poor insect control, all of which can be significantly improved in future crops. The other parameters of cost of labour, cost of heating and market price all produced favourable results that would support the establishment of a greenhouse capsicum industry.

Overall, the pilot commercial crop has addressed the four issues raised from previous work, namely yield, market price, cost of labour and cost of heating. Assuming some critical management strategies are followed and market prices do not drop, a viable greenhouse capsicum industry is achievable. To this end, at least one commercial crop of capsicums is being grown in Tasmania this season as a direct result of this project.

Parameters that need changing from the pilot commercial crop are improved humidity and insect control, and an increase in plant density, which can largely be achieved by increasing the number of rows in the house and reducing the size of the central pathway and other unproductive areas.

Attention to detail to focus on producing the highest possible quality fruit is an essential philosophy to achieve success. If this is not the plan then greenhouse capsicums should not be attempted, as the quality of field grown capsicums will too easily rival sub standard greenhouse grown capsicums and the resulting prices will be too low for the operation to remain viable.

TECHNICAL SUMMARY:

The financial results from this project produced a very unfavourable outcome. A negative gross margin of -\$18,165 was recorded and after fixed costs are taken into account an overall loss of -\$59,267 was the final result for this pilot commercial crop.

The data clearly shows that the gross yield and yield per m^2 achieved in the pilot commercial crop were more than 50% below the expected yield in the DPIWE model. The Grade 1 pack out was also substantially lower in the pilot commercial crop than the DPIWE model, and conversely the Grade 2 and 3 pack outs were much higher in the pilot commercial crop than the DPIWE model.

The market price achieved per kg for all grades of fruit was higher in the pilot commercial crop than the DPIWE model.

The variable costs were in the order of \$20/m^2 lower in the pilot commercial crop and most of this can be attributed to the large saving in heating cost. The cost of heating a large house was the variable from the previous work that was the least certain, and this result coupled with the market price improves the possibility of establishing a viable industry.

The labour costs were very similar in both budgets, however due to the substantially lower yield in the pilot commercial crop, the cost of labour was expected to be lower since there was less fruit to harvest, grade and pack.

The yield of each variety was measured throughout the season and while there was variation in performance between varieties even the best variety was still at least 10kg/m^2 below the yield expected in the DPIWE model, which is the yield being achieved in New Zealand and Holland.

The density used in the pilot commercial crop was 2.5 plants/m^2. If this was increased to the recommended density of 3.5 plants/m^2 and only the two best red and yellow varieties were planted in equal quantities, then the expected yield would be 17.76kg/m^2 instead of the average achieved of 9.89kg/m^2.

It is likely that fluctuations in humidity also contributed to the overall lower yield and also to the very low recovery of Grade 1 fruit. It is well documented that if the humidity is either too low or too high capsicum plant physiology is disrupted and both growth and fruit carrying capacity can be severely restricted. The quality faults present in the Grade 2 and 3 fruit were consistent with problems associated with humidity fluctuations and included blossom end rot, fruit cracking and Botrytis and Sclerotinia disease.

Parameters that need changing from the pilot commercial crop to achieve a viable crop are improved humidity and insect control, and an increase in plant density.

Overall, the pilot commercial crop has addressed the four issues raised from the previous project VG97064, namely yield, market price, cost of labour and cost of heating. Assuming some critical management strategies are followed and market prices do not drop, a viable greenhouse capsicum industry is achievable. To this end, at least one commercial crop of capsicums is being grown in Tasmania this season as a direct result of this project.

INTRODUCTION:

Tasmania's cool temperate climate and relatively low pest and disease incidence is ideal for greenhouse capsicum production. In 1996, Japan granted Tasmania area freedom from Tobacco Blue Mould (ref: AQIS 94); offering Tasmania an opportunity to export Solanaceous fruits such as tomatoes and capsicums to Japan. With the aim of exploring this opportunity further the Department of Primary Industries Water & Environment (DPIWE), the Tasmanian Greenhouse Tomato & Vegetable Growers Association (TGTVGA) and Field Fresh Tasmania put forward a joint industry/HRDC funded three year research and development project.

Initial screening trials and test marketing identified capsicums as the crop with the most export potential. Capsicums therefore became the major focus of this project with an emphasis on production under Tasmanian conditions, for export to Japan. During the third year of the project it became evident that there was also a significant opportunity for developing a greenhouse capsicum market in Australia.

The project VG97064 "Assessment of tomato, capsicum and eggplant cultivars and production techniques for export to Japan and Taiwan and demonstration of IPM of Botrytis cinerea for local and export crops" has been completed, and has identified the need for a further step before commercial production would be able to commence.

The project VG97064 results were very encouraging, however the trial work was conducted in a very small greenhouse ($200m^2$), which is too small to be considered to represent a commercial scale operation. Heating costs, in particular, are influenced significantly by the size and volume of the structure. It is assumed that larger structures will require a lower heating cost to maintain the same temperature as a small greenhouse. Other environmental parameters such as humidity are more stable in a larger volume house. Therefore, a pilot commercial scale trial was proposed to be able to rigorously test the cost of production and market returns for greenhouse capsicums.

From the R&D project VG97064 a cost model has been produced. However, there are several aspects of the model that require verification on a commercial scale before expansion of production would occur. The cost-effectiveness of production requires the following to be verified: the cost of heating a larger house, the yield and pack out, the labour cost and the market price. Based on comparisons with New Zealand production, the cost of heating should be lower than in the model, the yield and pack out can be expected to be the same, but the market price in the model appears to be higher than would be expected on a larger commercial scale.

The R&D project VG97064 has produced a manual describing how to grow greenhouse capsicums. This manual was used to guide production in the commercial pilot demonstration described in this report.

The plan of this project was to establish a capsicum crop in a $2,000m^2$ state of the art greenhouse and verify the cost of production on this commercial scale and contrast the results with the model produced from project VG97064. Field Fresh Tasmania is Australia's largest exporter of onions, currently marketing 35,000 tonnes, and also packs and sells 7,500t of carrots to both export and local markets. These market links and the network of Australian market contacts were utilised to explore opportunities for selling greenhouse capsicums both overseas and locally.

METHODS:

The project essentially consists of growing a capsicum crop following the DPIWE manual produced from project VG97064 "A guide to growing export quality hydroponic greenhouse capsicums in Tasmania" with modifications agreed to by team consensus following regular reviews. The final result of this project is the preparation of the budget for production and market figures based on the actual data from this crop, which will be compared with the original model budget from project VG97064.

The greenhouse used in this project is a 2,000m^2 state of the art environmentally controlled house. It is a double skin Richel house with a 3.5m gutter, electric heating circulated by a forced air ducting system. The greenhouse environment is electronically monitored and controlled to maintain air temperature, relative humidity and nutrient temperature to predetermined levels. A computer controlled CO_2 circulation system was used to improve early growth as recommended in the manual. The growing system was a recirculating nutrient film technique (NFT) where nutrient levels and pH are also computer monitored and controlled.

The full production protocol is detailed in the production manual prepared by the DPIWE project VG97064. The following is a brief summary of that production protocol which was used for the pilot commercial trial:

- Night temperature range 19-21°C
- Day temperature range 22-28°C
- Nutrient solution temperature range 19-24°C
- Humidity range 75-85%
- Leaf wetness range 0-10
- EC range 2.0-2.5
- PH range 5.5-5.8
- 2.5 plants per m^2
- 2 stems per plant, 5 per m^2
- Fruit storage temp, 8-12°C

Pruning and training strategy:

- Remove terminal bud and allow two leaders per plant.
- Prune 1st nodes of each leader to leave 5 leaves.
- Allow fruit to set on 2nd node of laterals.
- Allow all fruit to reach full colour before harvest.

The three leading varieties from the previous DPIWE trials, Mazurka (red), Fiesta (yellow) and Nassau (orange) were included in the variety mix. The house was planted with 36.9% red varieties, 35.5% yellow varieties, 24.8% orange varieties and 2.8% chillies. The colour and variety mix have been selected to maximise the opportunity for test marketing product in Australia as well as Japan and are detailed in Table 1.

The seed for this project was sourced from Rijk Zwaan and Enza Zaden in Holland, and from South Pacific Seeds (SPS), LeFroy and S&G in Australia, and planted on 5th June 2000. Seeds were planted in starter rock wool cubes and maintained at 25°C. After 3 weeks they were transplanted into seedling raising rock wool cubes and maintained at 20°C. Seedlings were transplanted into the main 2,000m^2 house when the first flower buds were beginning to swell on 22nd and 23rd August 2000.

Table 1. Capsicum varieties and seed suppliers.

Code	Colour & Type	Variety	No. rows	Supplier
R1	Red Blocky	Raptor	5	S&G
R2	Red Blocky	Rocky	4	S&G
R3	Red Blocky	Mazurka	4	Rijk Zwaan
R4	Red Blocky	Mandy	2	Rijk Zwaan
R5	Red Blocky	Danza	2	Rijk Zwaan
R6	Red Blocky	Maratos F1	2	Enza Zaden
R7	Red Blocky	Maite F1	2	Enza Zaden
R8	Red Blocky	Spirit F1	2	Enza Zaden
R9	Red Blocky	Spirit	2	SPS
R10	Red Blocky	FA867	0.5	LeFroy
R11	Red Blocky	FA866	0.5	LeFroy
		Total Red	26	36.88%
Y1	Yellow Blocky	Fiesta	7	Enza Zaden
Y2	Yellow Blocky	Sunset	4.5	Enza Zaden
Y3	Yellow Blocky	Inca	4	S&G
Y4	Yellow Blocky	Romeca RZ	6	Rijk Zwaan
Y5	Yellow Blocky	Concerto	2	SPS
Y6	Yellow Blocky	FA2001	0.375	LeFroy
Y7	Yellow Blocky	FA959	0.375	LeFroy
Y8	Yellow Blocky	FA490	0.75	LeFroy
		Total Yellow	25	35.46%
O1	Orange Blocky	Nassau	6	Rijk Zwaan
O2	Orange Blocky	Lion	4.5	Enza Zaden
O3	Orange Blocky	Orange Belle	2	S&G
O4	Orange Blocky	Nakita	5	SPS
		Total Orange	17.5	24.82%
C1	Green/Red Conical	35-66 RZ	0.5	Rijk Zwaan
C2	Green Conical	Sammy RZ	0.5	Rijk Zwaan
C3	Green/Red Hot conical	Yanka RZ	0.5	Rijk Zwaan
C4	Hot Jalapeno	Hotlips	0.5	S&G
		Total Other	2	2.84%
		Total rows	70.5	100%

RESULTS & DISCUSSION:

The financial results from this project are detailed in Table 2 and overall show a very unfavourable outcome. A negative gross margin of -$18,165 was recorded and after fixed costs are taken into account an overall loss of -$59,267 is the final result for this pilot commercial crop.

Table 2. Crop Budget (Excluding Project Management and R&D costs).

2,000m^2 Greenhouse		
Profit & Loss Statement for Pilot Commercial Capsicum Production 2000/01		
Saleable Yield	19,784.75kg	9.89kg/m^2
Sales	**$83,833**	**$41.91/m^2**
Average sales price	$4.23/kg	
Variable Costs	**Total**	**Per m^2**
Packaging – trays	$819	$0.40
Packaging – cartons	$3,389	$1.69
Freight – Sydney	$2,284	$1.14
Freight – Melbourne	$1,454	$0.72
Freight - Tasmania	$1,012	$0.50
Levies	$118	$0.05
Consultancy	$1,565	$0.78
Crop Consumables	$8,137	$4.06
CO_2	$3,302	$1.65
Freight	$98	$0.04
General Expenses	$1,351	$0.67
Insurance – Workers Comp	$2,825	$1.41
Nutrients	$4,719	$2.35
Fuel & oil – vehicle	$701	$0.35
Vehicle registration	$294	$0.14
Vehicle running costs	$248	$0.12
General expenses	$68	$0.03
Packaging	$4,844	$2.42
Pest & Disease	$810	$0.40
Plant Hire	$120	$0.06
Postage	$165	$0.08
Power	$21,812	$10.90
Repairs & Maintenance	$2,063	$1.03
Salary & Wages	$34,228	$17.11
Seedlings/Plants	$1,969	$0.98
Superannuation	$1,953	$0.97
Travelling – Accommodation	$675	$0.33
Waste Disposal	$975	$0.48
Total variable costs	$101,998	$50.99
Gross Margin	**-$18,165**	**-$9.08**
Fixed Costs	**Total**	**Per m^2**
Allocated overheads (greenhouse rent)	$20,000	$10.00
Land rent	$800	$0.40
Permanent Labour (Management Fee)	$20,004	$10.00
Stationery	$61	$0.03
Telephone	$237	$0.11
Total fixed costs	$41,102	$20.55
Net Loss (before interest and tax)	**-$59,267**	**-$29.63**

To fully understand the reasons behind this disappointing loss, detailed analysis of yields, pack outs, cost of production and market prices have been undertaken. Table 3 summarises the differences in budgets between the DPIWE model and this pilot commercial crop.

Table 3. Comparison of DPIWE Crop Model with Pilot Commercial Crop Outcome. (Excluding Project Management and R&D costs)

	DPIWE ($2,000m^2$)	Pilot Commercial ($2,000m^2$)	DPIWE	Pilot Commercial
Saleable Yield	48,000kg	19,784kg	$24.00kg/m^2$	$9.89kg/m^2$
Grade 1			73%*	38.5%
Grade 2			25%*	44.1%
Grade 3			2%*	17.4%
Total Sales	$197,750	$83,833	$98.88/m^2	$41.91/m^2
Average Price			$3.96/kg	$4.23/kg
Grade 1			$4.85/kg	$5.01/kg
Grade 2			$2.50/kg	$5.54/kg
Grade 3			$2.50/kg	$3.56/kg
Variable Costs	$142,172	$101,998	$71.09/m^2	$50.99/m^2
Heating Costs	$56,000	$21,812	$28.00/m^2	$10.90/m^2
Labour Costs	$39,208	$39,006	$19.60/m^2	$19.50/m^2
Gross Margin	$55,578	-$18,165	$27.79/m^2	-$9.08/m^2
Fixed Costs	$54,228	$41,102	$27.11/m^2	$20.55/m^2
Net Profit	$1,350	-$59,267	$0.67/m^2	-$29.63/m^2

*Proportion of total saleable yield, excluding waste.

The data clearly shows that the gross yield and yield per m^2 achieved in the pilot commercial crop were more than 50% below the expected yield in the DPIWE model. The Grade 1 pack out was also substantially lower in the pilot commercial crop than the DPIWE model, and conversely the Grade 2 and 3 pack outs were much higher in the pilot commercial crop than the DPIWE model. The significant reduction in yield achieved has also had a major negative impact on gross sales (Table 3).

The market price achieved per kg for all grades of fruit was higher in the pilot commercial crop than the DPIWE model (Table 3). This result is very encouraging and will facilitate a viable industry if the poor yield result can be corrected.

The variable costs were in the order of $20/m² lower in the pilot commercial crop and most of this can be attributed to the large saving in heating cost (Table 3). The cost of heating a large house was the variable from the previous work that was the least certain, and this result coupled with the market price improves the possibility of establishing a viable industry.

The labour costs were very similar in both budgets (Table 3), however due to the substantially lower yield in the pilot commercial crop, the cost of labour was expected to be lower since there was less fruit to harvest, grade and pack. The results suggest that either the DPIWE model underestimated labour costs, or that labour use may have been inefficient. The latter is consistent with observations made on site throughout the season, and could be corrected with an improved management strategy.

The yield and pack out results are detailed in Table 4 and show very poor results for both. Grade 1 pack out was only 38.46% whereas the proportion of Grade 2 and 3 was 44.12% and 17.42% respectively, which are both much higher than desirable.

Table 4. Summary of capsicum yield and pack out results.

	Grade 1		Grade 2		Grade 3		
	Yield (kgs)		Yield (kgs)		Yield (kgs)		Total (kgs)
November	1,845	47.35%	1,565	40.16%	486	12.49%	3,896
December	1,790	50.72%	1,345	38.11%	393.75	11.17%	3,528.75
January	1,475	37.66%	1,780	45.44%	661.5	16.9%	3,916.5
February	590	30.64%	975	50.64%	360	18.72%	1,925
March	810	30.09%	1,355	50.34%	526.5	19.57%	2,691.5
April	715	28.66%	1,095	43.90%	684	27.44%	2,494
May	385	28.88%	615	46.13%	333	24.99%	1,333
Season Total	**7,610**	**38.46%**	**8,730**	**44.12%**	**3,444.75**	**17.42%**	**19,784.75**

The Grade 1 pack out results are detailed in Table 5 and show that regardless of colour, production declined sharply in February and never recovered to the volumes achieved in November, December and January,

Table 5. Grade 1 capsicum pack out results by colour.

	Grade 1 (Interstate markets)			
	Red	Orange	Yellow	Sub-total
November				
Number Cartons (5kg)	159	41	169	369
Pack Out (kgs)	795	205	845	1,845
December				
Number Cartons (5kg)	131	76	151	358
Pack Out (kgs)	655	380	755	1,790
January				
Number Cartons (5kg)	124	36	135	295
Pack Out (kgs)	620	180	675	1,475
February				
Number Cartons (5kg)	44	17	57	118
Pack Out (kgs)	220	85	285	590
March				
Number Cartons (5kg)	71	26	65	162
Pack Out (kgs)	355	130	325	810
April				
Number Cartons (5kg)	59	23	61	143
Pack Out (kgs)	295	115	305	715
May				
Number Cartons (5kg)	24	29	24	77
Pack Out (kgs)	120	145	120	385
Total Number Cartons (5kg)	612	248	662	1,522
Total Pack Out (kgs)	3,060	1,240	3,310	7,610

The Grade 2 and 3 pack out results are detailed in Tables 6 and 7 respectively. Although the volume of these grades did decline in February it was not as severe as with the Grade 1. The results are consistent with observations made in the greenhouse where yield and quality overall declined in February and never fully recovered. The possible reasons for this are explored later in this report.

Table 6. Grade 2 capsicum pack out results by colour.

	Grade 2 (Tasmanian markets)					
	Red	Orange	Yellow	Green	Mixed	Sub-total
November						
Number Cartons (5kg)	141	74	60	34	4	313
Pack Out (kgs)	705	370	300	170	20	1,565
December						
Number Cartons (5kg)	109	75	56	29	0	269
Pack Out (kgs)	545	375	280	145	0	1,345
January						
Number Cartons (5kg)	184	69	103	0	0	356
Pack Out (kgs)	920	345	515	0	0	1,780
February						
Number Cartons (5kg)	77	31	87	0	0	195
Pack Out (kgs)	385	155	435	0	0	975
March						
Number Cartons (5kg)	133	42	96	0	0	271
Pack Out (kgs)	665	210	480	0	0	1,355
April						
Number Cartons (5kg)	94	39	86	0	0	219
Pack Out (kgs)	470	195	430	0	0	1,095
May						
Number Cartons (5kg)	56	30	37	0	0	123
Pack Out (kgs)	280	150	185	0	0	615
Total Number Cartons (5kg)	794	360	525	63	4	1,746
Total Pack Out (kgs)	3,970	1,800	2,625	315	20	8,730

Table 7. Grade 3 capsicum pack out results by colour.

	Grade 3 (Tasmanian markets)				
	Red	Orange	Yellow	Green	Sub-total
November					
Number Crates (9kg)	21	13.5	19.5	0	54
Pack Out (kgs)	189	121.5	175.5	0	486
December					
Number Crates (9kg)	11.25	16.25	15.75	0.5	43.75
Pack Out (kgs)	101.25	146.25	141.75	4.5	393.75
January					
Number Crates (9kg)	25	24	24.5	0	73.5
Pack Out (kgs)	225	216	220.5	0	661.5
February					
Number Crates (9kg)	12	12	16	0	40
Pack Out (kgs)	108	108	144	0	360
March					
Number Crates (9kg)	24.5	14	20	0	58.5
Pack Out (kgs)	220.5	126	180	0	526.5
April					
Number Crates (9kg)	34	18	24	0	76
Pack Out (kgs)	306	162	216	0	684
May					
Number Crates (9kg)	15	8.5	13.5	0	37
Pack Out (kgs)	135	76.5	121.5	0	333
Total Number Crates (9kg)	142.75	106.25	133.25	0.5	382.75
Total Pack Out (kgs)	1,284.75	956.25	1,199.25	4.5	3,444.75

The yield of each variety was measured throughout the season and while there was variation in performance between varieties even the best variety was still at least 10kg/m^2 below the yield expected in the DPIWE model. Table 8 details the yields achieved and shows the best red variety Spirit produced 13.74kg/m^2, the best yellow variety Concerto produced 14.51kg/m^2 and the best orange variety Lion produced 9.98kg/m^2. All of these yields are well below the target of 25kg/m2 set in the DPIWE model, which is the yield being achieved in New Zealand and Holland.

The poor performance of some varieties (Table 8) contributed to the overall poor yield result, however variety selection alone cannot account for the disappointing gross yield as even the best variety only produced 14.51kg/m^2, which was still well below the target of 25kg/m^2.

Table 8. Yield data for the individual capsicum varieties.

Colour & Type	**Variety**	**Supplier**	**Yield per row***	**Yield per m^2**	**Yield per plant***
Red Blocky	Raptor	S&G	332.2 kg	11.71 kg	4.74 kg
Red Blocky	Rocky	S&G	343.7 kg	12.11 kg	4.91 kg
Red Blocky	Mazurka	Rijk Zwaan	358.2 kg	12.62 kg	5.11 kg
Red Blocky	Mandy	Rijk Zwaan	353.5 kg	12.46 kg	5.05 kg
Red Blocky	Danza	Rijk Zwaan	375.9 kg	13.25 kg	5.37 kg
Red Blocky	Maratos F1	Enza Zaden	380.7 kg	13.41 kg	5.43 kg
Red Blocky	Maite F1	Enza Zaden	346.8 kg	12.22 kg	4.95 kg
Red Blocky	Spirit F1	Enza Zaden	389.8 kg	13.74 kg	5.56 kg
Red Blocky	Spirit	SPS	368.1 kg	12.97 kg	5.25 kg
Red Blocky	FA867	LeFroy	254.2 kg	8.96 kg	3.63 kg
Red Blocky	FA866	LeFroy	249.9 kg	8.80 kg	3.57 kg
Yellow Blocky	Fiesta	Enza Zaden	398.8 kg	14.05 kg	5.69 kg
Yellow Blocky	Sunset	Enza Zaden	368.9 kg	13.00 kg	5.27 kg
Yellow Blocky	Inca	S&G	156.6 kg	5.52 kg	2.23 kg
Yellow Blocky	Romeca RZ	Rijk Zwaan	373.0 kg	13.14 kg	5.32 kg
Yellow Blocky	Concerto	SPS	411.7 kg	14.51 kg	5.88 kg
Yellow Blocky	FA2001	LeFroy	252.1 kg	8.88 kg	3.60 kg
Yellow Blocky	FA959	LeFroy	311.2 kg	10.96 kg	4.44 kg
Yellow Blocky	FA490	LeFroy	294.6 kg	10.38 kg	4.20 kg
Orange Blocky	Nassau	Rijk Zwaan	239.2 kg	8.43 kg	3.41 kg
Orange Blocky	Lion	Enza Zaden	283.2 kg	9.98 kg	4.04 kg
Orange Blocky	Orange Belle	S&G	244.7 kg	8.62 kg	3.49 kg
Orange Blocky	Nakita	SPS	272.6 kg	9.60 kg	3.89 kg
Green/Red Conical	35-66 RZ	Rijk Zwaan	247.0 kg	8.70 kg	3.52 kg
Green Conical	Sammy RZ	Rijk Zwaan	343.3 kg	12.10 kg	4.90 kg
Green/Red Hot conical	Yanka RZ	Rijk Zwaan	234.6 kg	8.26 kg	3.35 kg
Hot Jalapeno	Hotlips	S&G	217.1 kg	7.65 kg	3.10 kg

*Each row was 30m long and averaged 70 plants.

The density used in the pilot commercial crop was 2.5 plants/m^2 (this is averaged across the entire greenhouse so incorporates unproductive areas such as pathways). If this was increased to the recommended density of 3.5 plants/m^2 and only the two best red and yellow varieties were planted in equal quantities, then the expected yield would be 17.76kg/m^2 instead of the average achieved of 9.89kg/m^2 (calculated by multiplying the average yield per plant achieved of the 4 varieties by 3.5 plants/m^2 and then subtracting 10% to allow for unproductive areas such as pathways). This simple calculation demonstrates the significant impact that density and variety selection can have on total yield. Analysis of environmental factors and management strategies are detailed later in this report and data indicates that management is also likely to have had a significant impact on both yield and quality.

Due to strong early growth and market concern over low prices for green fruit, no green fruit was harvested from the first two flowers set as recommended in the DPIWE manual. Instead the first harvest was of fully coloured fruit. The first harvest commenced on 31st October 2000, which was at least one month ahead of schedule. The DPIWE production manual guide recommends removing the first two flower buds and then harvest the first two picks as green fruit. This pilot demonstration has deviated from that guide by removing only one flower bud and then commencing with colour harvest. This was only possible due to the very strong early growth of the capsicum plants and accounts for the colour yield commencing ahead of schedule. Although the earlier colour harvest was encouraging, it may have reduced subsequent yields and pack outs by placing the relatively small plants under additional stress. Rapid early growth can lead to problems later in the crop and can also reduce the life of the crop, as the capsicum plant would reach the top of the greenhouse too early. To slow the rapid growth, the nutrient EC was increased from 2.0 to 2.5 in gradual steps. After only a few weeks the EC was returned to 2.0 as the plants showed signs of minor nutrient deprivation.

At the time of the last harvest the crop was still growing well and had plenty of new fruit forming, however rising heating costs resulted in the cost of production rapidly becoming greater than the revenue from sales. Tables 9, 10 and 11 summarise sales for each colour by market and grade. Grade 1 or export quality fruit was all sold interstate to wholesalers in Melbourne and Sydney.

Table 9. Summary of Grade 1 capsicum gross sales.

	Grade 1 (Interstate sales)			
	Red	Orange	Yellow	Sub-total
November				
Sales (kgs)	695	220	1,065	1,980
Price ($/kg)	$5.18	$5.53	$5.52	$5.40
December				
Sales (kgs)	480	185	325	990
Price ($/kg)	$5.18	$5.11	$5.41	$5.24
January				
Sales (kgs)	505	395	840	1,740
Price ($/kg)	$3.71	$4.52	$3.59	$3.83
February				
Sales (kgs)	305	105	355	765
Price ($/kg)	$4.00	$4.42	$4.91	$4.47
March				
Sales (kgs)	360	145	440	945
Price ($/kg)	$6.83	$4.75	$5.80	$6.03
April				
Sales (kgs)	300	100	310	710
Price ($/kg)	$6.47	$4.60	$5.57	$5.81
May				
Sales (kgs)	0	0	0	0
Price ($/kg)	-	-	-	-
Total Sales (kgs)	2,645	1,150	3,335	7,130
Average Price ($/kg)	$5.13	$4.83	$4.99	$5.01

The drop in Grade 1 prices in January and February (Table 9) reflects competition in the market from field grown capsicums, which at that time of year were of very high quality. Field grown capsicums could be a threat in the future especially if greenhouse grown capsicums are of sub optimal quality. Therefore the key to manage the risk of price competition is to focus greenhouse production on producing the absolute highest quality possible. This was not achieved in the pilot commercial crop evidenced by the poor Grade 1 pack out results (Table 4).

Grade 2 and 3 fruit was all sold in Tasmania to local retail outlets. Despite a supermarket's initial interest in supporting the project, the supermarket chain was not prepared to pay a premium for the greenhouse grown red capsicums above field grown red capsicums as they thought the quality was similar, and were only prepared to offer prices in the order of $2.50 per kilogram. For yellow and orange capsicums the supermarket offered prices in the order of $5.50 per kilogram, however the volume required by the supermarket chain in Tasmania is very small and this pilot commercial crop alone would have exceeded their requirements. As can be seen in Table 9, the price interstate at the wholesale markets was considerably higher than the supermarket price for red capsicums of $2.50 per kilogram. The prices achieved in this project exceeded the price used for all grades of product in the DPIWE model budget, which is a very important result as it vindicates the market price used in the model, and confirms the market potential exists for greenhouse capsicums.

Table 10. Summary of Grade 2 capsicum gross sales.

	Grade 2 (Tasmanian sales)				
	Red	Orange	Yellow	Mixed	Sub-total
November					
Sales (kgs)	0	0	0	0	0
Price ($/kg)	-	-	-	-	-
December					
Sales (kgs)	25	15	55	0	95
Price ($/kg)	$5.60	$6.00	$5.82	-	$5.79
January					
Sales (kgs)	0	0	0	0	0
Price ($/kg)	-	-	-	-	-
February					
Sales (kgs)	0	0	0	0	0
Price ($/kg)	-	-	-	-	-
March					
Sales (kgs)	0	0	0	0	0
Price ($/kg)	-	-	-	-	-
April					
Sales (kgs)	15	20	45	0	80
Price ($/kg)	$6.00	$6.00	$6.00	-	$6.00
May					
Sales (kgs)	30	0	0	240	270
Price ($/kg)	$6.00	-	-	$5.25	$5.33
Total Sales (kgs)	70	35	100	240	445
Average Price ($/kg)	$5.85	$6.00	$5.90	$5.25	$5.54

Table 11. Summary of Grade 3 capsicum gross sales.

	Grade 3 (Tasmanian sales)						
	Red	Orange	Yellow	Green	Mixed	Seconds	Sub-total
November							
Sales (kgs)	-	-	-	-	2,228	-	2,228
Price ($/kg)	-	-	-	-	$3.09	-	$3.09
December							
Sales (kgs)	35	40	30	0	1,630	145	1,880
Price ($/kg)	$3.75	$3.75	$3.75	-	$3.62	$2.75	$3.56
January							
Sales (kgs)	100	20	70	0	1,800	280	2,270
Price ($/kg)	$4.50	$4.50	$4.50	-	$4.07	$2.63	$3.92
February							
Sales (kgs)	245	105	325	0	610	135	1,420
Price ($/kg)	$3.75	$4.00	$3.90	-	$3.77	$2.74	$3.71
March							
Sales (kgs)	535	205	475	0	330	190	1,735
Price ($/kg)	$3.75	$3.75	$3.75	-	$3.86	$2.87	$3.67
April							
Sales (kgs)	575	235	475	10	20	243	1,558
Price ($/kg)	$3.75	$3.75	$3.75	$3.00	$3.75	$2.64	$3.57
May							
Sales (kgs)	305	135	205	250	0	75	970
Price ($/kg)	$3.75	$3.75	$3.75	$2.52	-	$3.00	$3.37
Total Sales (kgs)	1,795	740	1,580	260	6,618	1,068	12,061
Average Price ($/kg)	$3.79	$3.80	$3.81	$2.53	$3.59	$2.73	$3.56

The use of 3 grades has successfully optimised market returns and the different pricing levels highlight the value of marketing product selectively. Although the prices for Grade 2 fruit sold in Tasmania were often very high, the volume that the market would actually take was very small. This situation has highlighted that any industry expansion would need to concentrate on interstate markets due to the very small volume demand in Tasmania, and so the interstate prices should be used for any future budgeting.

Significant changes have occurred in the Japanese market place over recent years, which have resulted in greenhouse capsicums changing from being a high priced niche product to a commodity product. This change has occurred largely due to the influence of Korean production and to a lesser extent by increases in freight costs. Korea has increased winter production dramatically and has over supplied the Japanese market during the same supply window as Tasmania's production season. This has seen the price fall away in recent years as detailed in Table 12. At these prices and allowing for the additional $3 per kilogram for airfreight, it is not viable to send product to Japan. Previous work conducted by Field Fresh Tasmania has verified the supply chain to Japan and established that suitable varieties are being grown and that they can be successfully transported to Japan and arrive in acceptable condition. The impact of Korean production has led to some of the New Zealand production being sent to Australia where in previous years all New Zealand production was sent to Japan. It is reported that Korean production has been heavily subsidised by their government, and given the much lower freight costs, it is unlikely that Tasmanian production would be competitive. For this situation to change there would need to be a substantial change in Korean production, which is unlikely in the short term given that the investment in infrastructure, technology and skill has already been made.

Table 12. Greenhouse capsicum prices at the Tokyo wholesale market.

Year	Price per 5kg carton	AUS$ Equivalent	AUS $/kg
1998	¥3,550	$50.70	$10.14
1999	¥2,415	$34.50	$6.9
2000	¥2,350	$33.50	$6.7
2001	¥2,100	$31.50	$6.3

A review of the greenhouse environmental parameters logged (Appendix 1) revealed that air temperatures and nutrient temperatures had not deviated markedly from the parameters set. Humidity and leaf wetness, however, had repeatedly been outside the desired range. Unfortunately, problems with humidity control and leaf wetness were not corrected and for the entire duration of the crop humidity fluctuated beyond desirable limits. Fluctuations in humidity are reported to increase the incidence of disorders such as blossom end rot, fruit cracking and Botrytis disease, all of which have been problematic for the crop. Attempts were made to correct the humidity levels in the greenhouse but efforts were unsuccessful.

The nutrient solution pH was maintained at 5.8 throughout the season. The EC level has also been maintained within the target range but has been manipulated to match growing conditions. Analysis of leaf tissues throughout the project reveals that most nutrients were maintained at very consistent levels (Appendix 2). The only disorder of any significance was the presence of blossom end rot. This is a highly complex disorder commonly associated with calcium deficiency. Testing indicated that sufficient calcium was being supplied in the nutrient solution and that the leaves had a high level of calcium (Appendix 2). However, the availability or mobility of calcium to the developing fruit may have been limited in some way, resulting in the symptoms of blossom end rot. It has been concluded that the large fluctuations in humidity (Appendix 1) are likely to be the primary cause for the severity of blossom end rot. A change in the Boron formulation and subsequent levels of Boron in the plants (Appendix 2) may have contributed to the reduction in severity of this disorder.

It is likely that the fluctuations in humidity contributed to the overall lower yield and also to the very low recovery of Grade 1 fruit. It is well documented that if the humidity is either too low or too high capsicum plant physiology is disrupted and both growth and fruit carrying capacity can be severely restricted. The quality faults present in the Grade 2 and 3 fruit were consistent with problems associated with humidity fluctuations and included blossom end rot, fruit cracking and Botrytis and Sclerotinia disease.

A physical deformity of fruit known as 'button' fruit occurred throughout the season. This is common in some varieties in New Zealand and is evident as very flat or button shaped fruit. In New Zealand it is recommended to remove these fruit as early as possible as they would need to be discarded during normal grading procedures. The general production philosophy is to only keep fruit on the plants that are likely to mature to Grade 1 standard. All other fruit should be removed as early as possible so as not to over burden plants with lower grade fruit.

In early October several plants began to wilt. At first the symptoms seemed typical of a root rot pathogen, such as Pythium, but closer examination of the stem bases revealed the presence of small insect larvae. The DPIWE were able to rapidly identify the insects as being larvae of the fungus gnat. Fungus gnats are common in nursery crops and can devastate capsicum crops early in the season. Kevin Harford outlined the New Zealand control measures and identified a class of chemicals that are anticholinesterase compounds and are very effective in controlling fungus gnats. The New Zealand product Vydate is registered in Australia but not for use on capsicums. However another anticholinesterase compound, Diazinon, was identified that is registered for use on capsicums in Australia. The product was applied and capsicums sampled several days later and sent to AGAL for testing. The results revealed no detectable residue from the fungus gnat treatment or any other residues. The fungus gnat remained present for the rest of the crop but only in very low numbers and no further plant damage occurred.

Other insect problems encountered included aphids, thrips and white fly. Whilst the aphids were easily controlled, the thrips required an intensive spray program and the white fly was never eradicated. Several weeks after the insect infestations had established themselves in the house and were still not controlled, the pathogen tomato spotted wilt virus was detected. The virus epidemic spread for some time unchecked and resulted in up to 10% of the orange plants being culled to remove the virus inoculum source from the greenhouse. The epidemic was successfully halted by a combination of infected plant eradication, insect control and site clean up to remove both inoculum sources and insect vectors. Glen Graham, General Manager Field Fresh Tasmania, is acknowledged for his particular vigilance on site clean up and vector eradication. Without this input the crop would have certainly been lost to either the virus or the insects. A fogger was the main equipment used to apply the insecticides and while the fogger is very convenient to use, this pilot commercial crop clearly demonstrated that it is not always the most effective means of applying a spray. Spot spraying with a knap sack sprayer is strongly recommended when disorders are first detected, and the every plant should be checked at least twice per week.

Throughout the season there were substantial difficulties with the management of the greenhouse, especially with humidity and insect control. Before the project commenced, a project team was established that agreed upon the parameters for production. During the cropping season it became evident that not all parameters and actions agreed by the project team were being implemented, the most serious of these being the control of humidity in the greenhouse. After several discussions and regular project meetings, staff at Field Fresh Tasmania took action in an attempt to correct the situation. Although a system was installed to attempt to regulate the humidity, the humidity control was not improved. The system included a combination of humidification units and changes to the temperature settings and venting regimes. Previous work by the DPIWE, who encountered the same problems, showed that changing the venting temperatures and installation of humidification devices corrected humidity fluctuations resulting in improved yields and pack outs.

Despite this situation, all of the key objectives have still been addressed in this project, namely verifying the heating cost, labour cost, yield and market price, although yield has almost certainly been compromised by problems with humidity and insect control. This situation has also caused considerable budget overruns on project management owing to the extra time needed from Field Fresh Tasmania staff to try and correct the situation in order to extract the best possible result from the project. Every effort was made by Field Fresh Tasmania staff to ensure the crop was managed in accordance with the DPIWE manual, however not all possible world's best practice production techniques were actually implemented, which accounts for the disappointing yields achieved.

Overall, the pilot commercial crop has addressed the four issues raised from the previous project VG97064, namely yield, market price, cost of labour and cost of heating. Assuming some critical management strategies are followed and market prices do not drop, a viable greenhouse capsicum industry is achievable. To this end, at least one commercial crop of capsicums is being grown in Tasmania this season as a direct result of this project.

RECOMMENDATIONS:

The following budget (Table 13) is proposed based on the findings from this pilot commercial crop and the findings from the DPIWE model.

Table 13. Future Crop Budget Guide*.

2,000m^2 Greenhouse				
Profit & Loss Statement				
Gross Yield			50,000kg	25kg/m^2
Pack out & Sales			Total	
Grade 1 (Interstate)	80%	$5.00/kg	$200,000	
Grade 2 (Tasmania)	15%	$3.50/kg	$26,250	
Grade 3 (Tasmania)	0%	$0.00/kg	$0	
Waste (nil value)	5%	$0.00/kg	$0	
		Average: $4.76/kg		
Total Income			**$226,250**	**$113.12**
Variable Costs			**Total**	**Per m^2**
Packaging – cartons			$14,000	$7.00
Freight – Sydney			$5,000	$2.50
Freight – Melbourne			$3,000	$1.50
Freight - Tasmania			$2,500	$1.25
Levies			$250	$0.12
Consultancy			$1,500	$0.75
Crop Consumables			$3,000	$1.50
CO_2			$8,000	$4.00
Nutrients			$6,000	$3.00
Vehicle running costs			$2,000	$1.00
Pest & Disease			$1,500	$0.75
Power			$30,000	$15.00
Repairs & Maintenance			$2,000	$1.00
Salary & Wages			$45,000	$22.50
Seedlings/Plants			$2,800	$1.40
Waste Disposal			$1,500	$0.75
Total variable costs			$128,050	$64.02
Gross Margin			**$98,200**	**$49.10**
Fixed Costs			**Total**	**Per m^2**
Allocated overheads (excluding interest)			$15,000	$7.50
Unallocated overheads			$5,000	$2.50
Permanent Labour (Management Fee)			$30,000	$15.00
Total fixed costs			$50,000	$25.00
Net Loss (before interest and tax)			**$48,200**	**$24.10**

*It is important to be aware that the budget presented here is only an indication of the possible returns. It cannot be guaranteed that the returns shown will be achieved.

Note that the cost of heating and labour has been increased above the actual costs incurred in the pilot commercial crop. This is to allow for extra heat to better control humidity at night and sufficient labour to process the added yield. The yield used in this budget is based on the yield in the DPIWE model, which is consistent with yields achieved in New Zealand and Holland.

To achieve this yield it is recommended that the following parameters be implemented:

- Night temperature range 19-21°C
- Day temperature range 22-28°C
- Nutrient solution temperature range 19-24°C
- Humidity range 75-85%
- Leaf wetness range 0-10
- EC range 2.0-2.5
- PH range 5.5-5.8
- 3.5 plants per m^2
- 2 stems per plant, 7 per m^2
- Fruit storage temp, 8-12oC

These parameters are far more than just a guide, and Growers not absolutely committed to wanting to grow the crop according to world's best practices are advised not to attempt greenhouse capsicum production. There is absolutely no room for corner cutting or "pet theories". It is strongly recommended to learn from previous mistakes, including the one's made during this pilot commercial project, and use the guides prepared by the DPIWE to minimise the risk of an unfavourable result.

In particular, parameters that need changing from the pilot commercial crop are improved humidity and insect control, and an increase in plant density, which can largely be achieved by increasing the number of rows in the house and reducing the size of the central pathway and other unproductive areas.

The permanent labour, or management fee, has also been increased above that actually incurred in the pilot crop. The permanent labour is critical to the financial success of the venture and must be a hands-on contributing role as the venture is far too small to carry the expense of a manager who is not a full time contributing member of the labour force needed. A dedicated manager is neither needed nor affordable for this scale of operation. Harvesting once per week should be considered to achieve labour efficiencies as considerable amounts of time are spent walking up and down rows. Harvesting twice per week results in significant inefficiencies but the frequency of harvest would need to be balanced against crop load and market requirements.

Attention to detail to focus on producing the highest possible quality fruit is an essential philosophy to achieve success. If this is not the plan then greenhouse capsicums should not be attempted, as the quality of field grown capsicums will too easily rival sub standard greenhouse grown capsicums and the resulting prices will be too low for the operation to remain viable.

A final note of caution is to remind potential Growers to consider very carefully the opportunity for placing increased volumes of product in markets that will achieve sustainable prices. Small volumes and high spot prices or niche market opportunities can sometimes create an impression of large returns, but industry expansion must consider realistic returns for increased volumes of product and must identify markets that can accommodate the increased production. Markets with the opportunity to take larger volumes of product and achieve consistent pricing will be needed to truly develop a sustainable greenhouse capsicum industry with minimal risk. Quality will ultimately be critical to achieving a viable sustainable industry, and Growers not absolutely committed to producing the highest possible quality product are advised not to attempt greenhouse capsicum production.

TRAVEL REPORT:

Prepared by Sam Graham after travelling to New Zealand in March 2001 to view New Zealand greenhouse capsicum production.

Report on visit to New Zealand to examine commercial green house production for techniques that may be applicable to Tasmanian production.

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Field Fresh Tasmania
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EXECUTIVE SUMMARY

This report sums up observations made during visits to commercial greenhouse operators on New Zealand's South Island. Attention was concentrated on production methodology as there a no commercial growers of capsicums in Tasmania. The objective of the visit was to gain information that may be integrated into our current production system, and to check that our current practices are on track.

Several basic production techniques were observed that could be implemented in our production system and include:

- Spacing & Training of plants
- Nutrient levels (K/N ratio) & their effect on fruit quality
- Pruning techniques
- Saw dust flooring
- Labour inputs
- Variety selection
- Beneficial insects & IPM
- Spray and disease control

ENVIRONMENTAL CONTROL

Optimum Nutrient levels:

- Nitrogen (ammonium) 4.5 – 6 %
- Phosphorous 0.4 – 0.7 %
- Potassium 4 – 6 %
- Calcium 1.5 – 3 %
- Sulphur 0.45 – 0.75 %
- Magnesium 0.45 – 0.9 %
- Iron 50 – 200 mg/kg
- Zinc 40-80 mg/kg
- Boron 40 – 70 mg/kg
- Copper 5 –15 mg/kg
- Manganese 100 –2500 mg/kg

pH: is maintained between 5.5 & 6.0 depending on variety

EC: Electro conductivity expressed as millisemens/cm^2. EC measures the total strength of a nutrient solution. The higher the mineral concentration the lower the resistance to the passage of an electric current. CF = conductivity factor units 700 ppm = 10 CF units = 1 millisemens/cm^2. Capsicum's EC levels are approximately 2, above 2.5 & BER may become a problem.

Humidity: generally only vent for high humidity above 85%

Temperature: air temperature 25°C - 30°C root zone temperature 20°C - 25°C

Co_2: was not generally used in the sites that were visited, although is greatly beneficial. The growers that we visited tended to concentrate on nutrient levels & other critical operational factors before the investment of additional equipment (Co_2 & misting).

Ozone: Oxygen subjected to high voltage at very low amps, it combines with bacteria and odours in the air or water rendering them harmless. Ozone purifies air & water, it can give added life to fresh fruit and vegetables, reduces pollen, mould, viruses, bacteria & air pollution.

Surfaces & Insulation: metal surfaces in contact with plastic are insulated by white plastic material that reduces the temperature variation between the outside environment and internal conditions.

Misting Systems: One site visited (tomatoes) used a misting system in their largest house, misting is attributed to lowering temperatures by 6°C –7°C and increasing humidity by up to 20%

Spacing & Training: Capsicum density was higher in New Zealand green houses both the inter row spacing & the plant spacing were increased, this aids in environmental conditions more conducive to capsicum plant growth. More plants tightly packed together helps to regulate humidity and sunscald through increased leaf area and transpiration.
The plants observed (both capsicum & tomato were not twisted to the same extent as seen on the pilot commercial operation. Single main stems were observed at one capsicum operation (no two leaders only a single main stem). Tomato plant spacing is varied depending on winter or summer crop, 1.8m for winter tomatoes and 2.2m spacing for summer crops to ensure room for optimum growth.

Shade cloth: shade cloth was not used at any of the visited sites, but the idea was accepted as a possible solution to reduce sunscald, and increase humidity to an extent.

Variety: Red capsicum varieties grown in sawdust were called *Special* and *Spirit*. Red variety grown in NFT was called *Tiffany*, orange was called *Emily* & grown in winter. *Nairobi* was grown through the summer months. *Moneto* is susceptible to botrytis and a hard to grow orange variety. Cracking and scaring is less of a problem in the orange varieties

PESTS & DISEASE
(Alex Smith NZ horticultural Advisory Service 03 3324945)

IPM – Biological controls: white fly is controlled with IPM techniques (*Encarcia*). New Zealand growers use a "koppet" card with wasp lava ready to hatch and attack aphids.
Fungus gnats have a predator called the *Hypoasisi* mite.
The green peach aphid is resistant to some insecticides.

Thrips spread the spotted wilt diseases and must be controlled and infected plants removed as an incubation period of 3 week takes place between infection and visible symptoms. (Control populations of insects and you control the infected plants).

Sprays: Thripx – predator – chews on thrips (*Amblyseius cucumeris*). 1 application only to control thrips regardless of population numbers. Dimalin 25W (diflubenzuron) controls fungus gnats, scarab flies and is used predominantly by mushroom growers applied as a spray.

Pyrimor and Chess are used to combat & control white fly populations; Sunlight liquid soap in small concentrations is also used to treat small-scale white fly infestations. Scomrid an aerosol spray is used after de-leafing tomatoes for botrytis control.
Melaphyrine is used for fungus gnats, hydro clear is also used in small concentrations with water in circulating systems to stop algae growth and thus reduce the food source for the gnats.

TECHNIQUES TO OPTIMISE PERFORMANCE
Prevention and attention to detail is absolute, it is much easier to control things before they start, rather than trying to control something that is out of control i.e. disease out breaks, pruning, and cleaning up sources of infection. Stop problems before they start! If this is done you don't have to have the most high tech and sophisticated house in the world to follow simple management techniques to maintain healthy and productive plants.

Labour cost and people management: the average number of people required to operate commercial crops full time seemed to be approximately 1 person per 1000m2, with additional labour hired as casuals as required (clean ups, setting up new crops etc).

Some growers are moving away from the traditional NFT system in favour of soil-less mediums such as sawdust and non-return systems. This is largely due to problems associated with excessive moisture around the root area of the plant, which favours the development of fungus gnats and algal build-ups.

The heat from concrete surfaces causes leaf curl, deformation and discoloration. Concrete surfaces should be avoided in favour of white weed mat layer over saw dust (which increases Co_2, day time humidity and reduces night time humidity as a source for moisture intake. Weed mat and saw dust floors control humidity at both day and night and also has an increasing effect on Co_2

Only 1 variety of tomatoes was grown in the green house crop that was visited
Only grow Mondeo and 1 half row of cocktail tomatoes, bumblebees are imported and used to increase pollination.

Nutrient tanks are kept on the full side, which allows more even nutrient dose, combined with ozone in the capsicums.

Drop CF to combat low humidity / vent for high humidity only.
K/N ratio tends to keep BER at controllable levels and they will grow out of it, as more leaf area is produced and greater transpiration over the entire crop. K/N ratio of 2 means potassium in ppms is double the nitrogen in ppm. A nutrient level of 200 ppm nitrogen & 300 ppm potassium gives a K/N ratio 300/200 = 1.5. A nutrient solution with a K/N ratio of

1 has a lot more nitrogen in proportion to one with a K/N ratio of 1.5. Levels lower than 1.5 = grow formula, levels above 1.5 = bloom formula.

Plants tend to require a lower conductivity level during hot growing conditions, as water requirements are much higher, therefore most plants will tolerate a slightly higher conductivity level (EC level) during colder conditions as their water requirements are less. Capsicums can have a pH as high as 6.0 – 6.5 & a CF of 18 –22 (total nutrient strength 1260 – 1540 ppm).

NAMES & PHONE NUMBERS OF GROWERS VISITED
All growers were based around the Christchurch / Canterbury Plains area of New Zealand on the South Island.

Chris Sinnott, Harbourhead Growers, 1394 Main Road, Waikuku: **Capsicum (non-recycling / saw dust crop)**

Ivan Kippenberger, 65 Walter Road Christchurch: **Capsicum NFT system**

Alex Smith NZ horticultural Advisory Service 03 3324945

Kevin Petrie, 83 Oxford Road, Rangiora: **Tomato NFT system**

RECOMMENDED REFERENCES:

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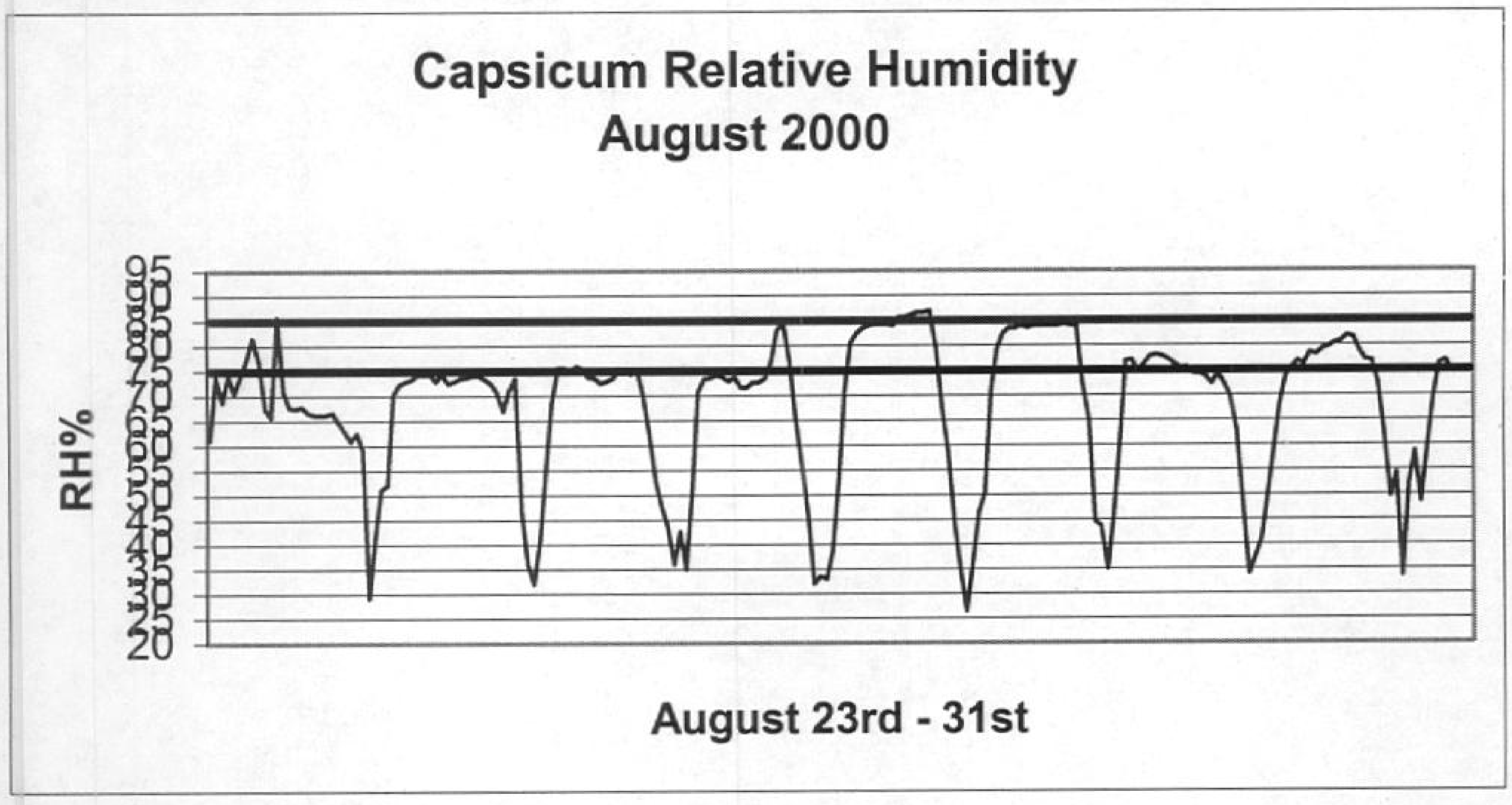
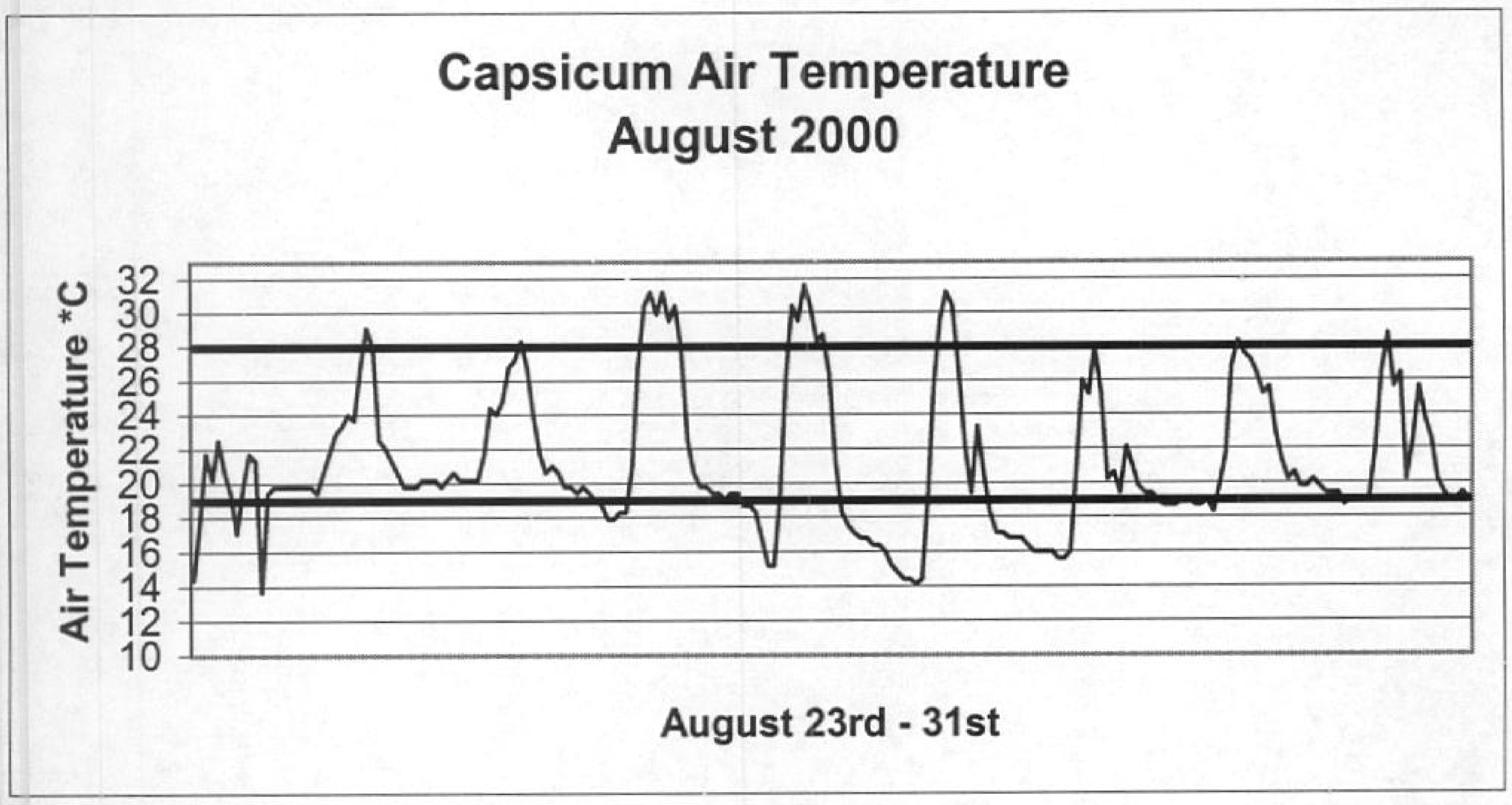
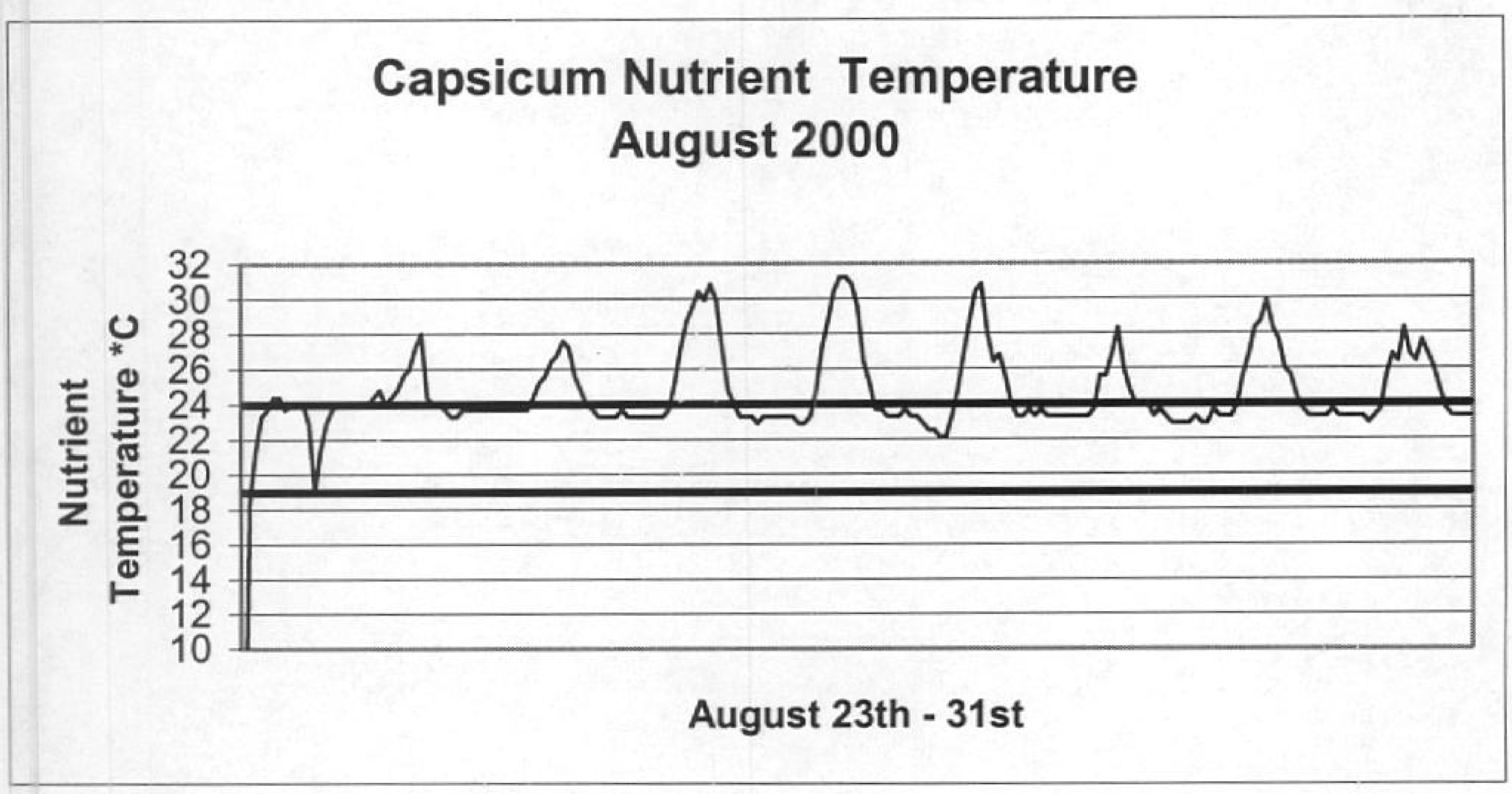
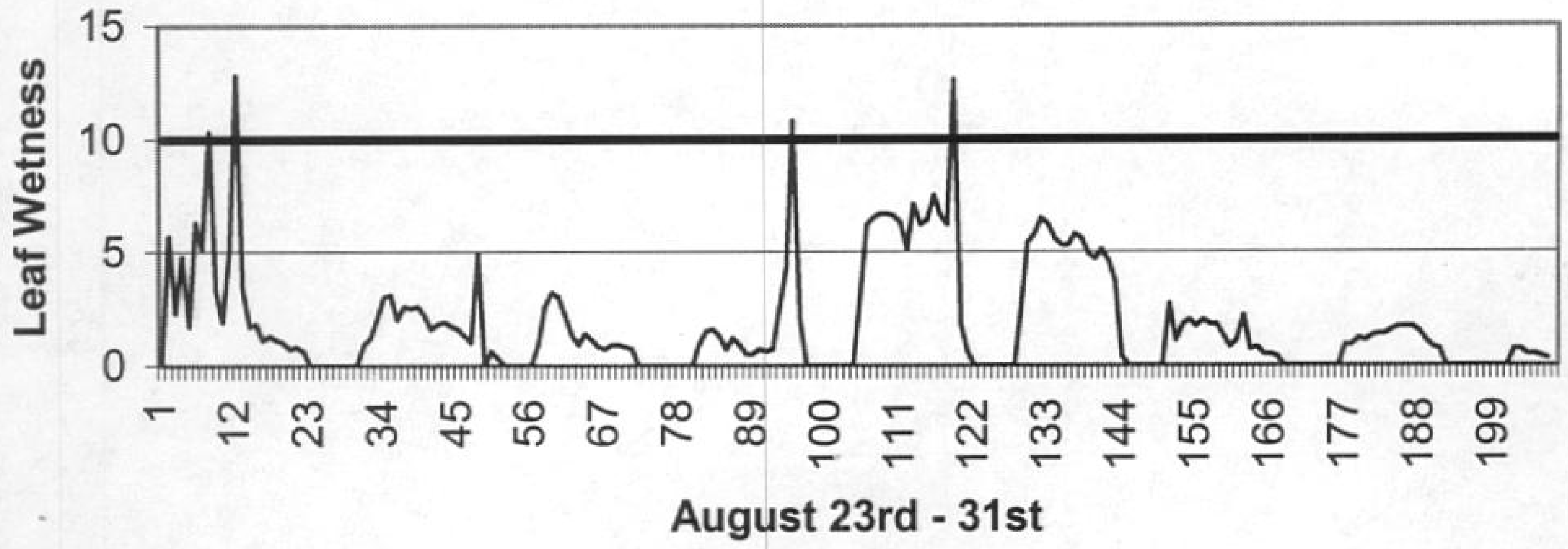
APPENDIX 1. GREENHOUSE ENVIRONMENT CONDITIONS



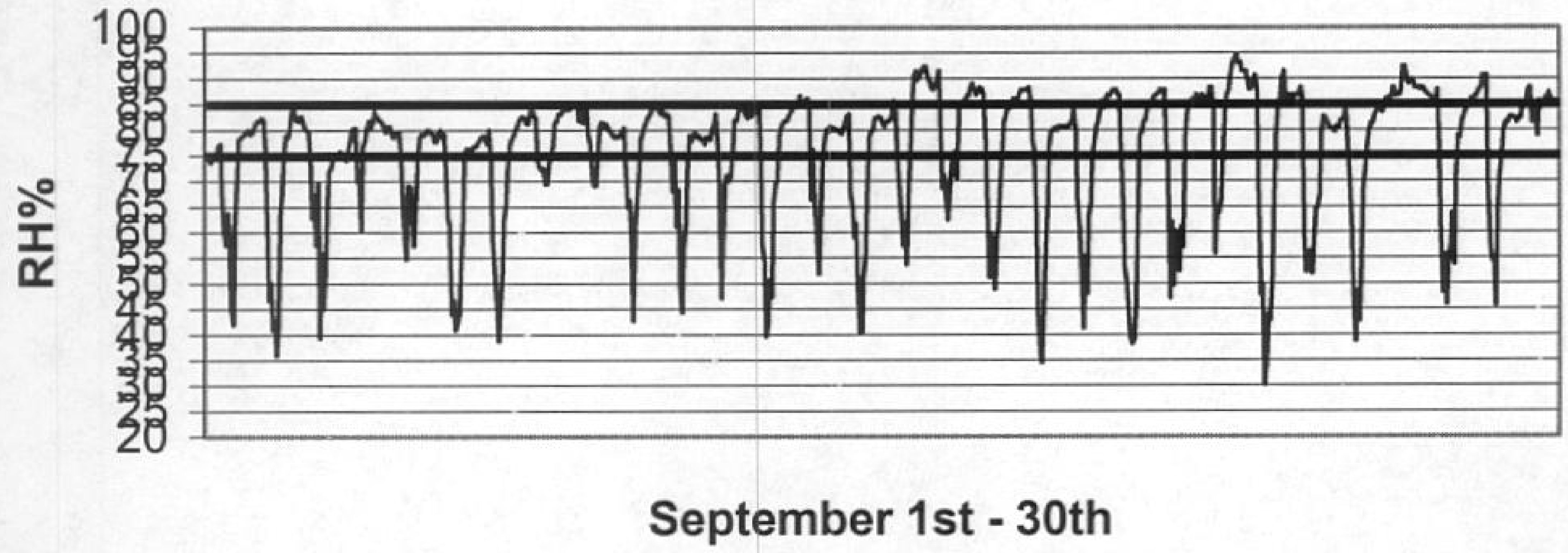




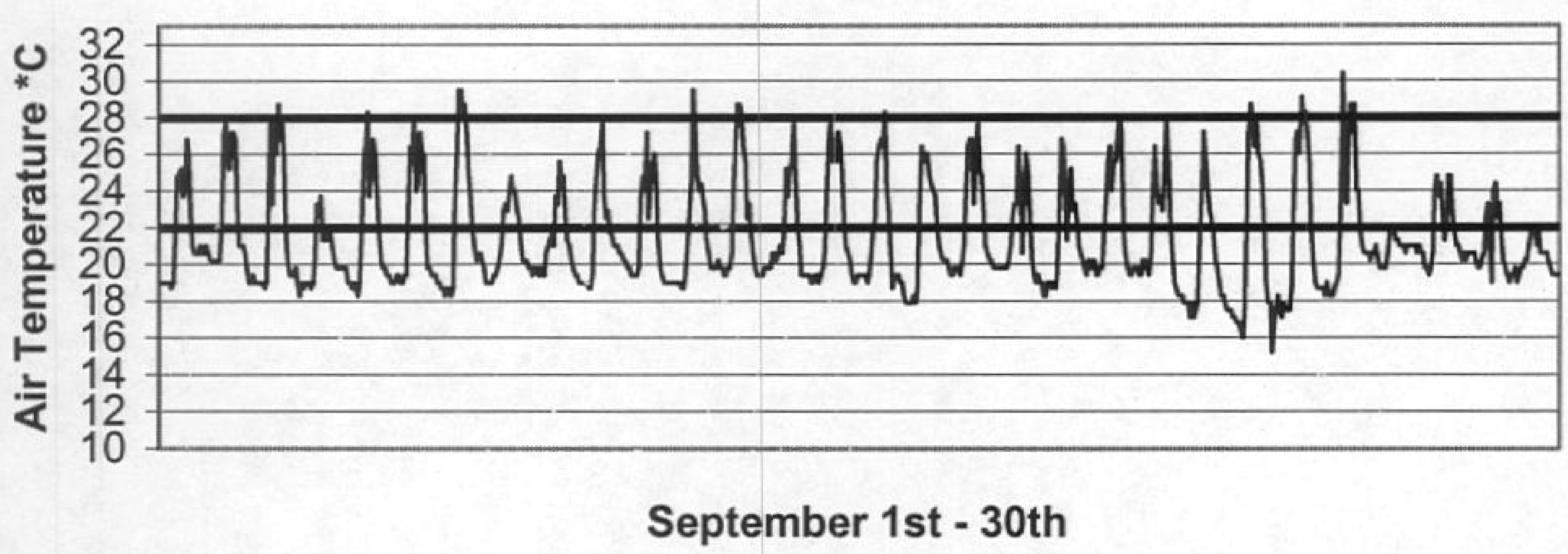
Capsicum Leaf Wetness
August 2000

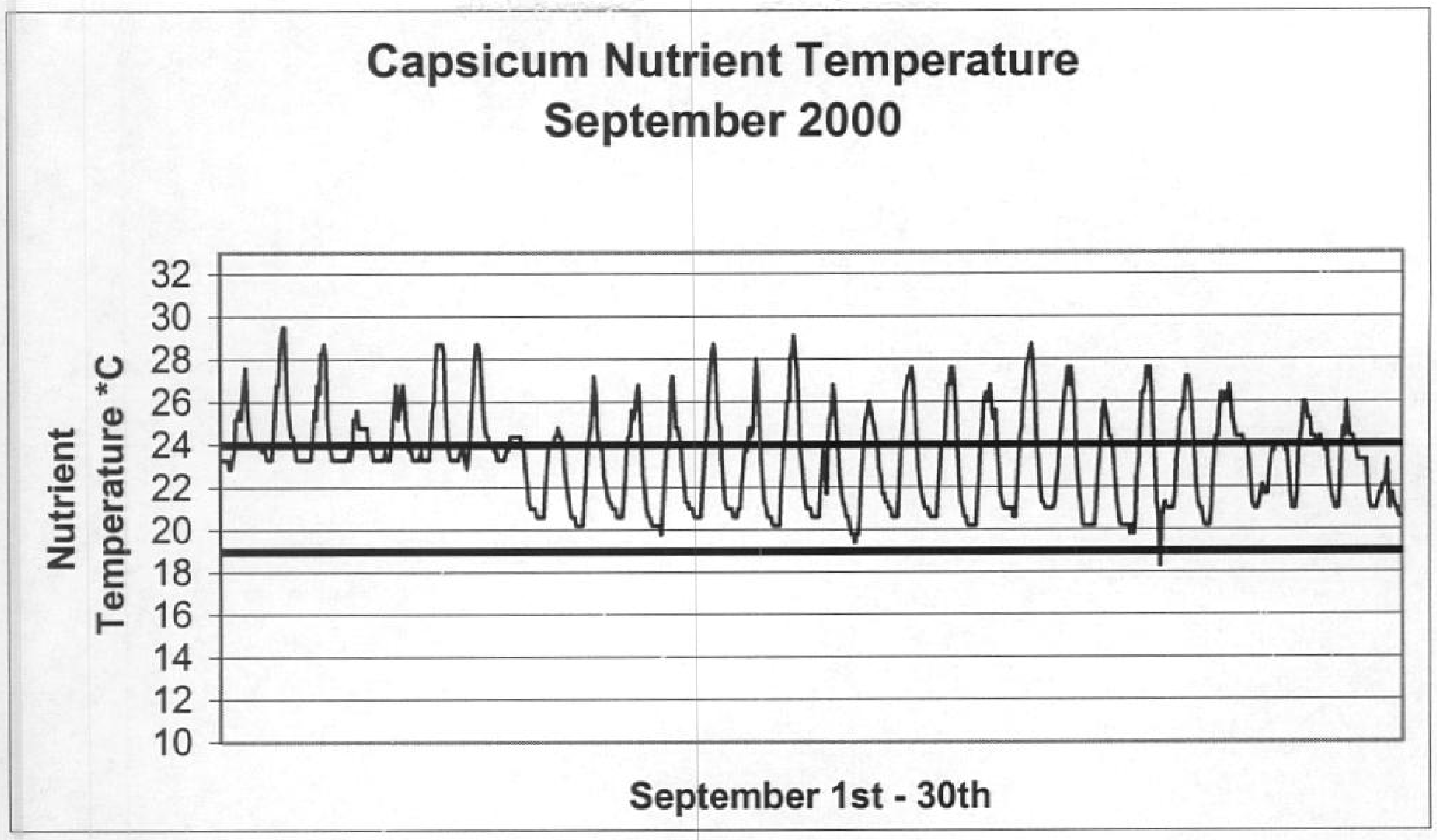


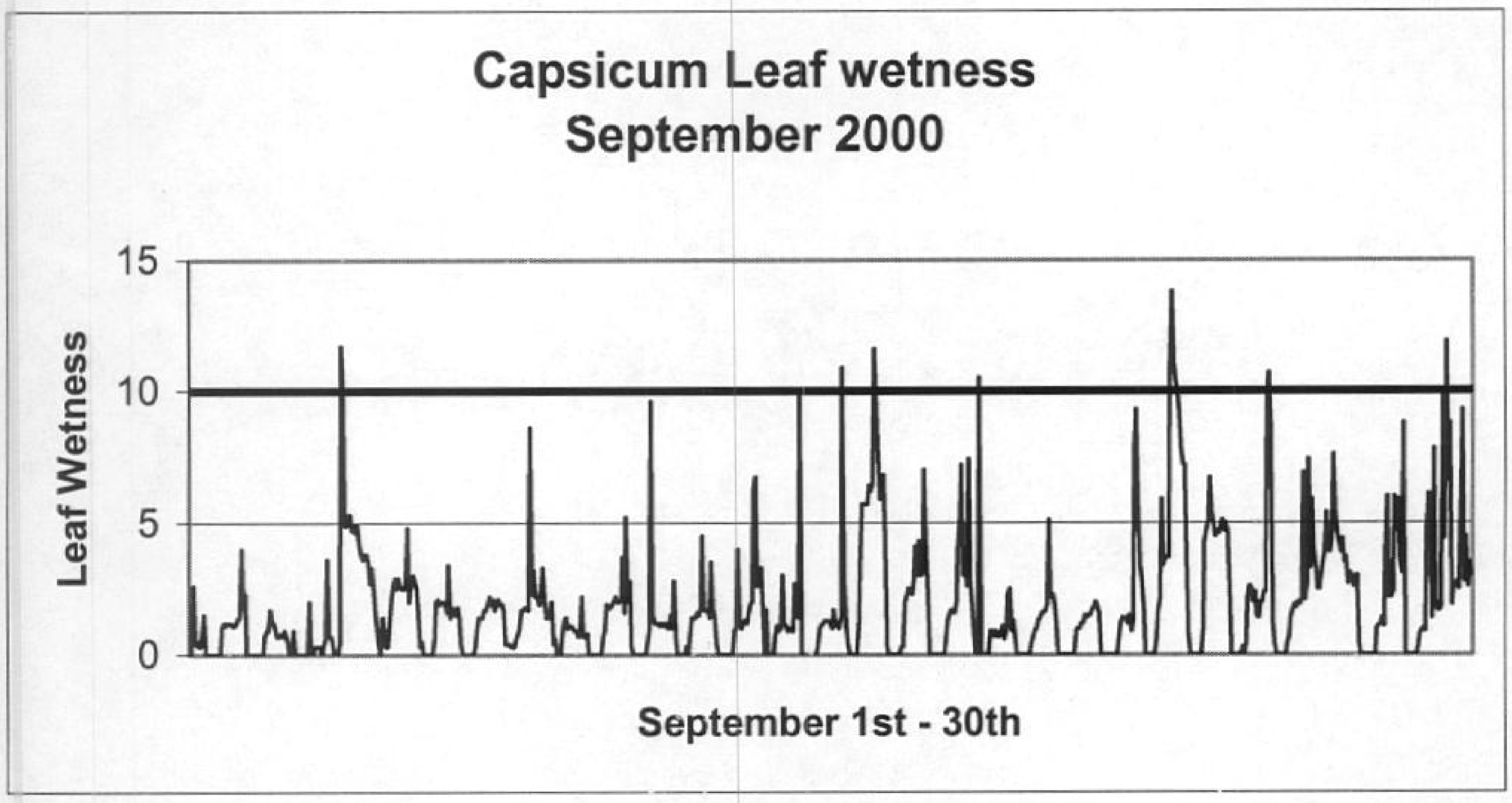
Capsicum Relative Humidity
September 2000

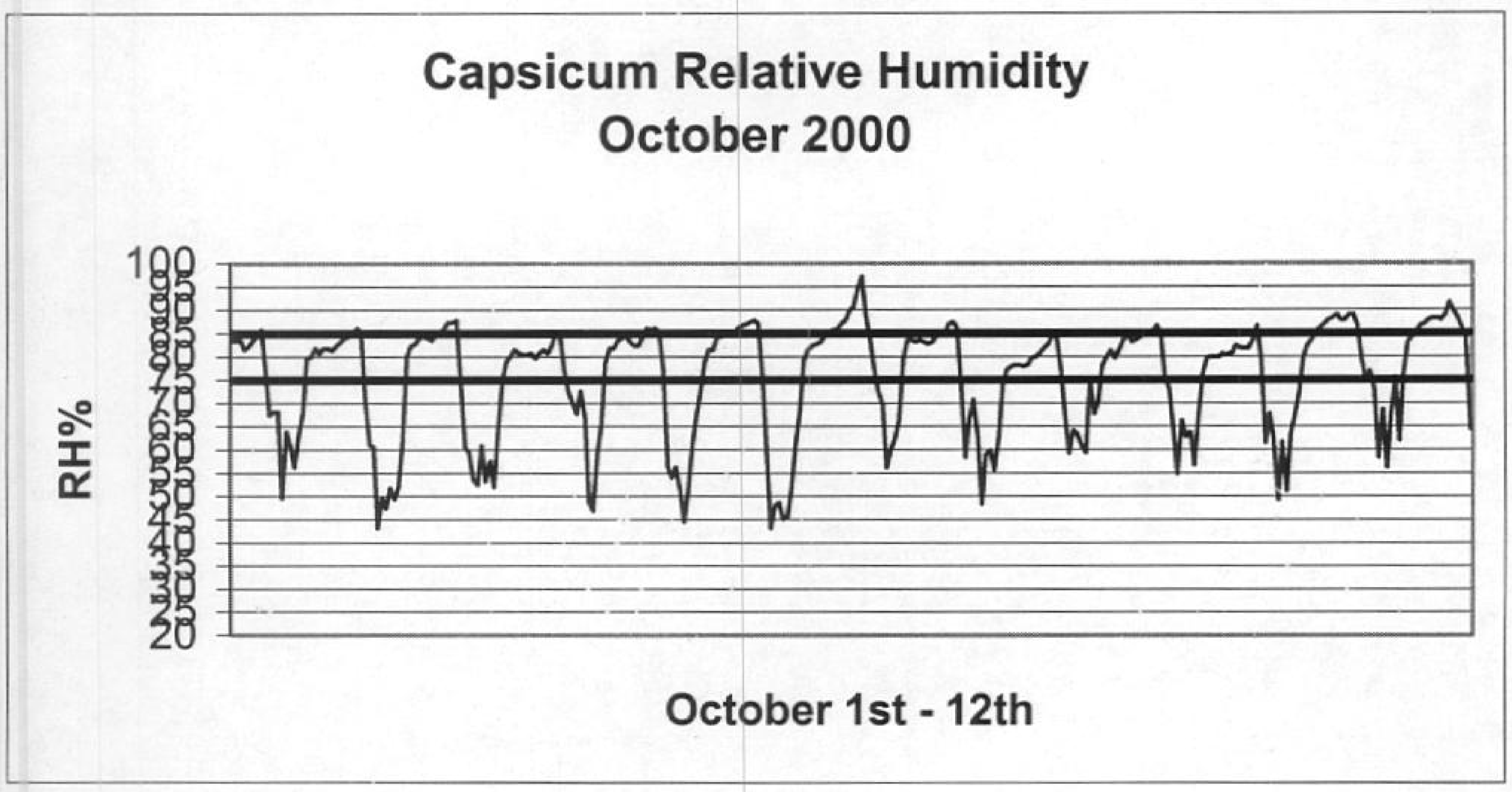


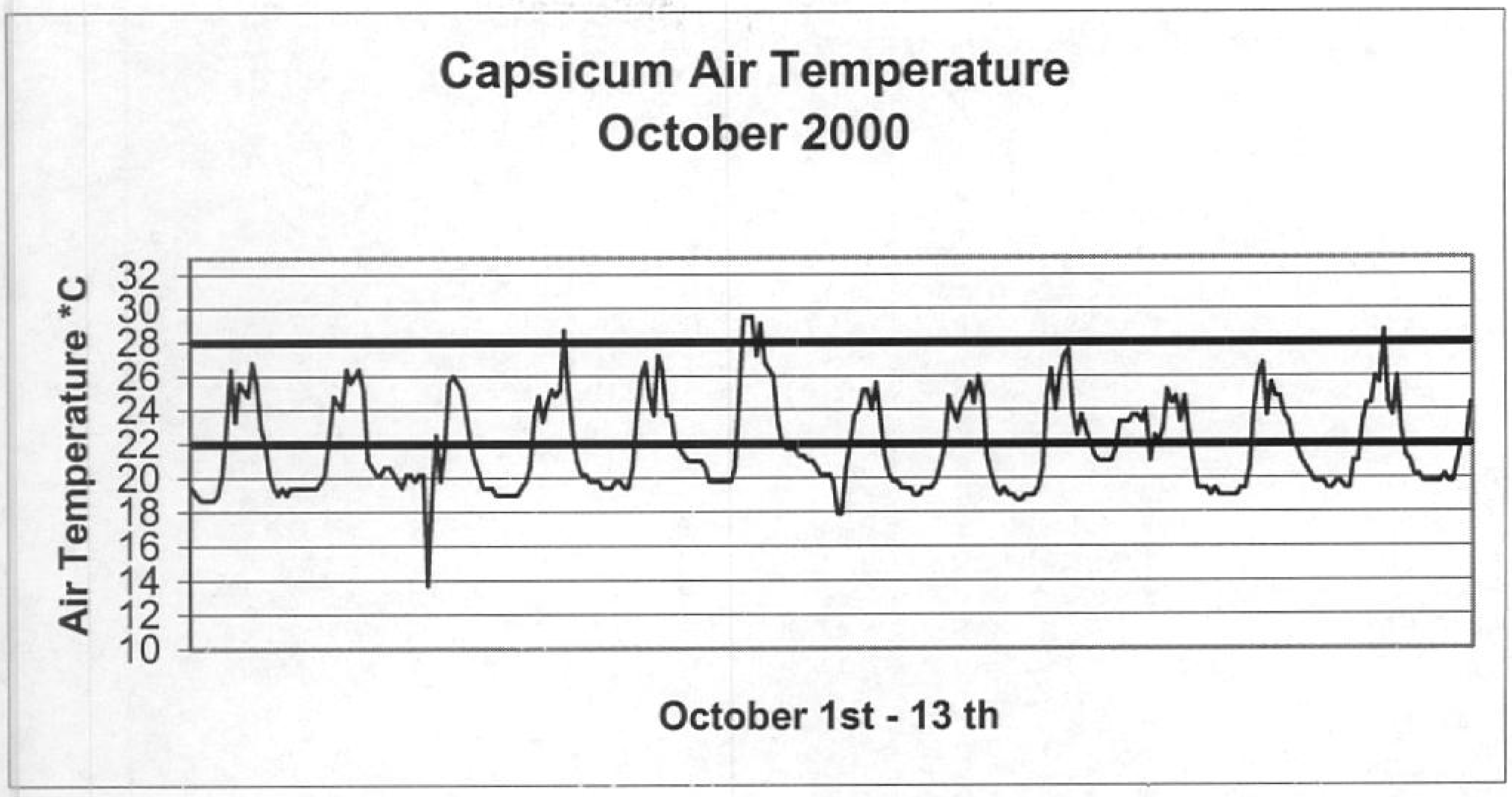
Capsicum Air Temperature
September 2000

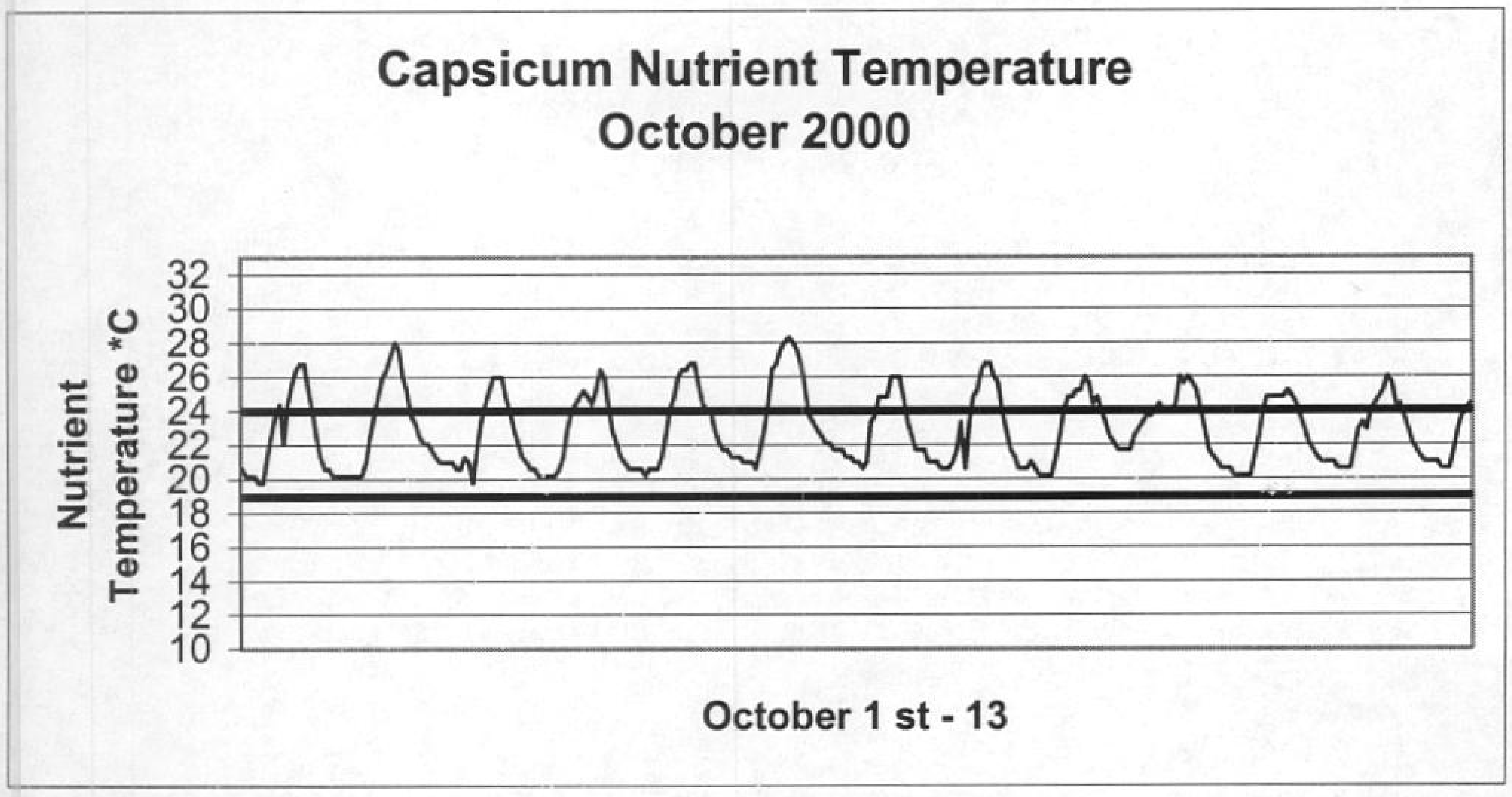


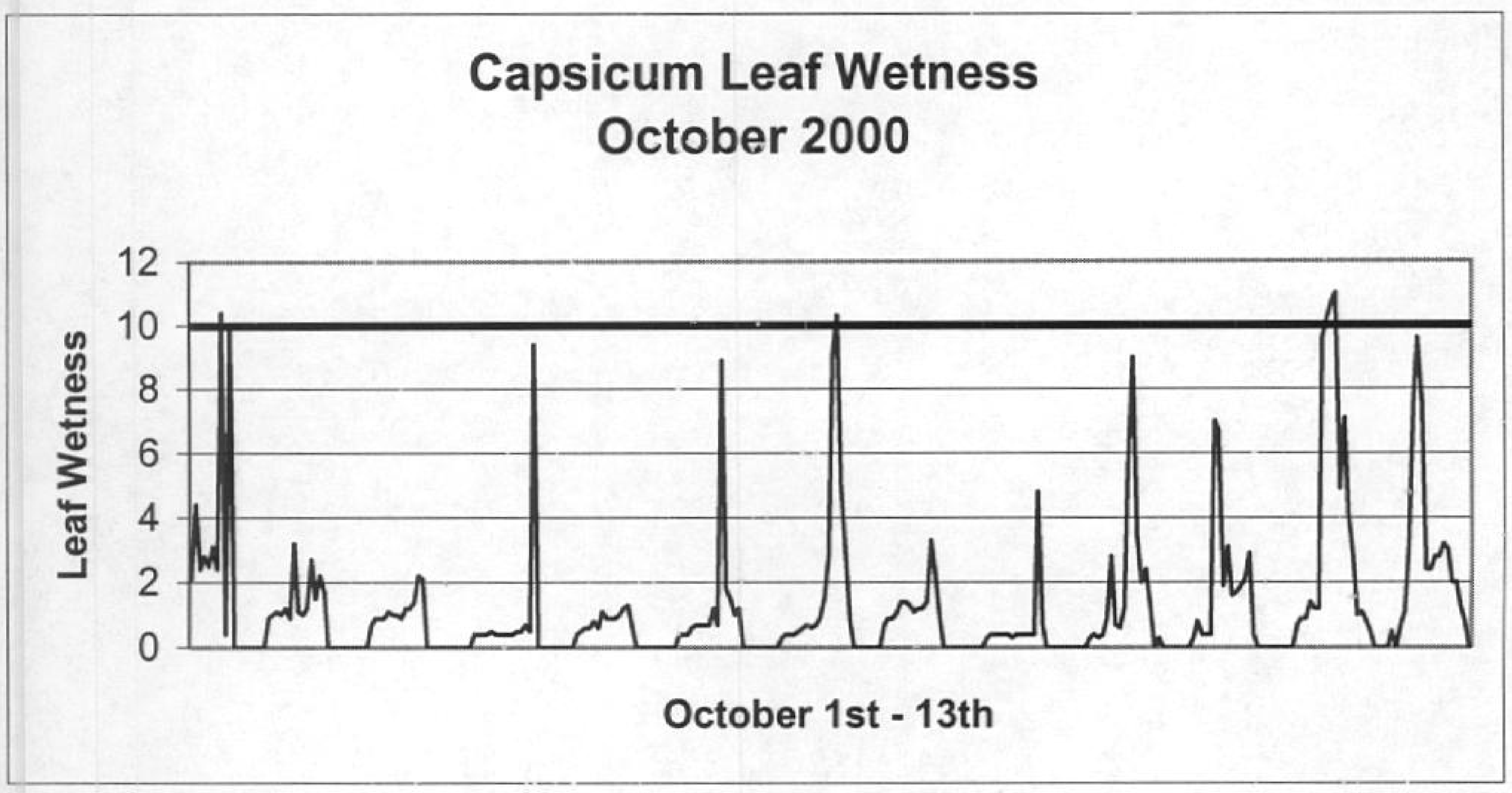

Capsicum Nutrient Temperature
September 2000
Nutrient Temperature *C
32
30
28
26
24
22
20
18
16
14
12
10
September 1st - 30th

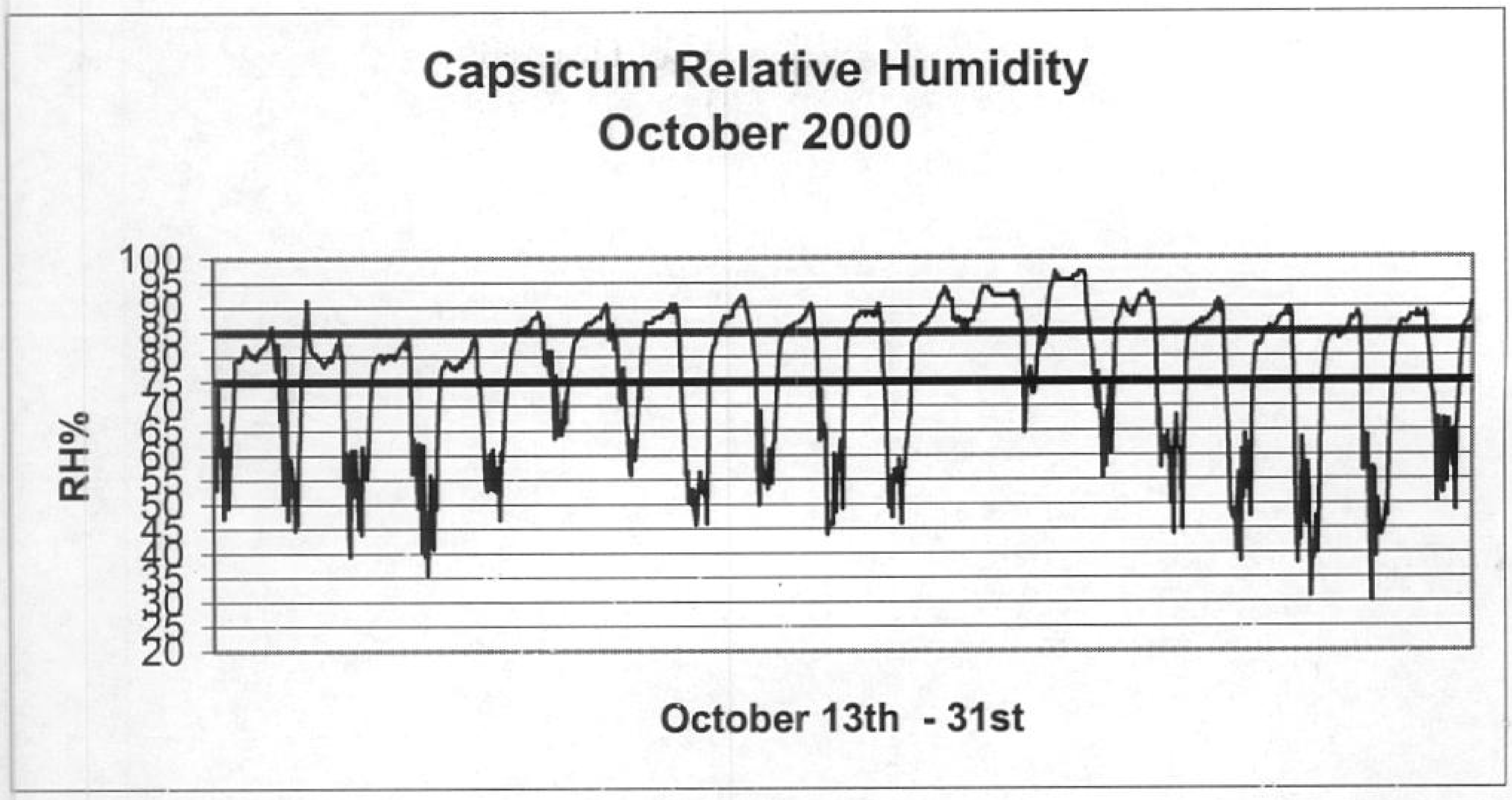

Capsicum Leaf wetness
September 2000
Leaf Wetness
15
10
5
0
September 1st - 30th

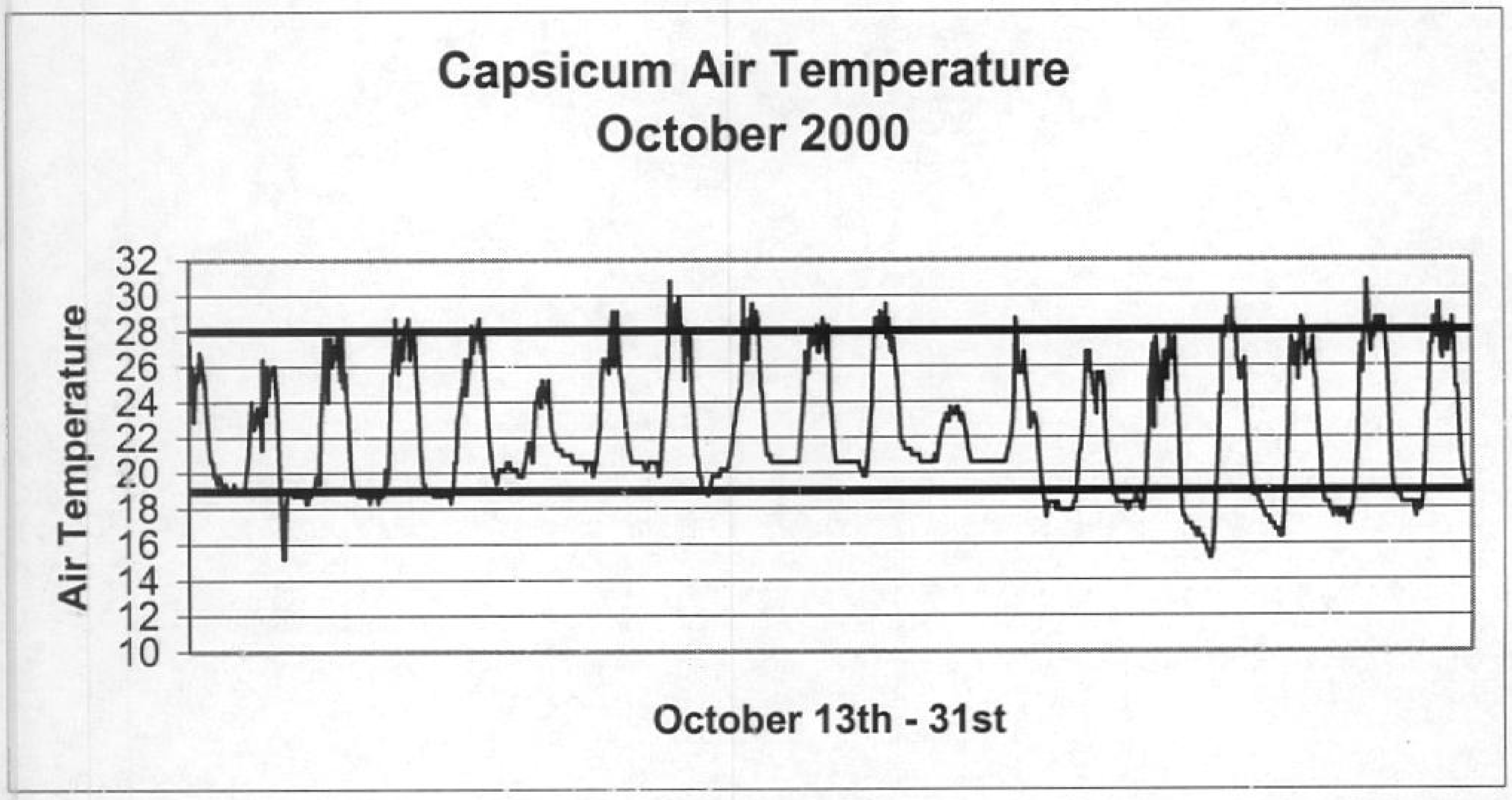

Capsicum Relative Humidity
October 2000
RH%
100
20
October 1st - 12th

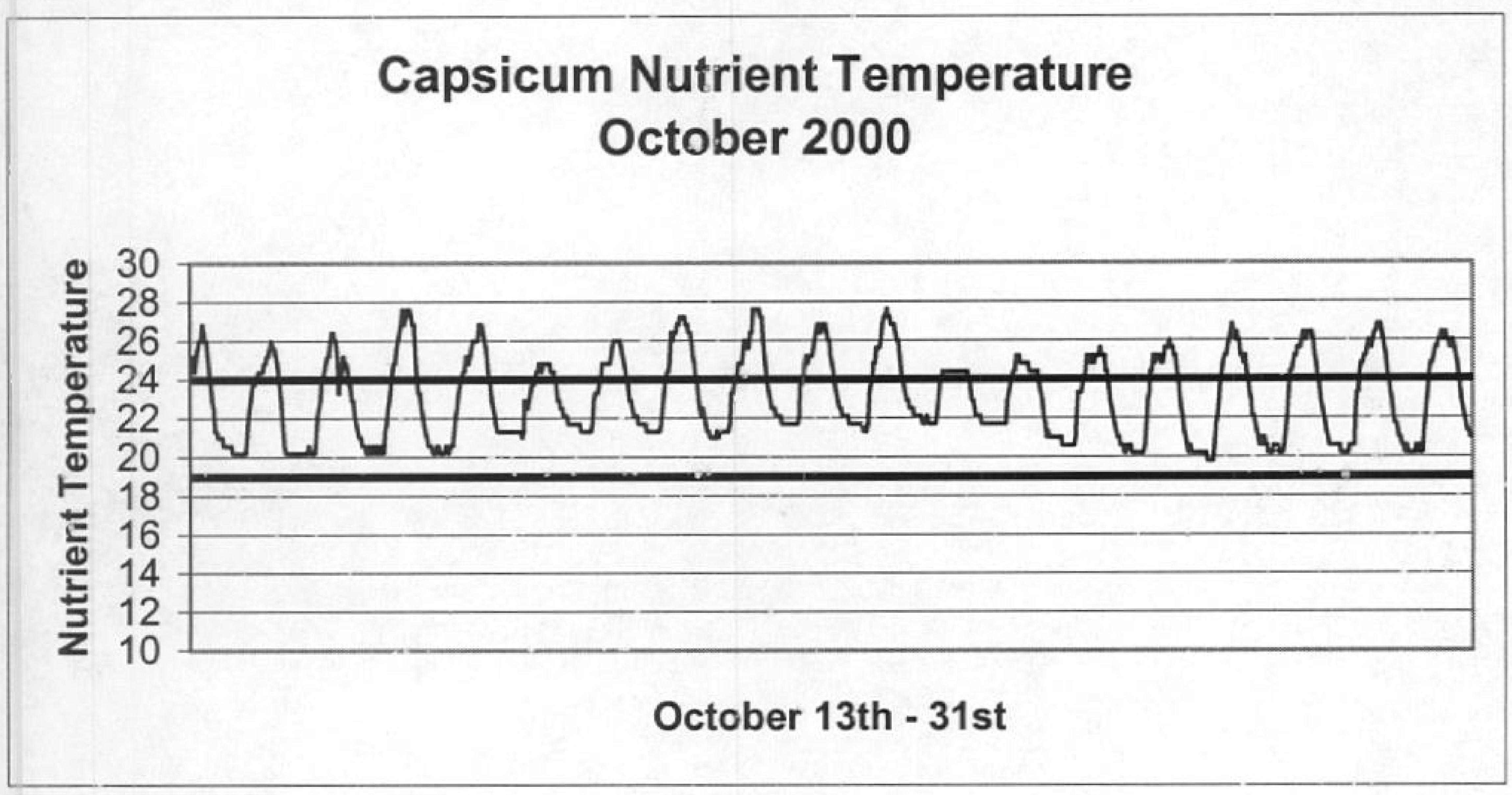

Capsicum Air Temperature
October 2000
Air Temperature *C
32
30
28
26
24
22
20
18
16
14
12
10
October 1st - 13 th

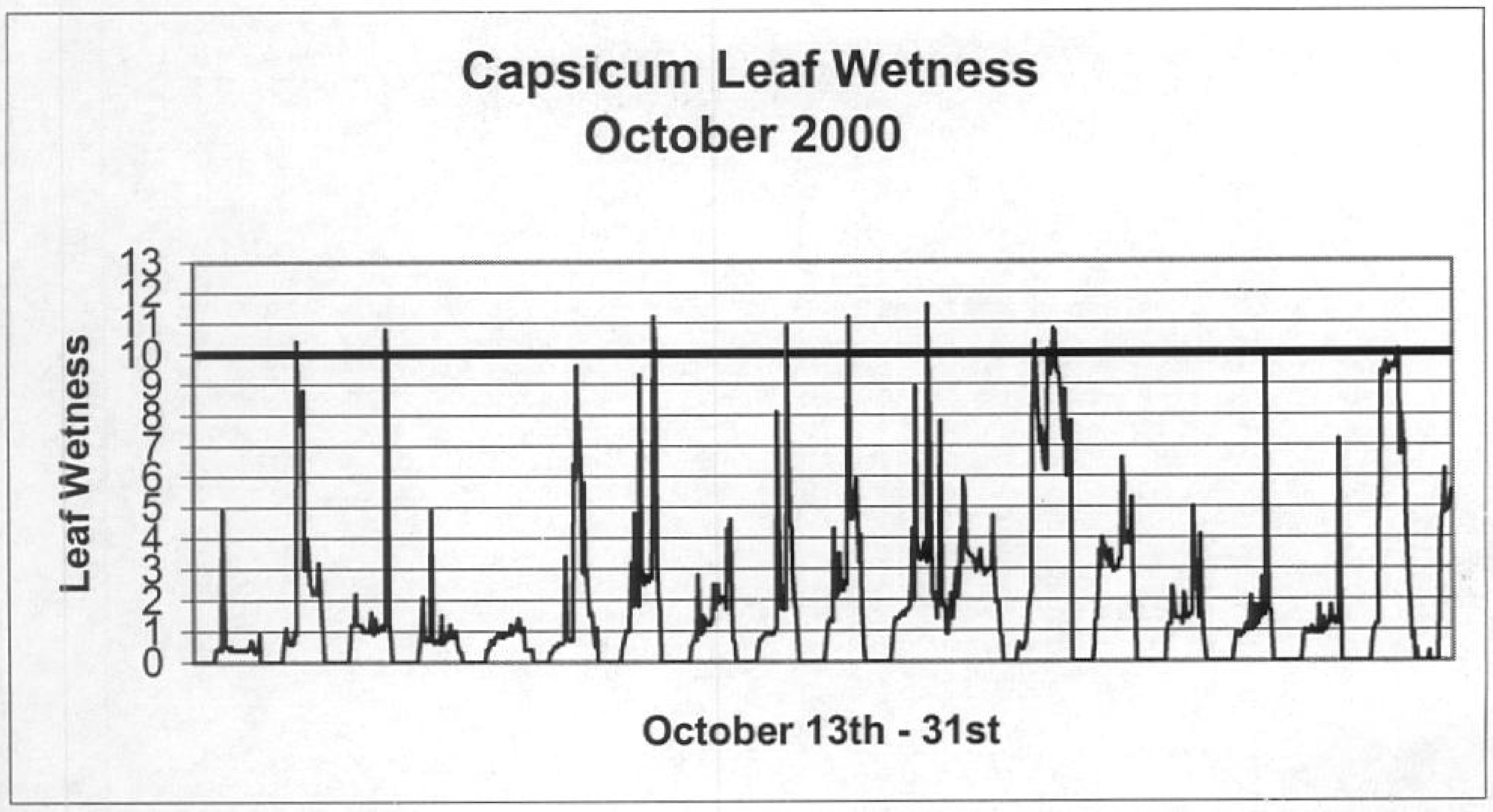

Capsicum Nutrient Temperature
October 2000
Nutrient Temperature *C
32
30
28
26
24
22
20
18
16
14
12
10
October 1 st - 13

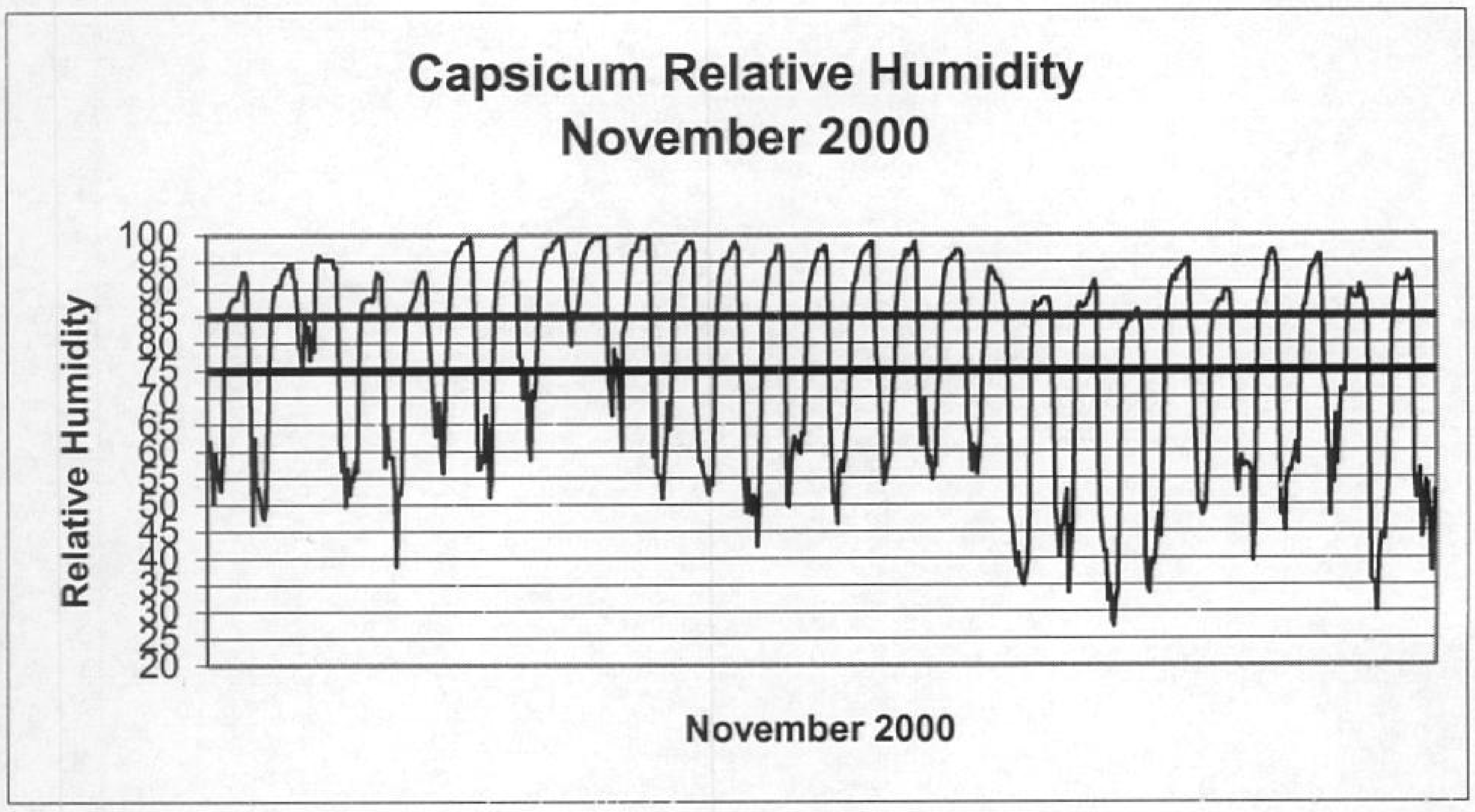

Capsicum Leaf Wetness
October 2000
Leaf Wetness
12
10
8
6
4
2
0
October 1st - 13th

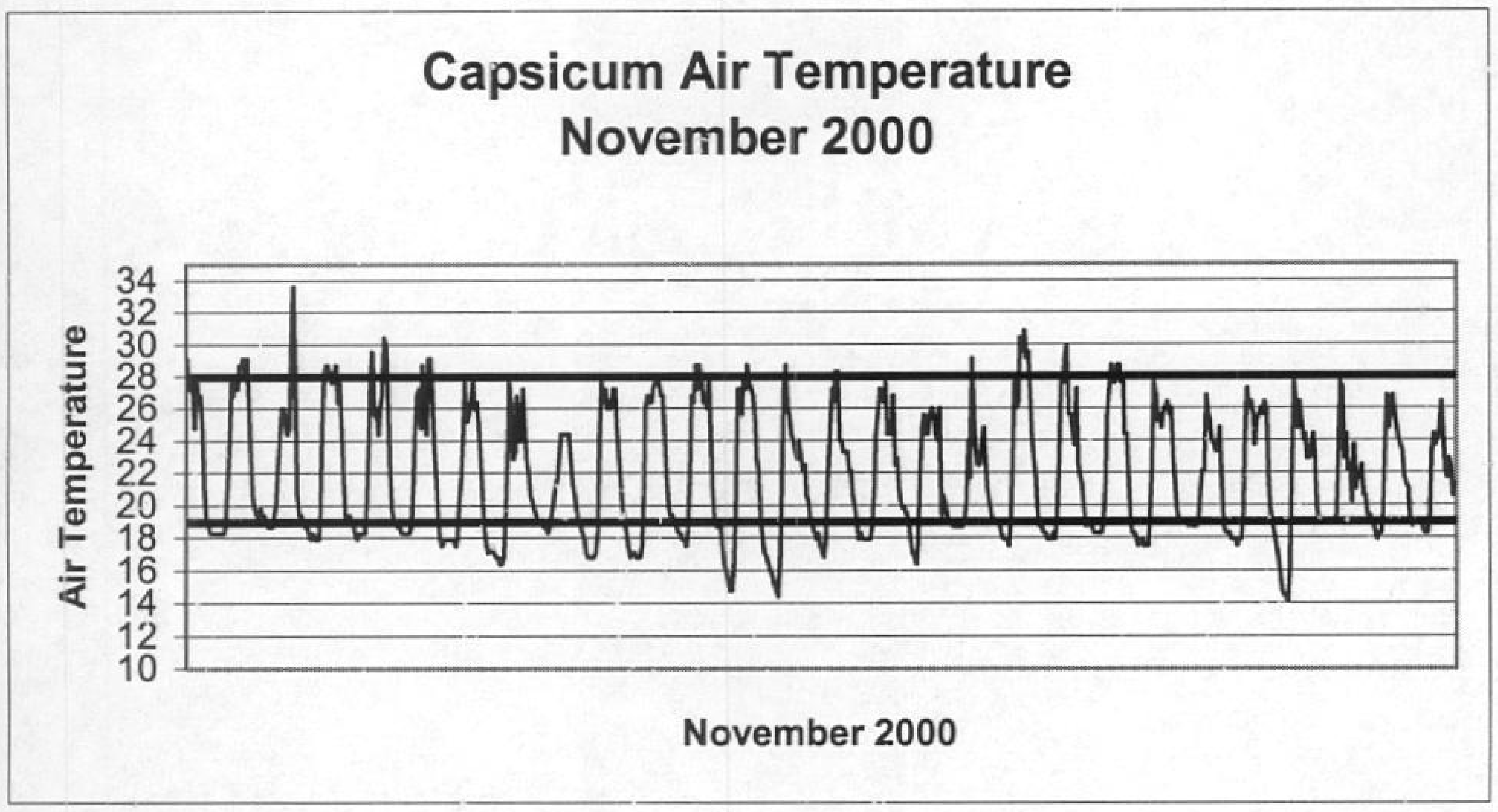

Capsicum Relative Humidity
October 2000
RH%
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
October 13th - 31st

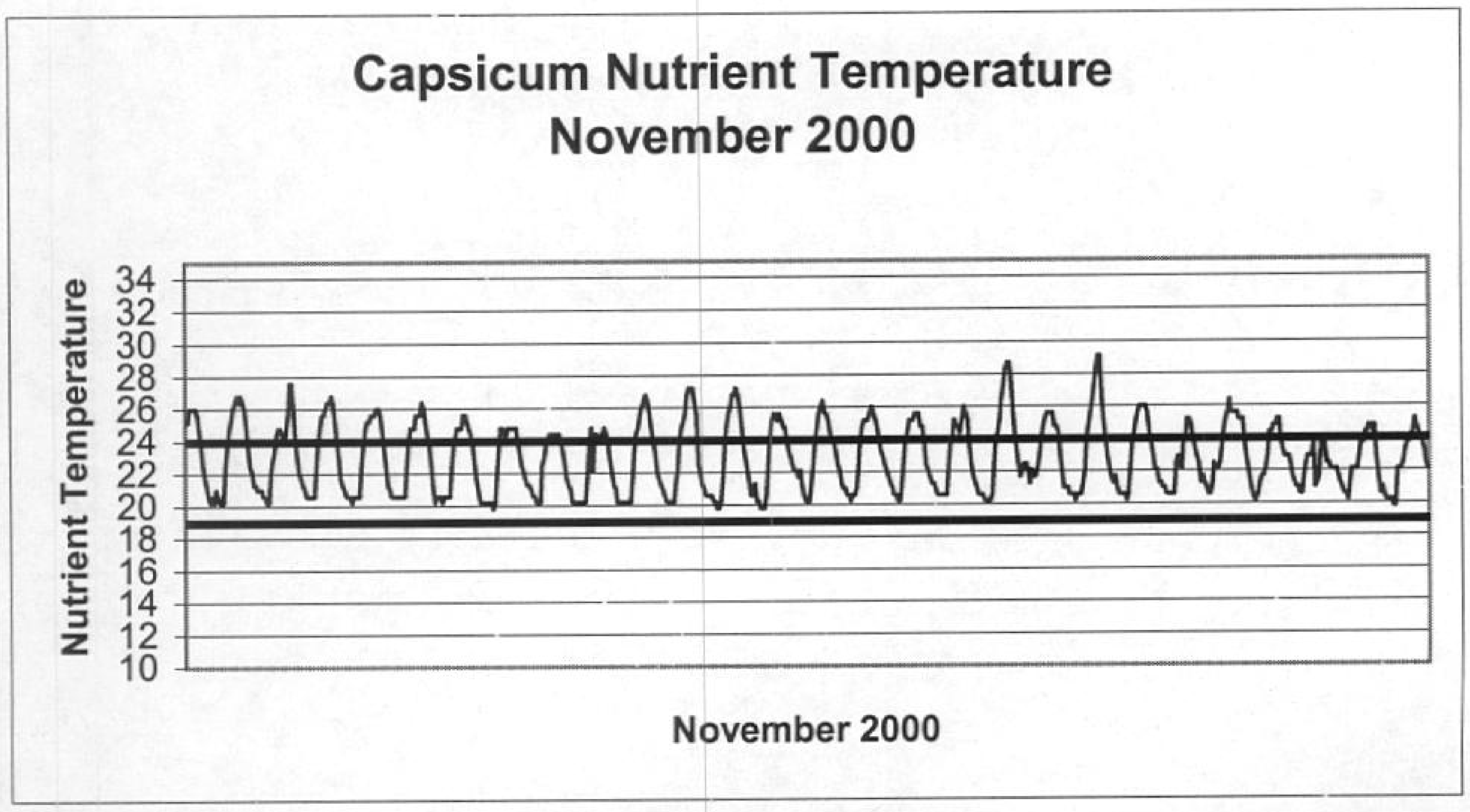

Capsicum Air Temperature
October 2000
Air Temperature
32
30
28
26
24
22
20
18
16
14
12
10
October 13th - 31st

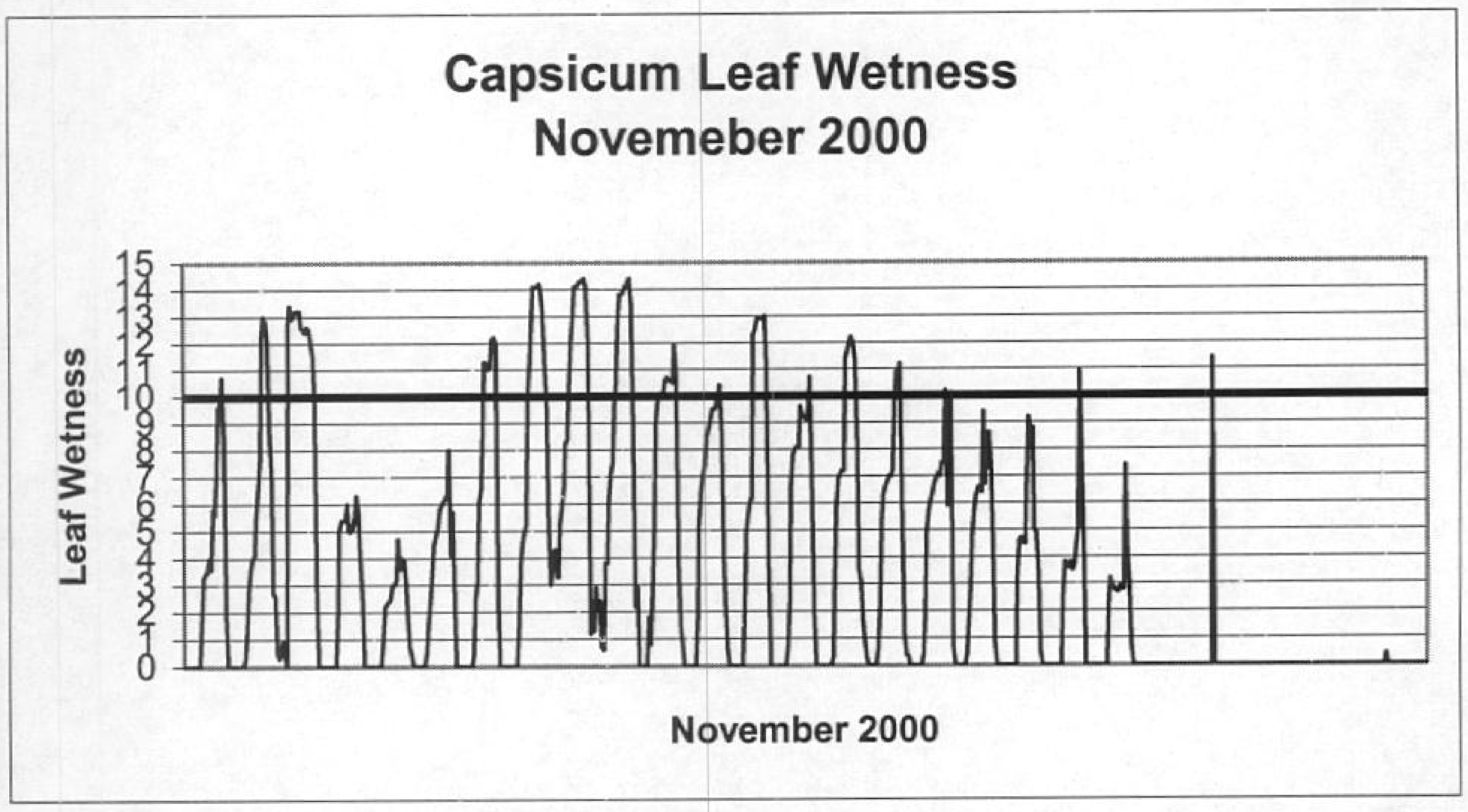

Capsicum Nutrient Temperature
October 2000
Nutrient Temperature
30
28
26
24
22
20
18
16
14
12
10
October 13th - 31st

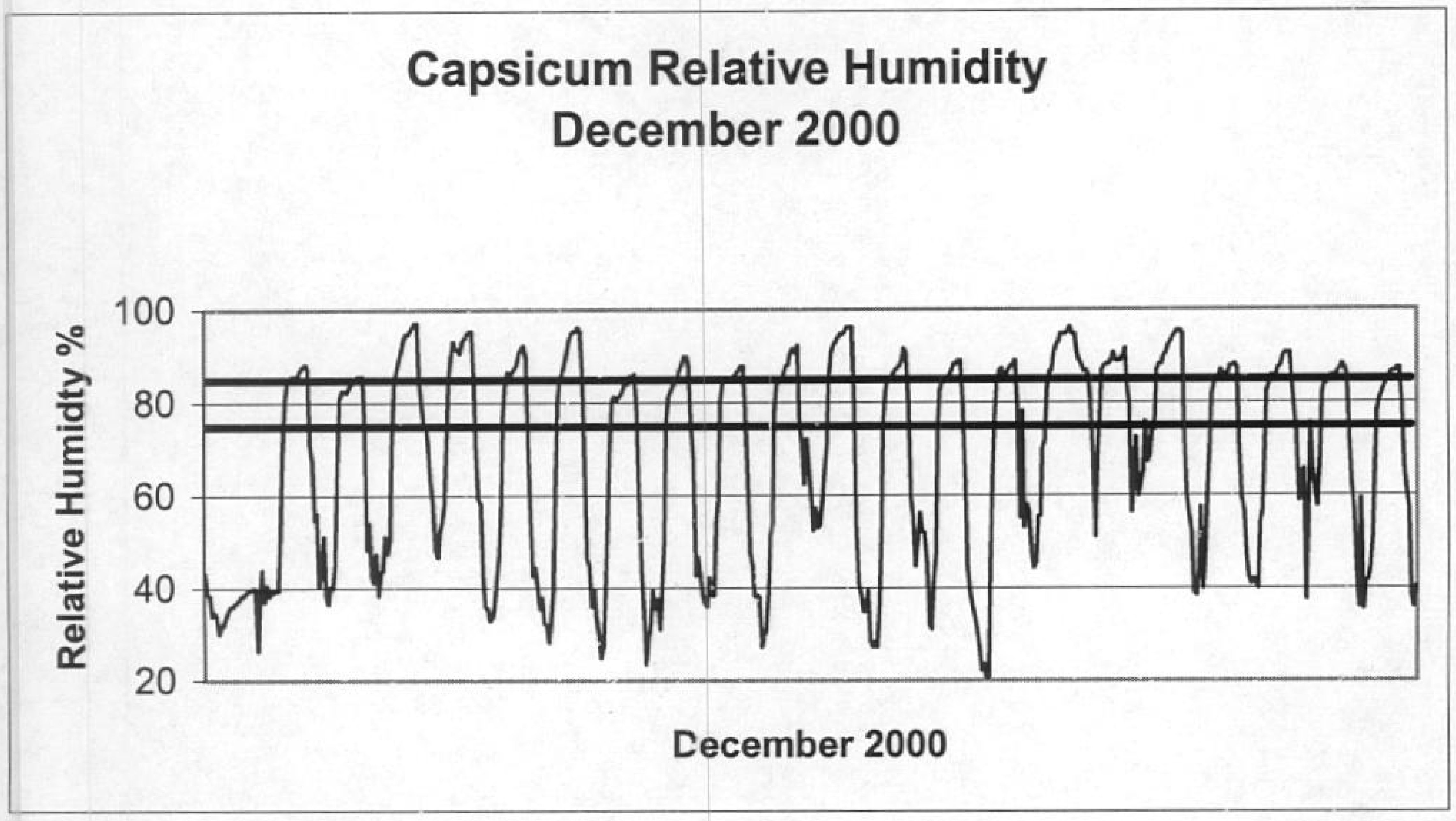

Capsicum Leaf Wetness
October 2000
Leaf Wetness
0
1
2
3
4
5
6
7
8
9
10
11
12
13
October 13th - 31st

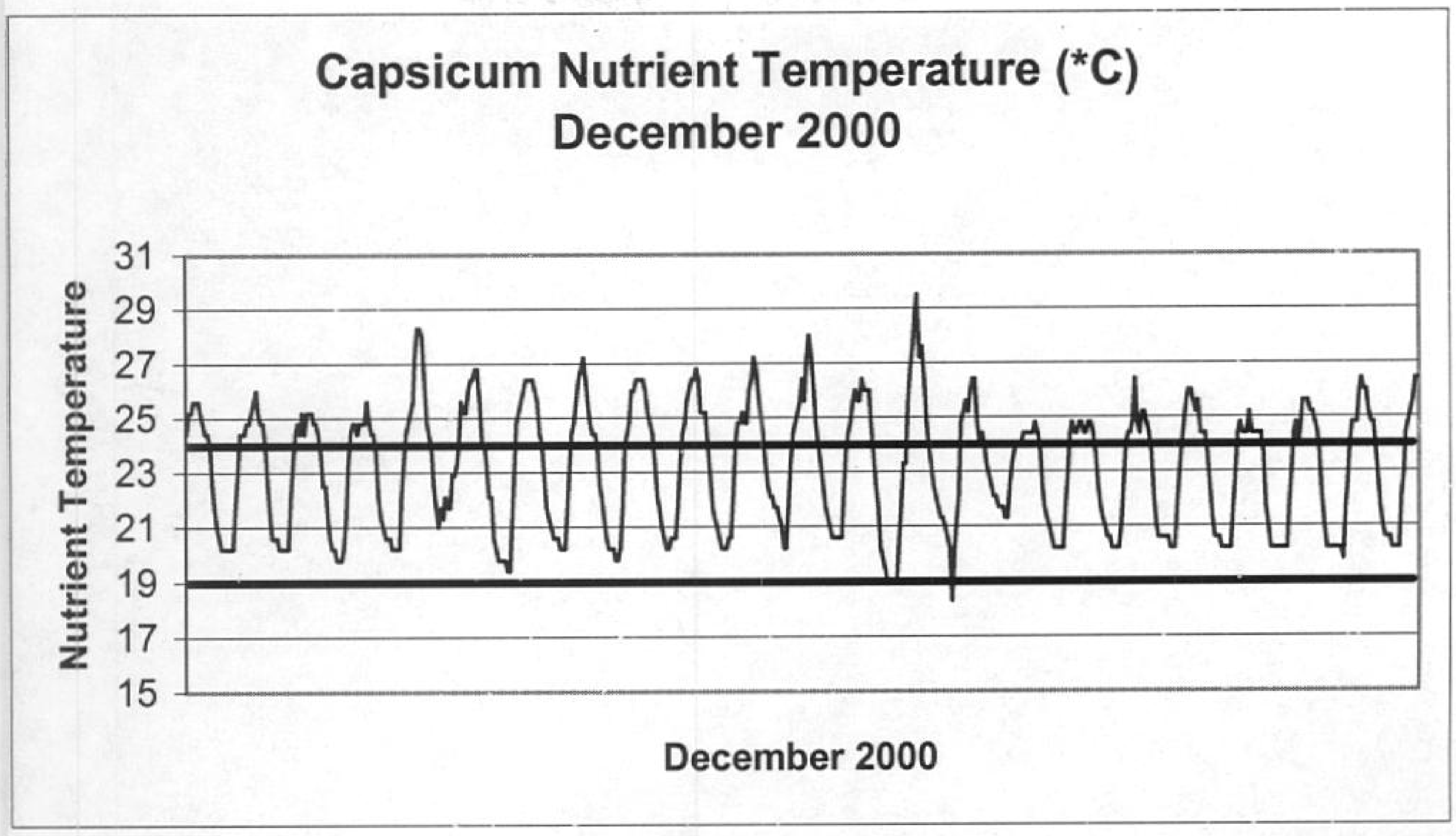

Capsicum Relative Humidity
November 2000
Relative Humidity
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
November 2000

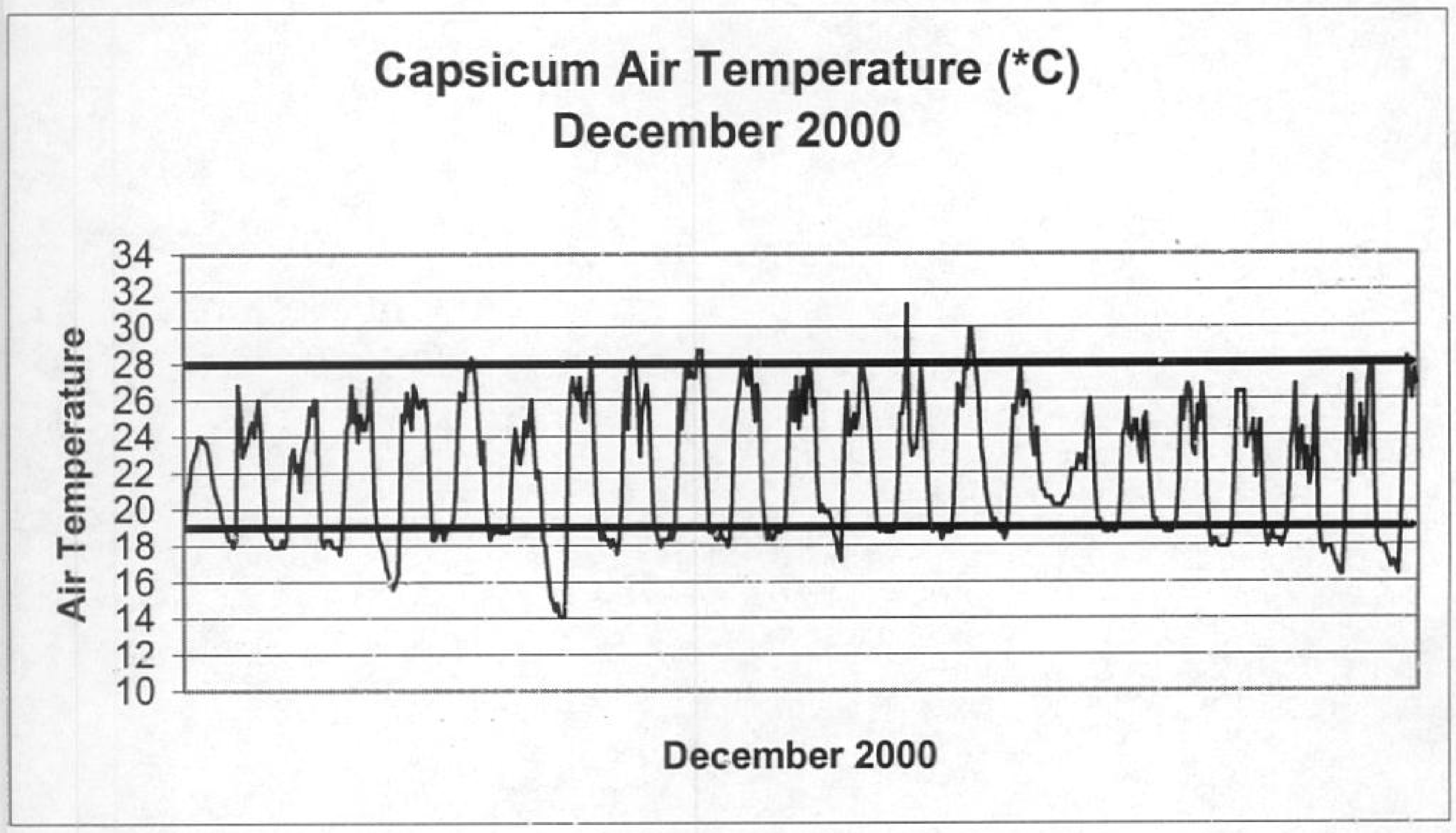

Capsicum Air Temperature
November 2000
Air Temperature
10
12
14
16
18
20
22
24
26
28
30
32
34
November 2000

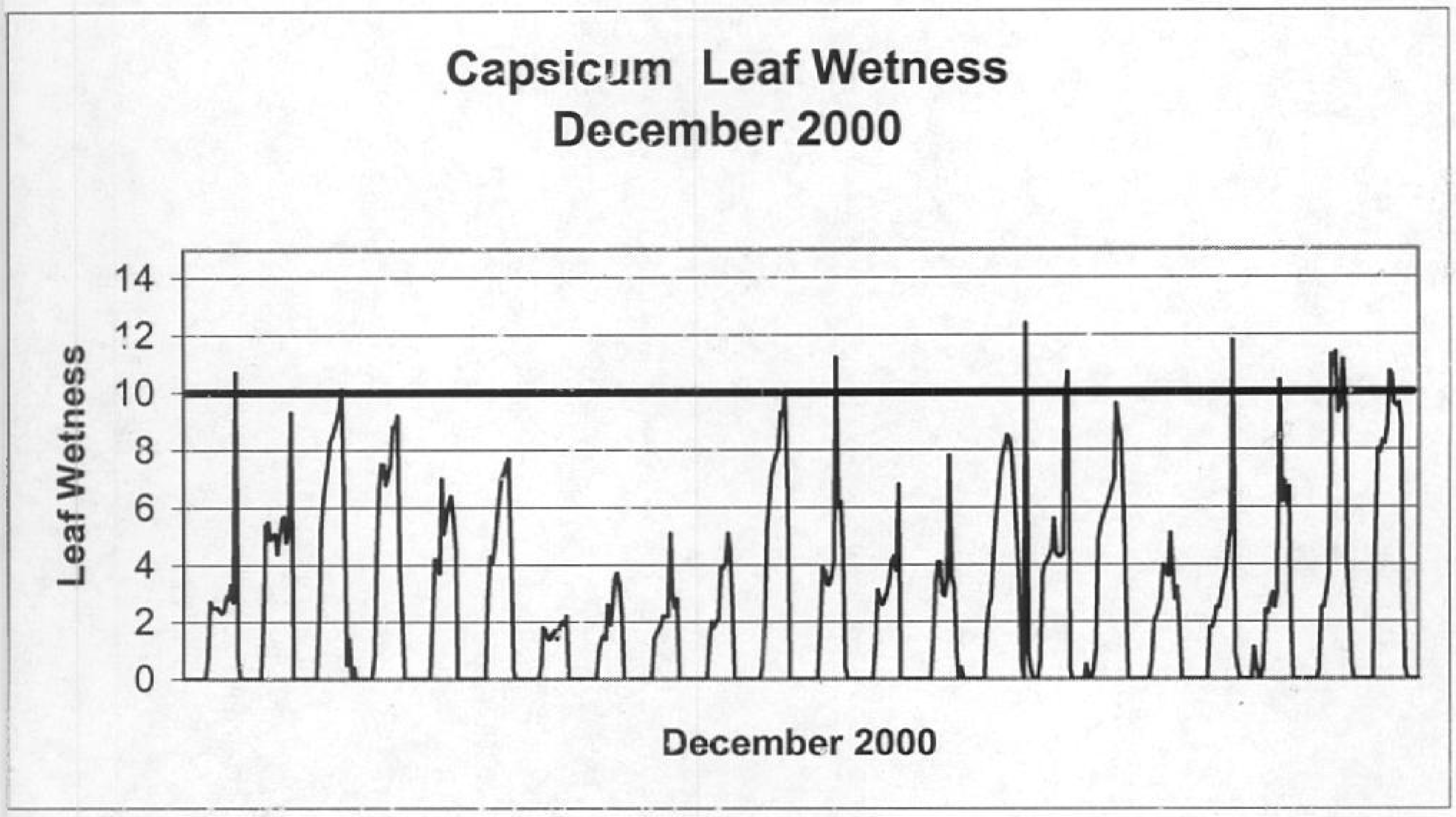

Capsicum Nutrient Temperature
November 2000
Nutrient Temperature
34
32
30
28
26
24
22
20
18
16
14
12
10
November 2000

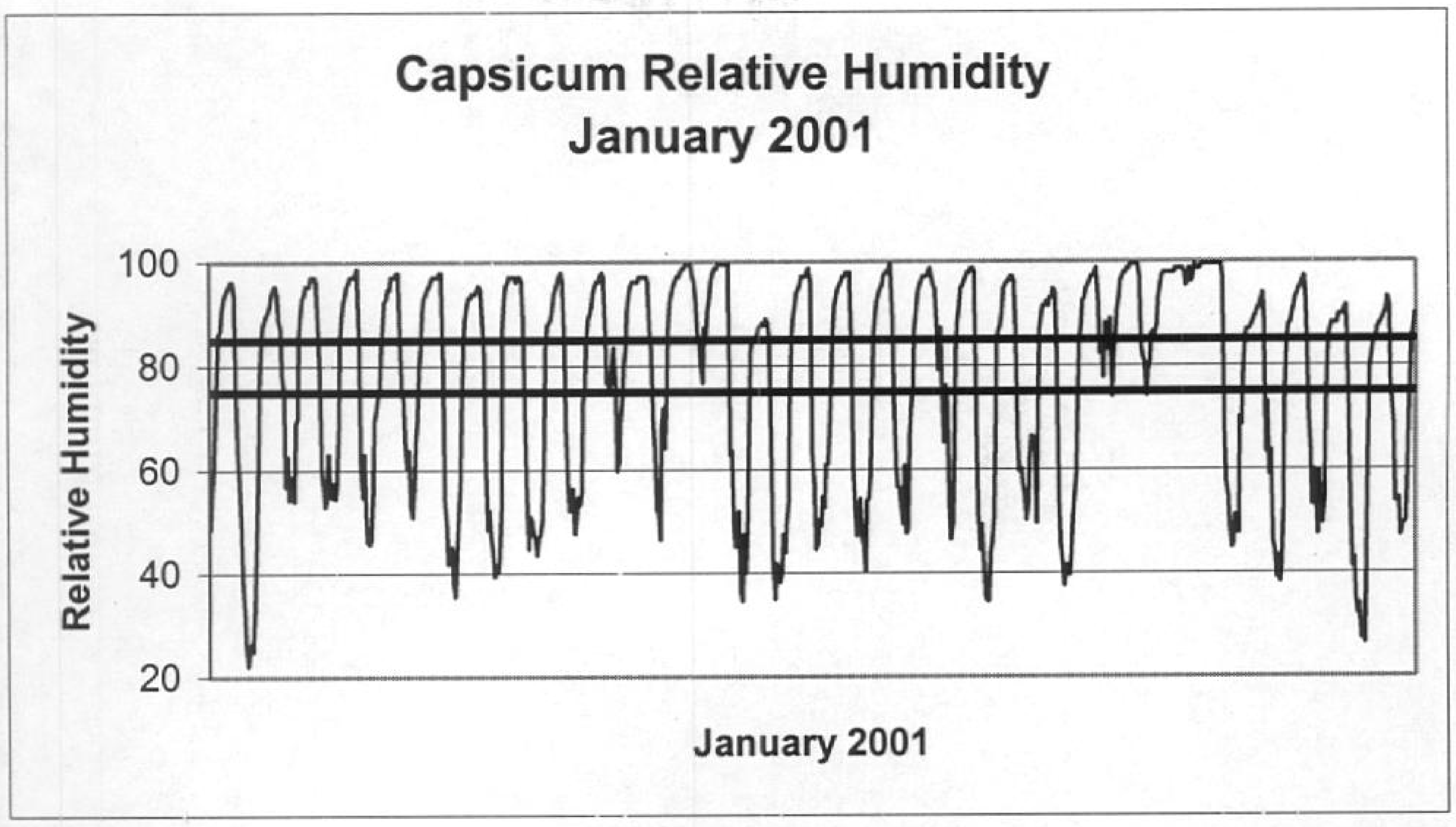

Capsicum Leaf Wetness
Novemeber 2000
Leaf Wetness
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
November 2000

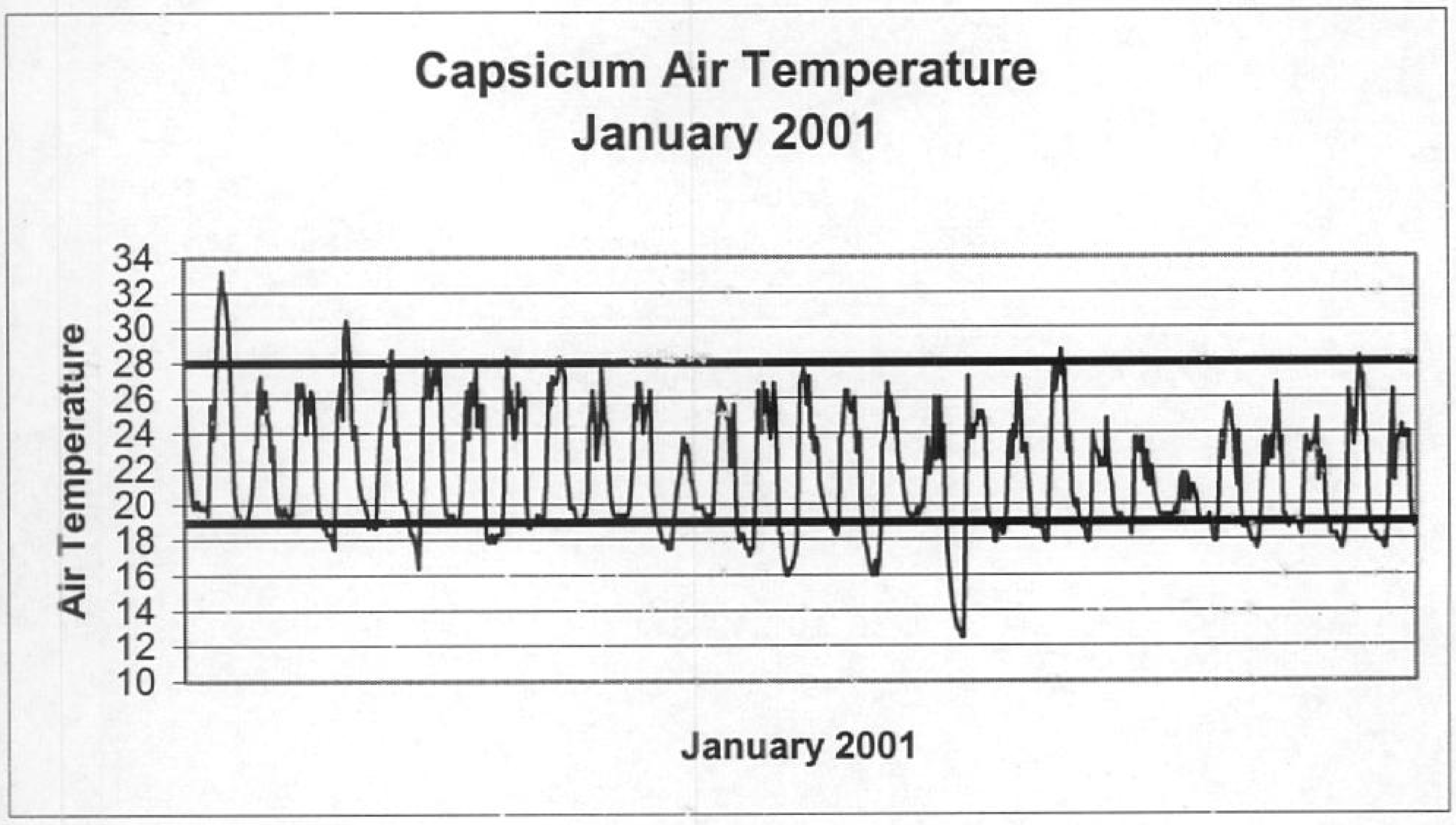

Capsicum Relative Humidity
December 2000
Relative Humidty %
100
80
60
40
20
December 2000

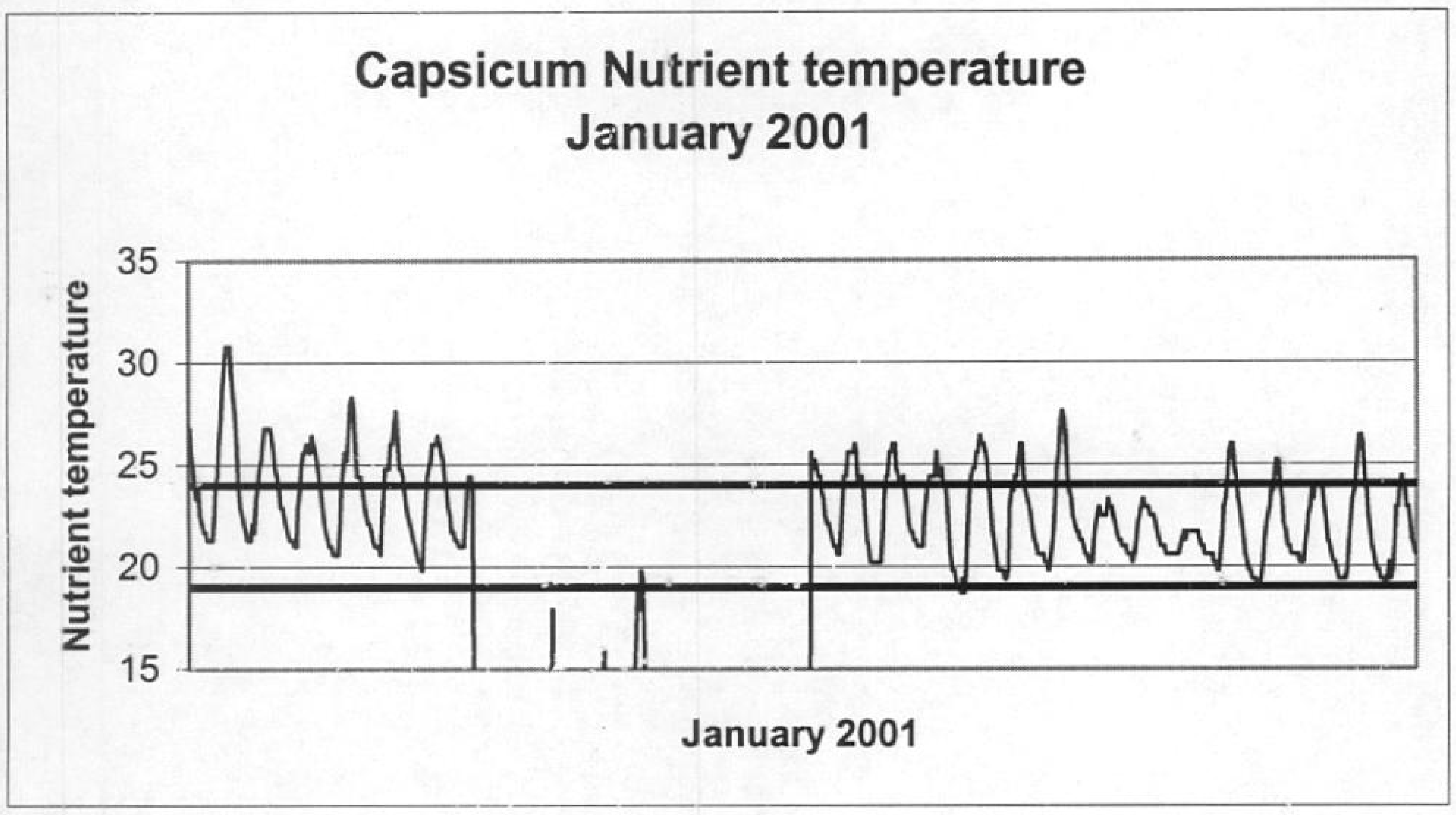

Capsicum Nutrient Temperature (*C)
December 2000
Nutrient Temperature
31
29
27
25
23
21
19
17
15
December 2000

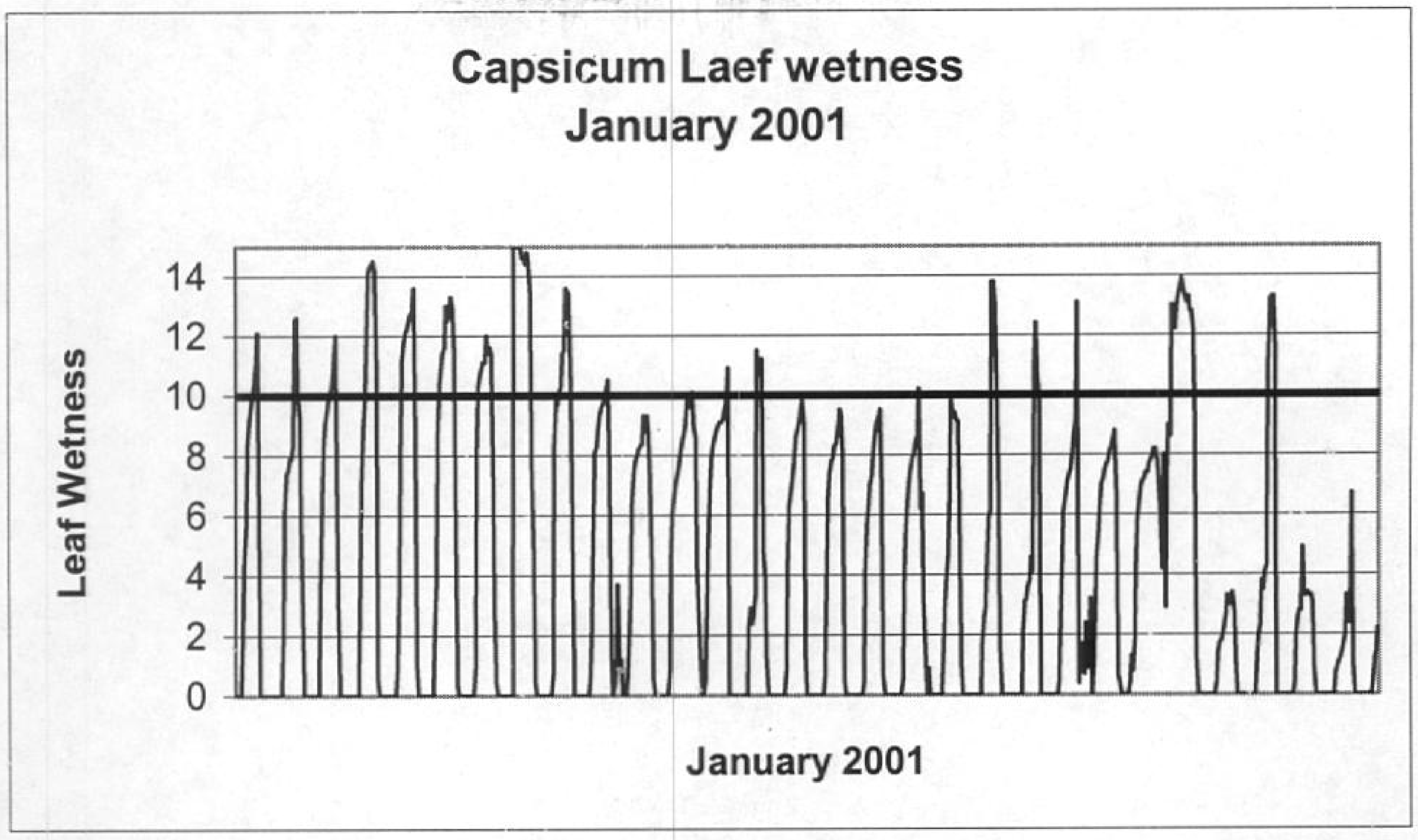

Capsicum Air Temperature (*C)
December 2000
Air Temperature
34
32
30
28
26
24
22
20
18
16
14
12
10
December 2000

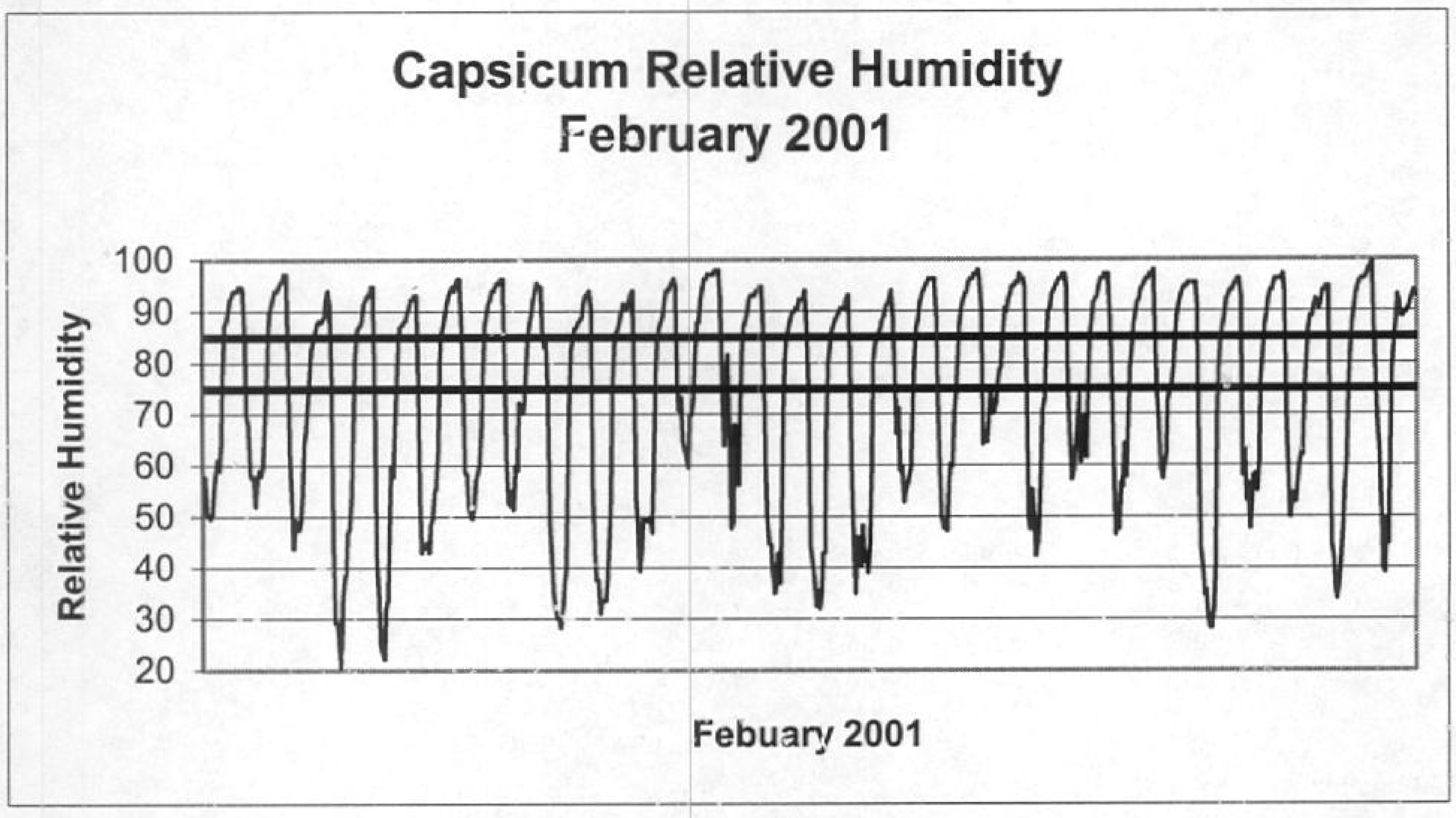

Capsicum Leaf Wetness
December 2000
Leaf Wetness
14
12
10
8
6
4
2
0
December 2000

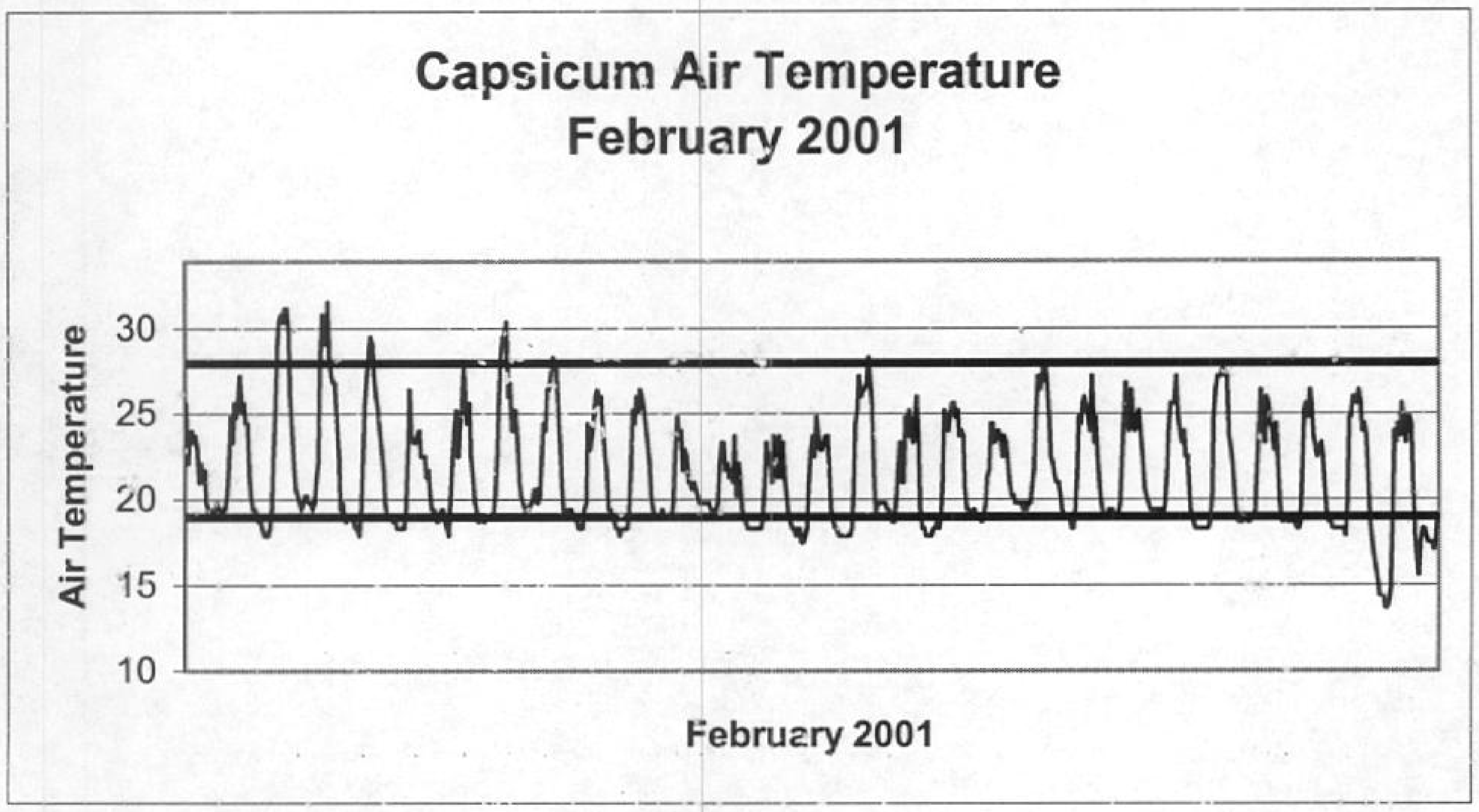

Capsicum Relative Humidity
January 2001
100
80
60
40
20
Relative Humidity
January 2001


Capsicum Air Temperature
January 2001
34
32
30
28
26
24
22
20
18
16
14
12
10
Air Temperature
January 2001

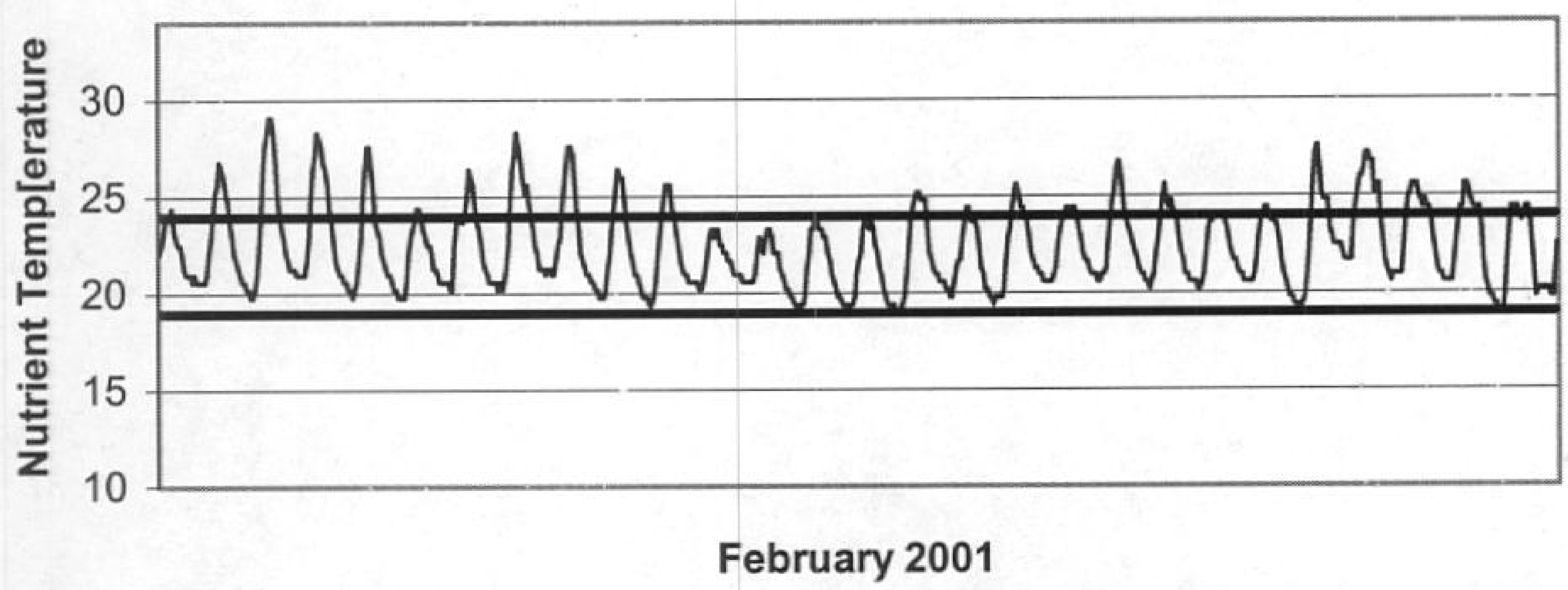

Capsicum Nutrient temperature
January 2001
35
30
25
20
15
Nutrient temperature
January 2001


Capsicum Laef wetness
January 2001
Leaf Wetness
14
12
10
8
6
4
2
0
January 2001

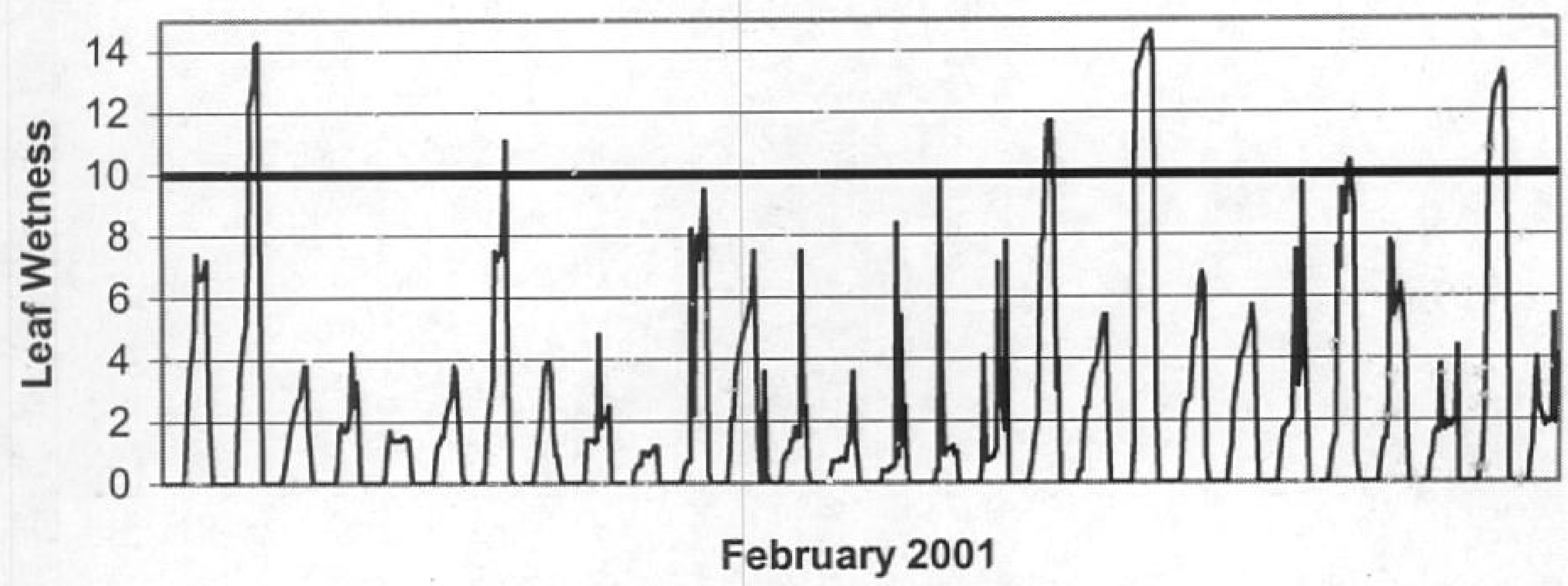

Capsicum Relative Humidity
February 2001
Relative Humidity
100
90
80
70
60
50
40
30
20
Febuary 2001


Capsicum Air Temperature
February 2001
Air Temperature
30
25
20
15
10
February 2001

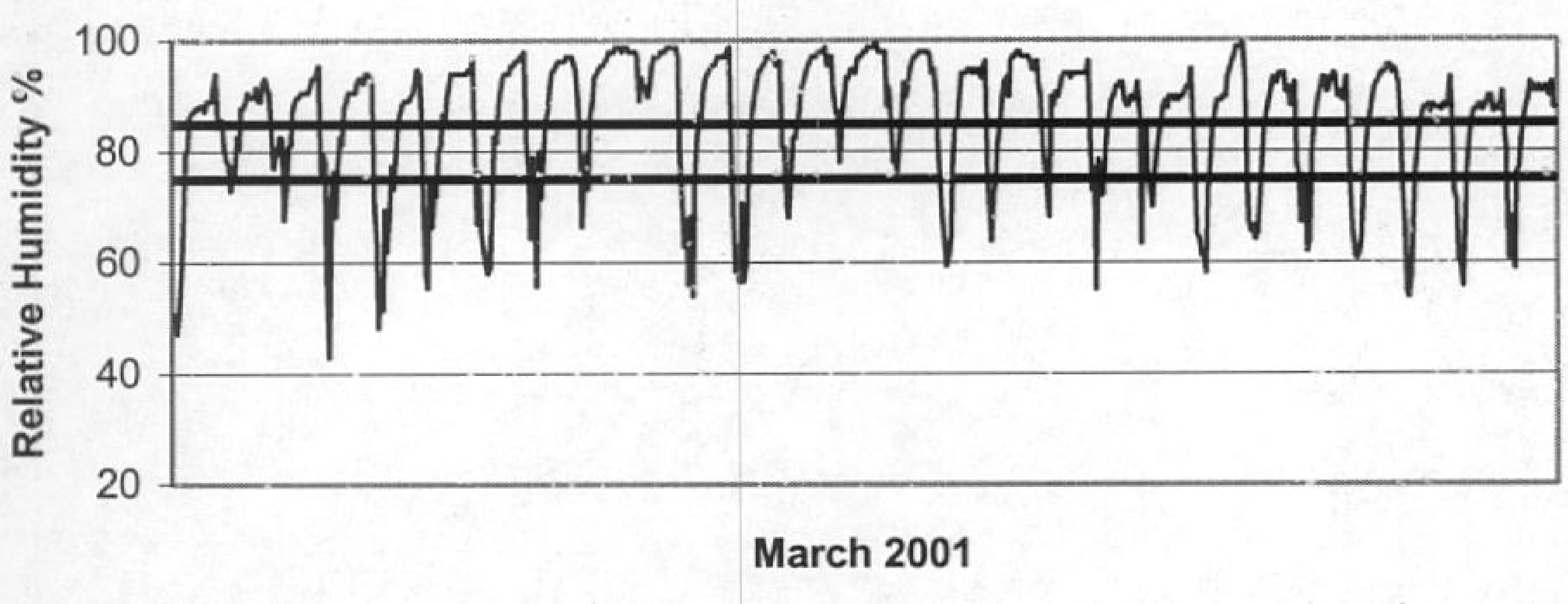
Capsicum Nutrient Temperature
February 2001

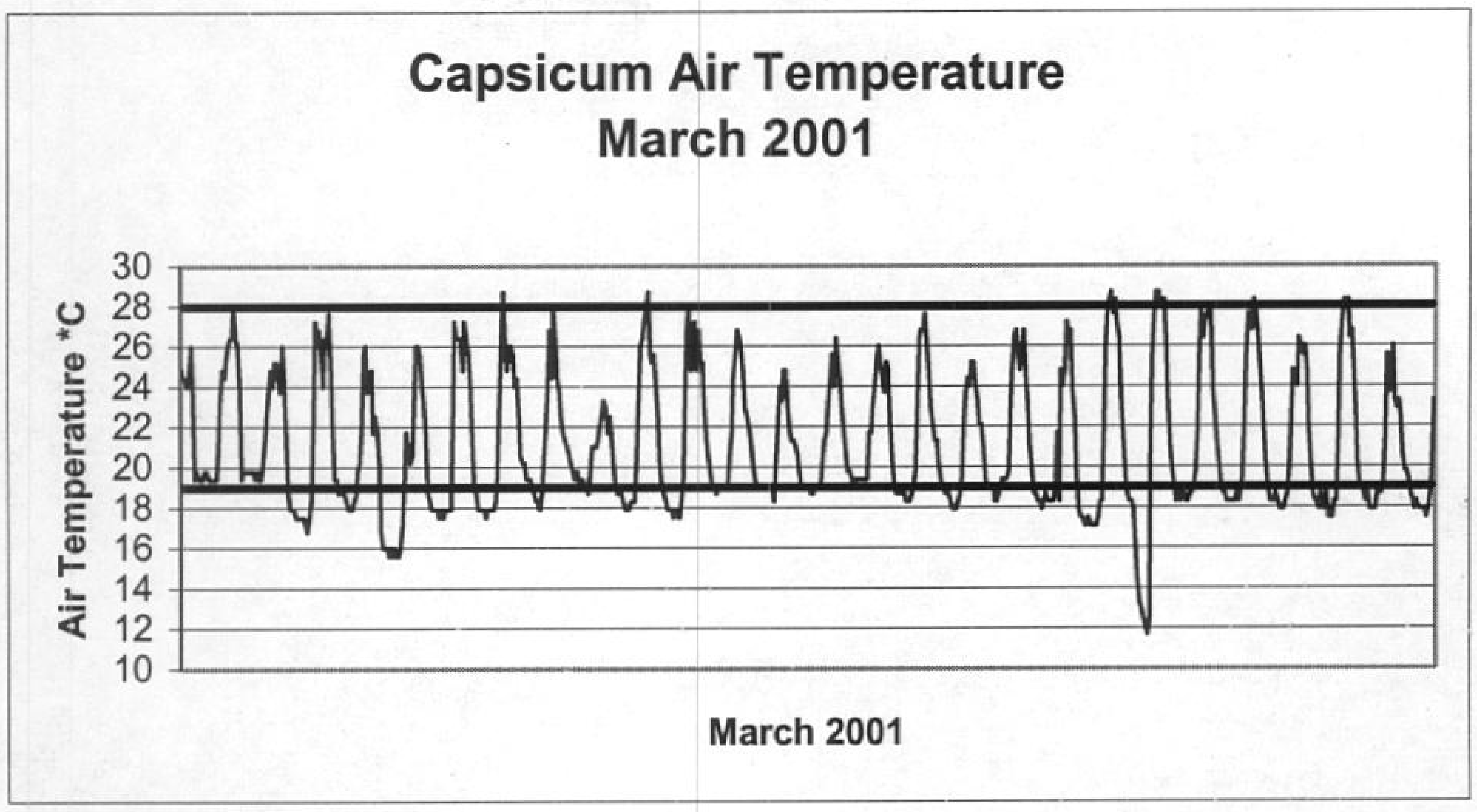


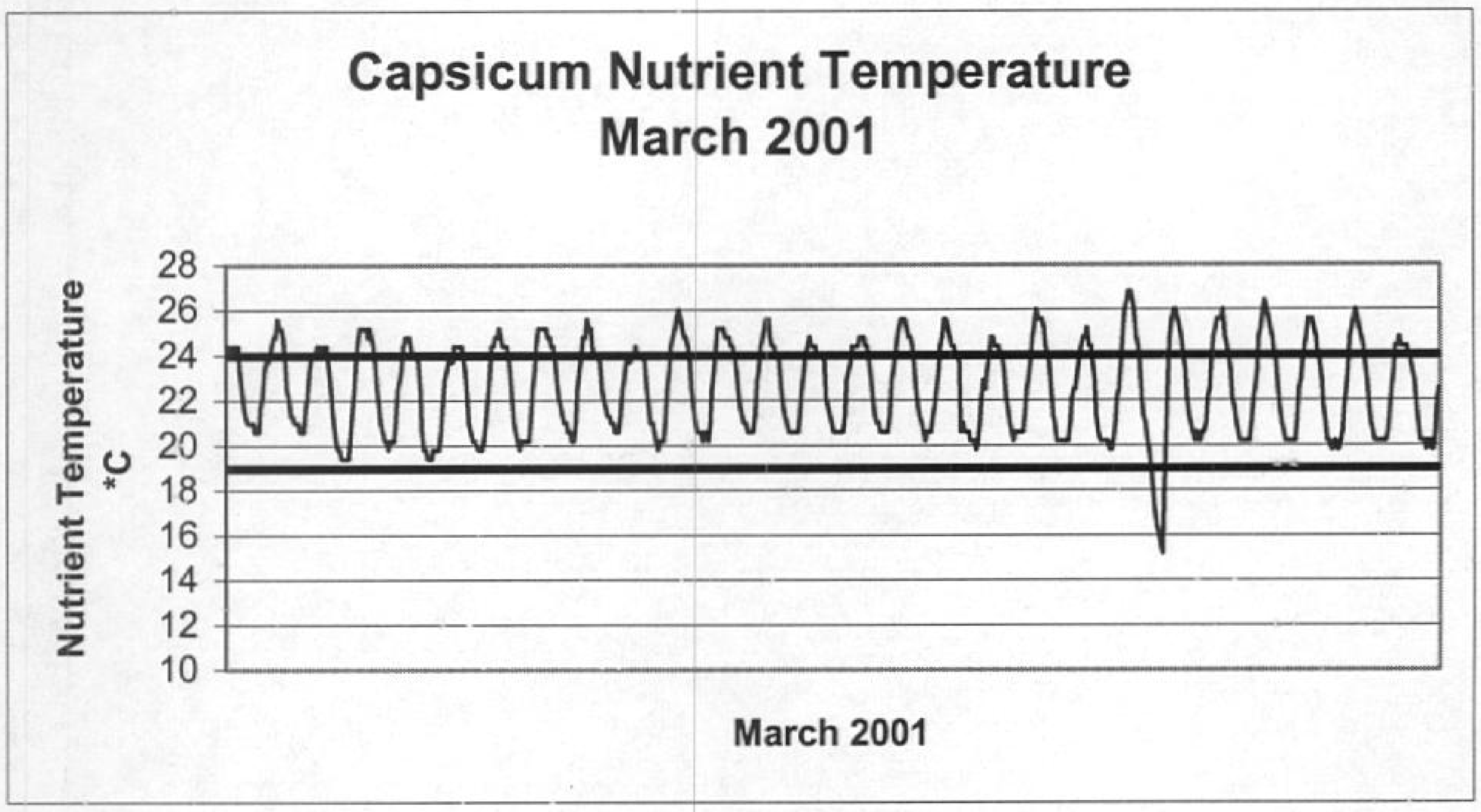
Capsicum Leaf Wetness
February 2001

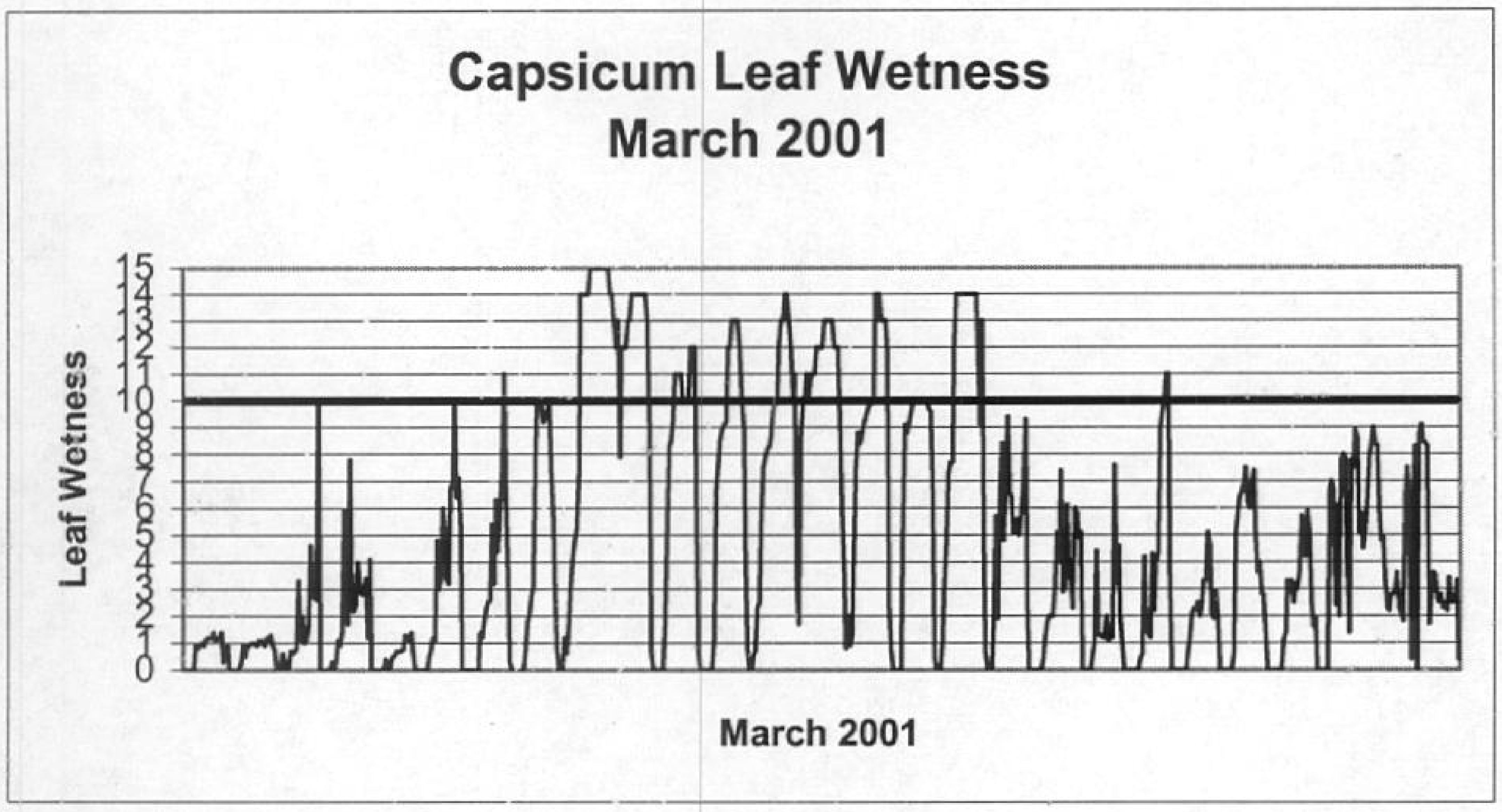


Capsicum Relative Humidity
March 2001

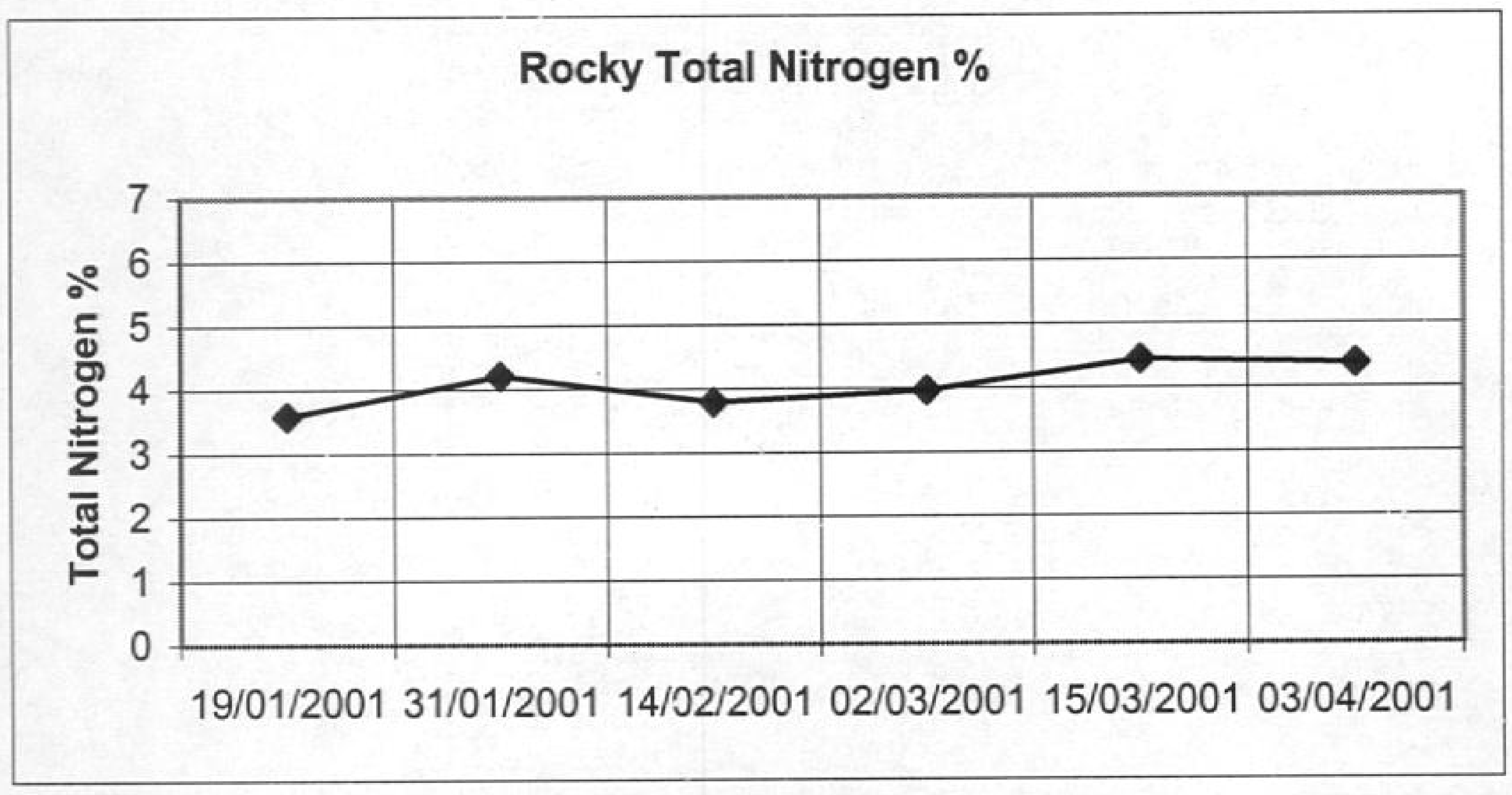


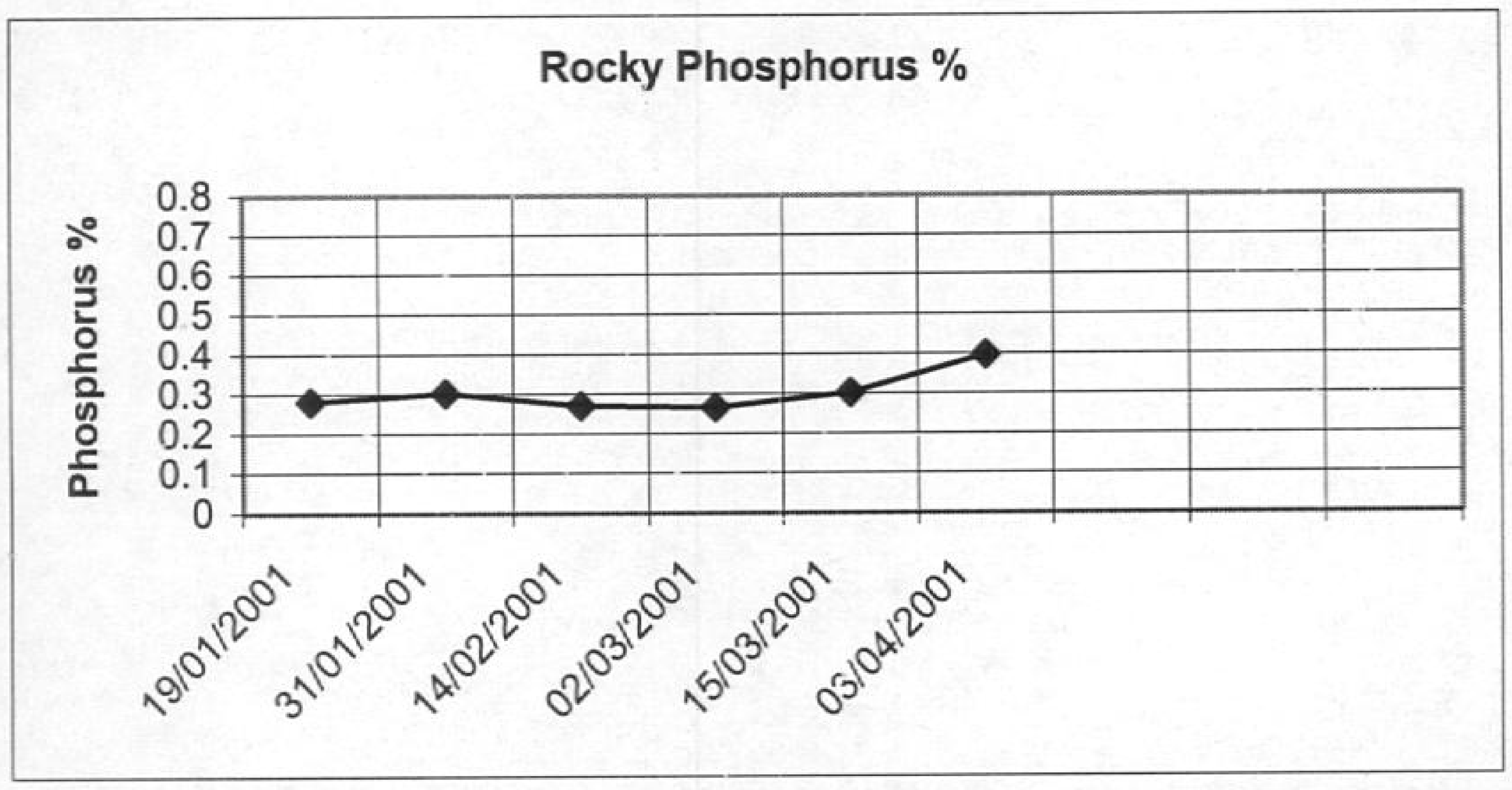

Capsicum Air Temperature
March 2001
Air Temperature *C
30
28
26
24
22
20
18
16
14
12
10
March 2001

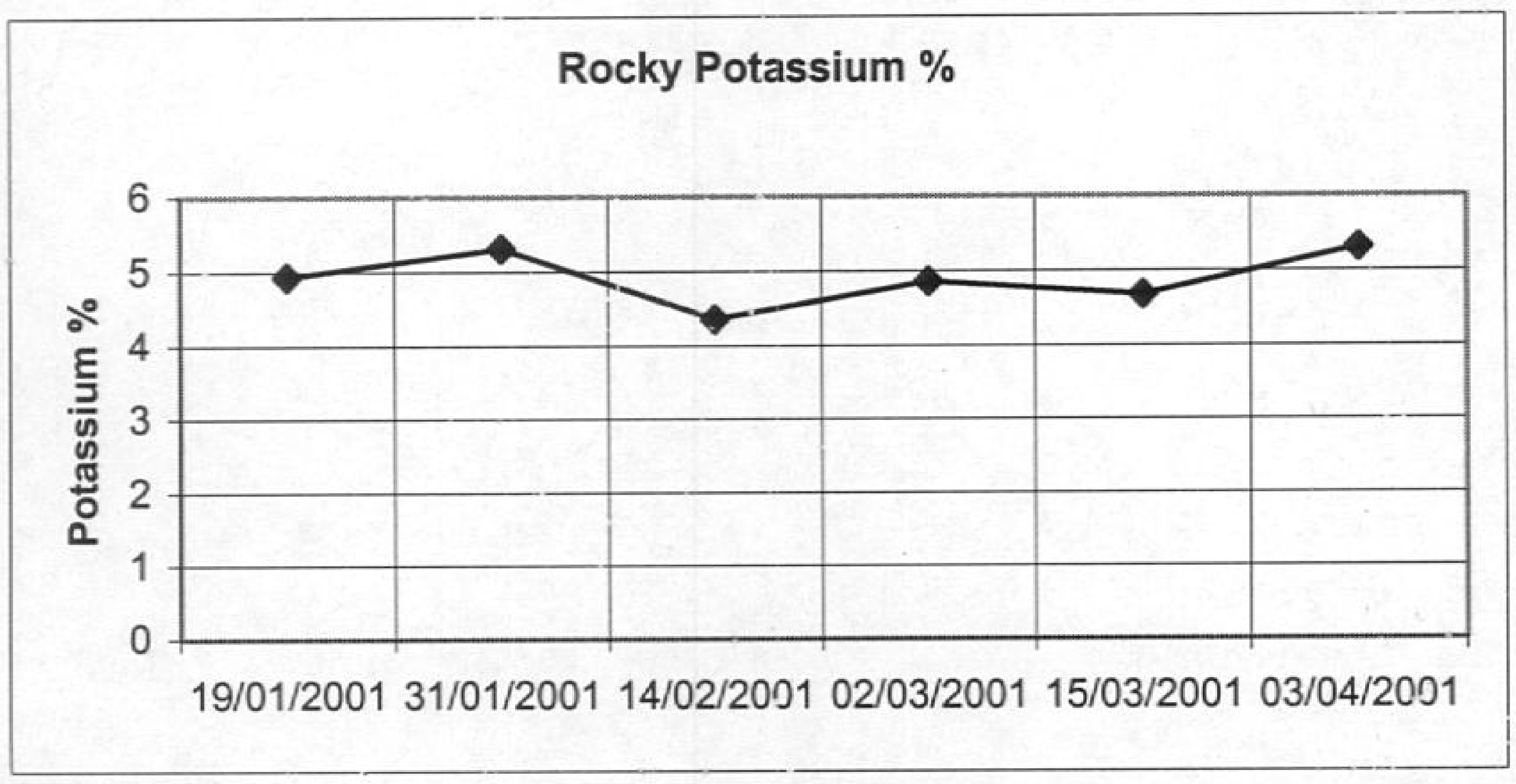

Capsicum Nutrient Temperature
March 2001
Nutrient Temperature *C
28
26
24
22
20
18
16
14
12
10
March 2001

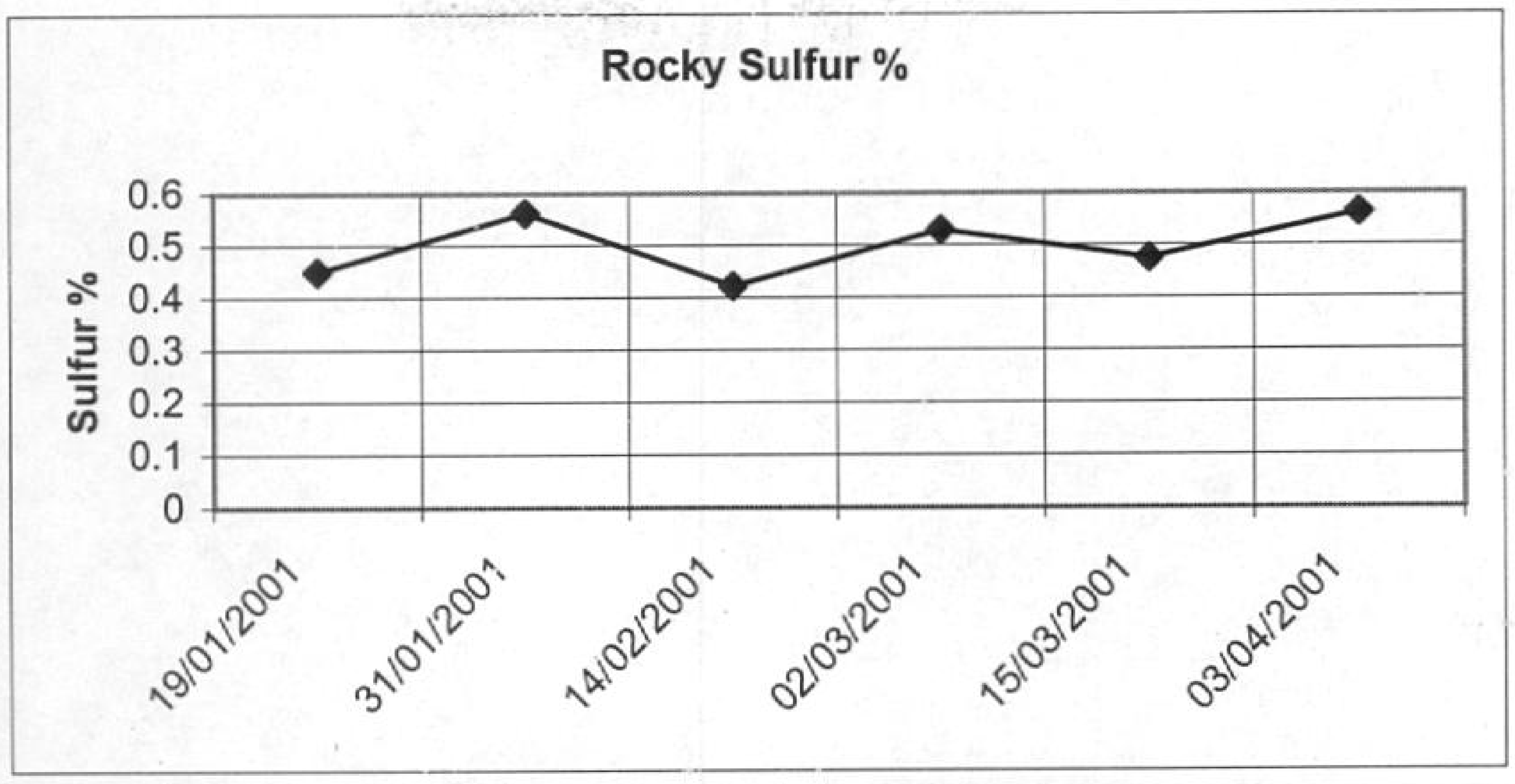

Capsicum Leaf Wetness
March 2001
Leaf Wetness
March 2001

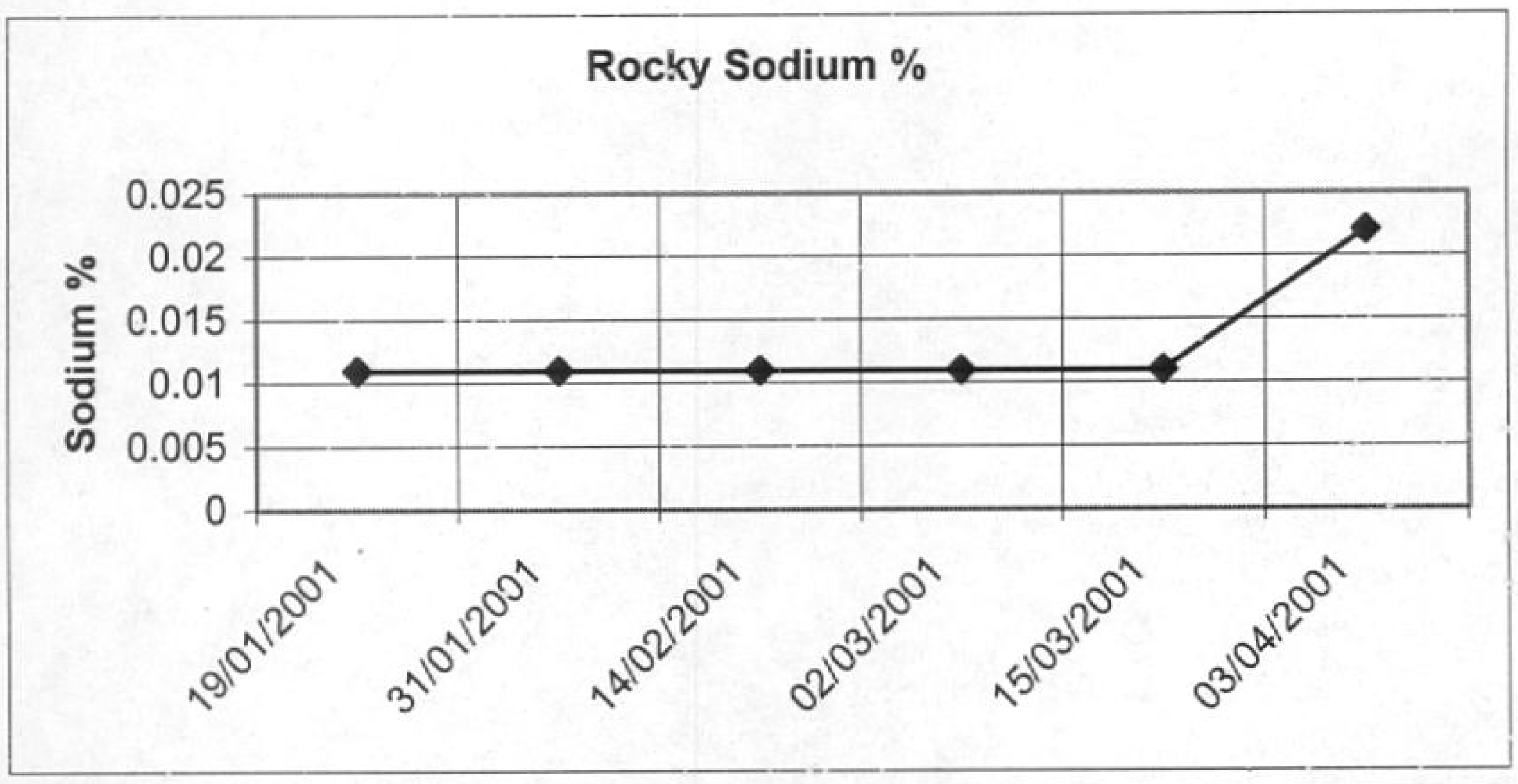
APPENDIX 2. LEAF ANALYSIS DATA

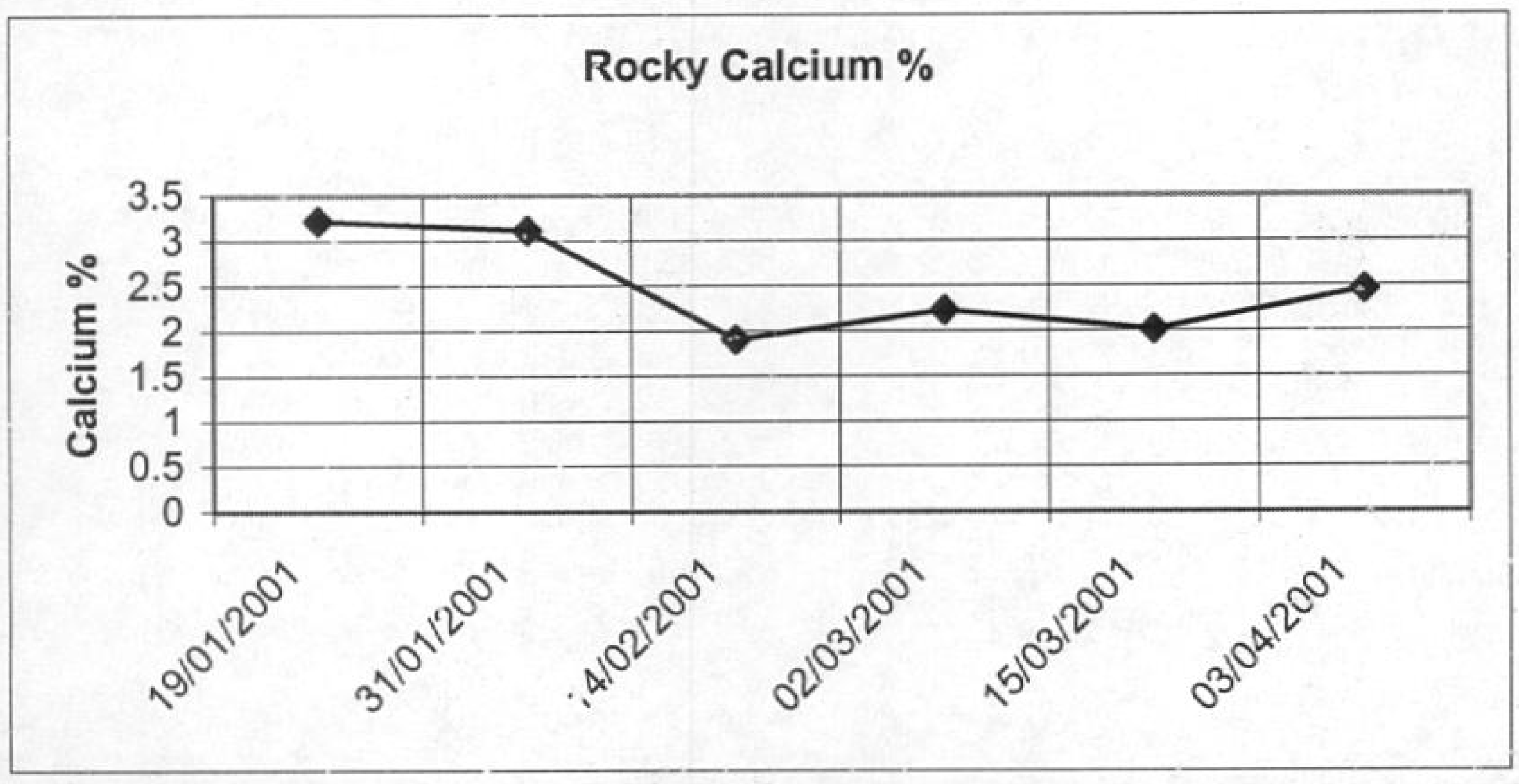


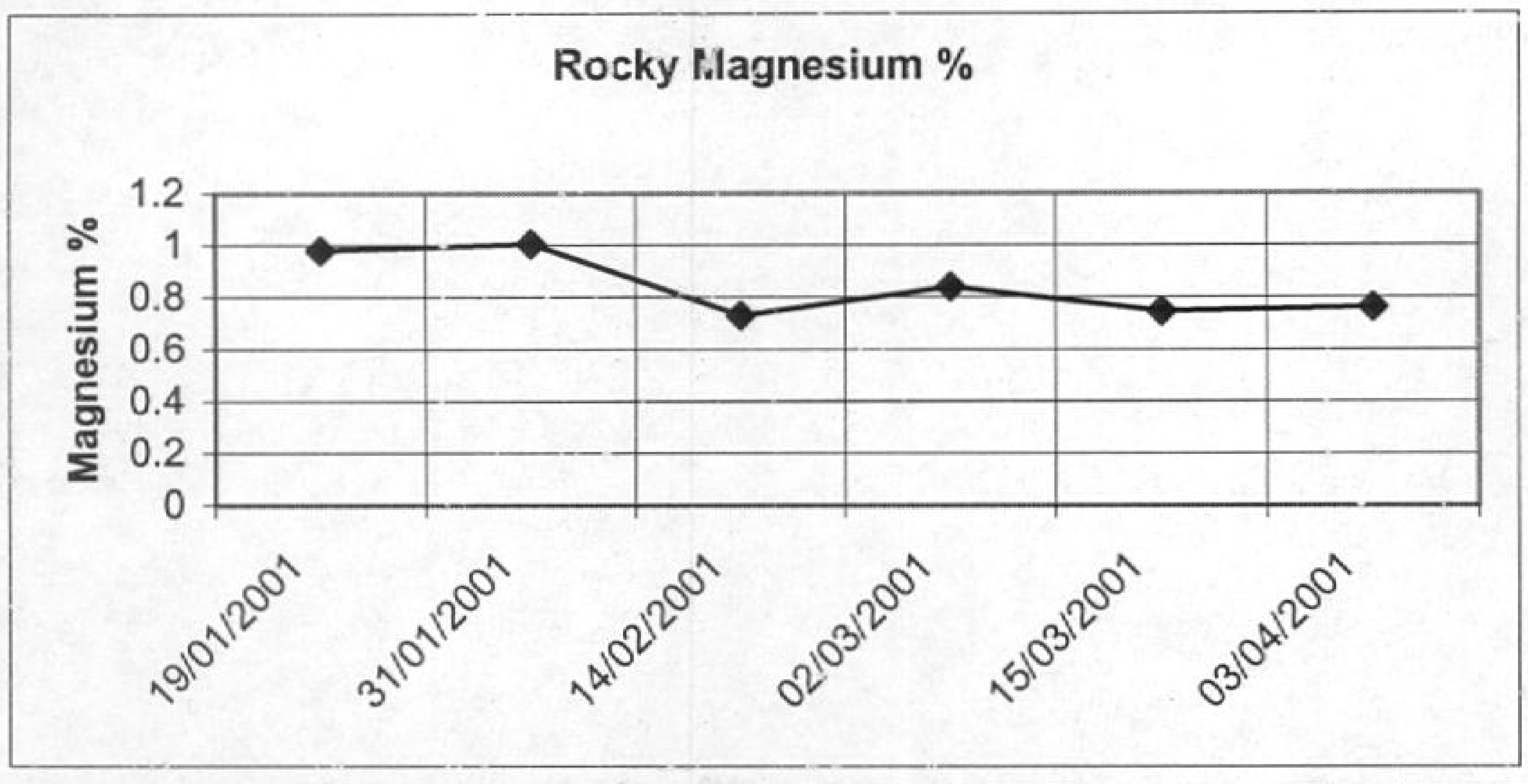


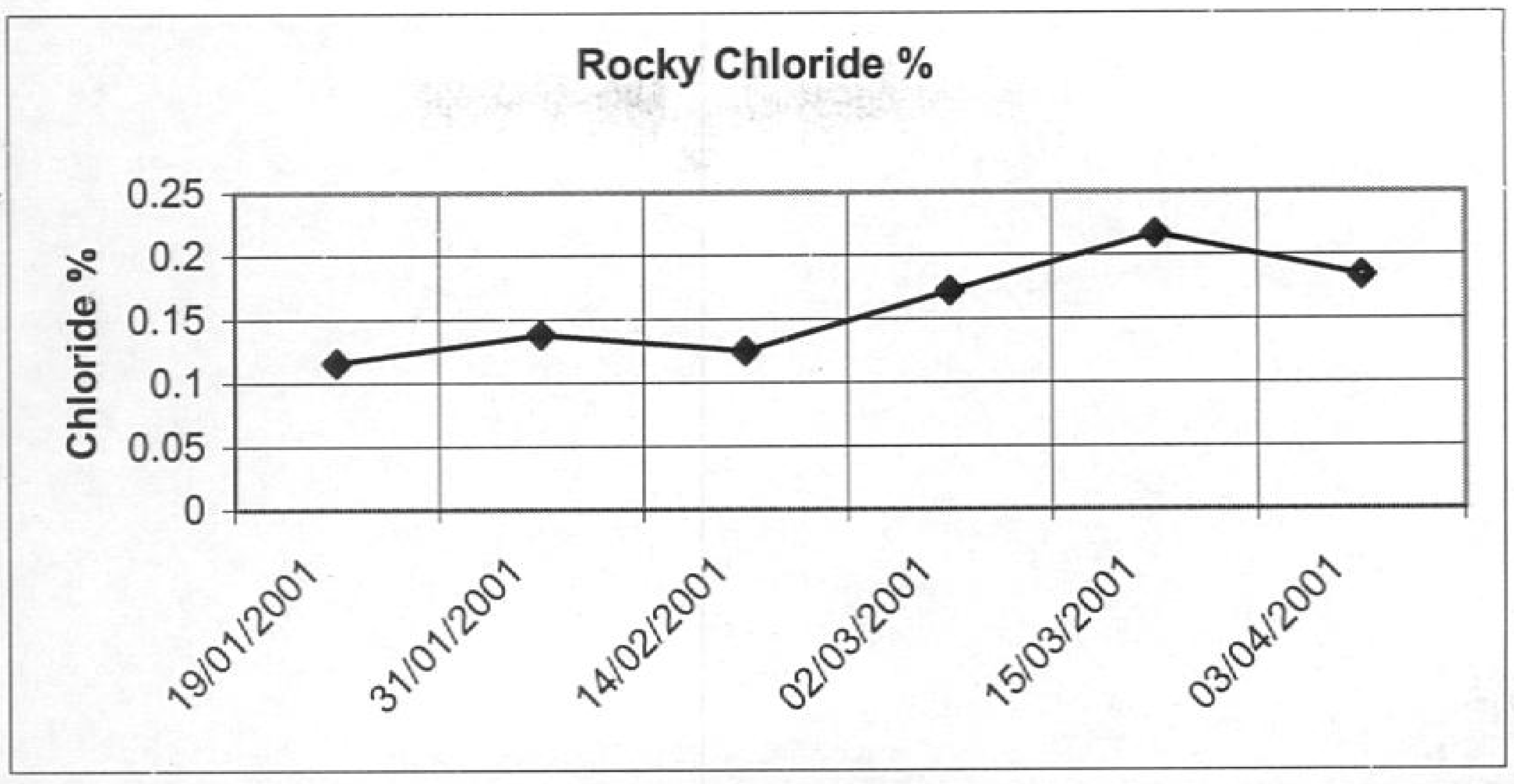


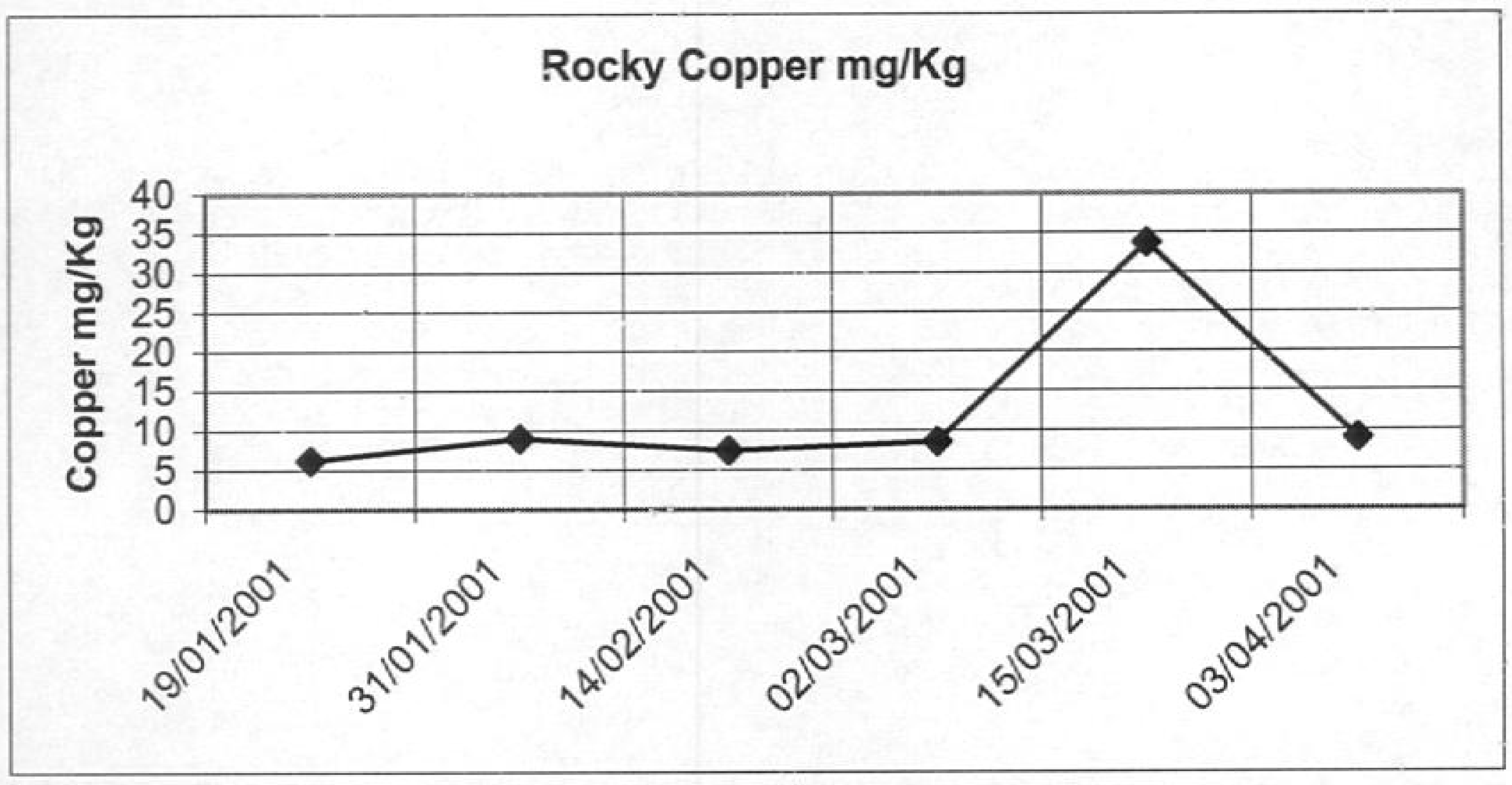

Rocky Sulfur %
Sulfur %
0.6
0.5
0.4
0.3
0.2
0.1
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

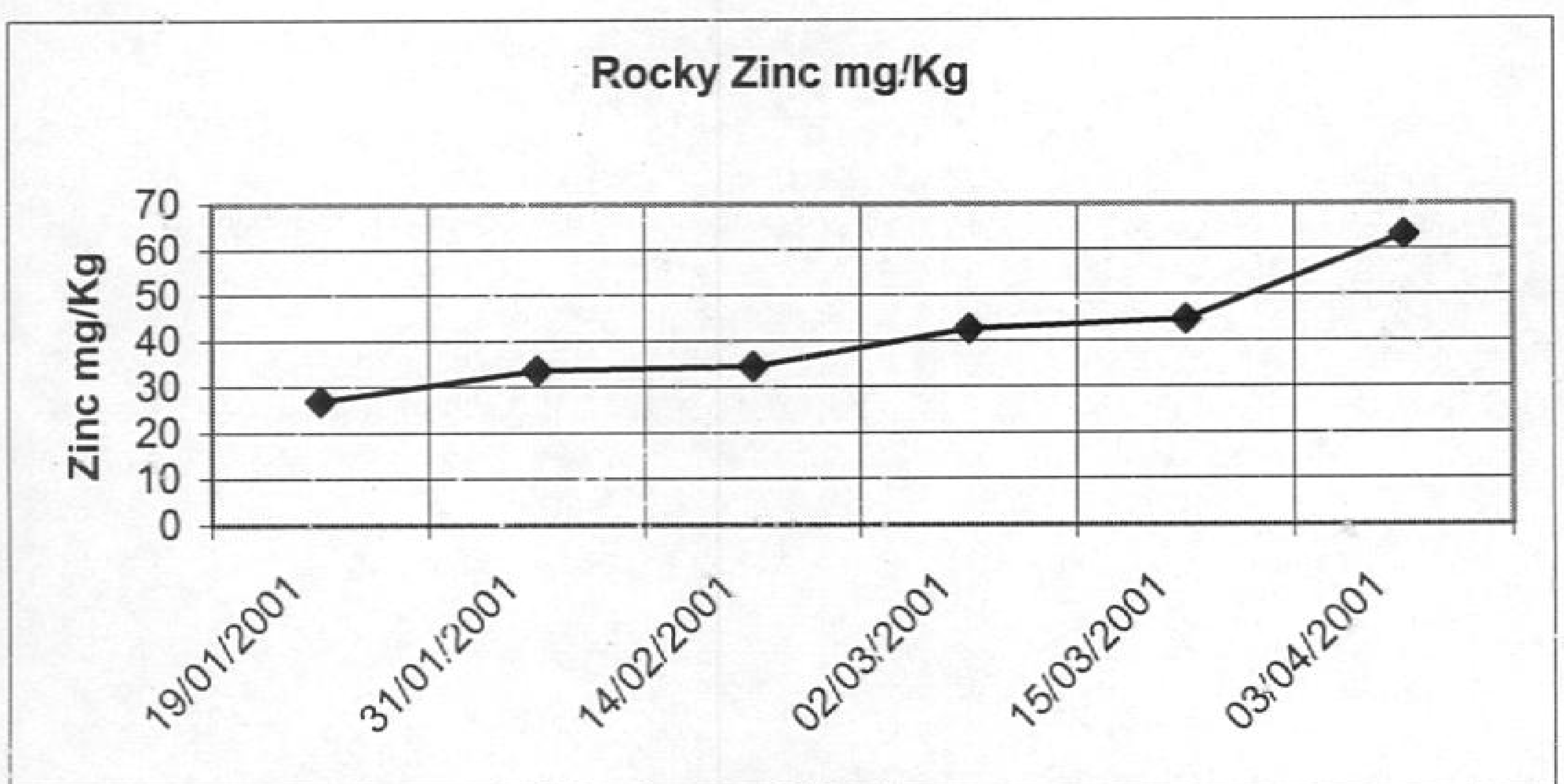

Rocky Sodium %
Sodium %
0.025
0.02
0.015
0.01
0.005
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

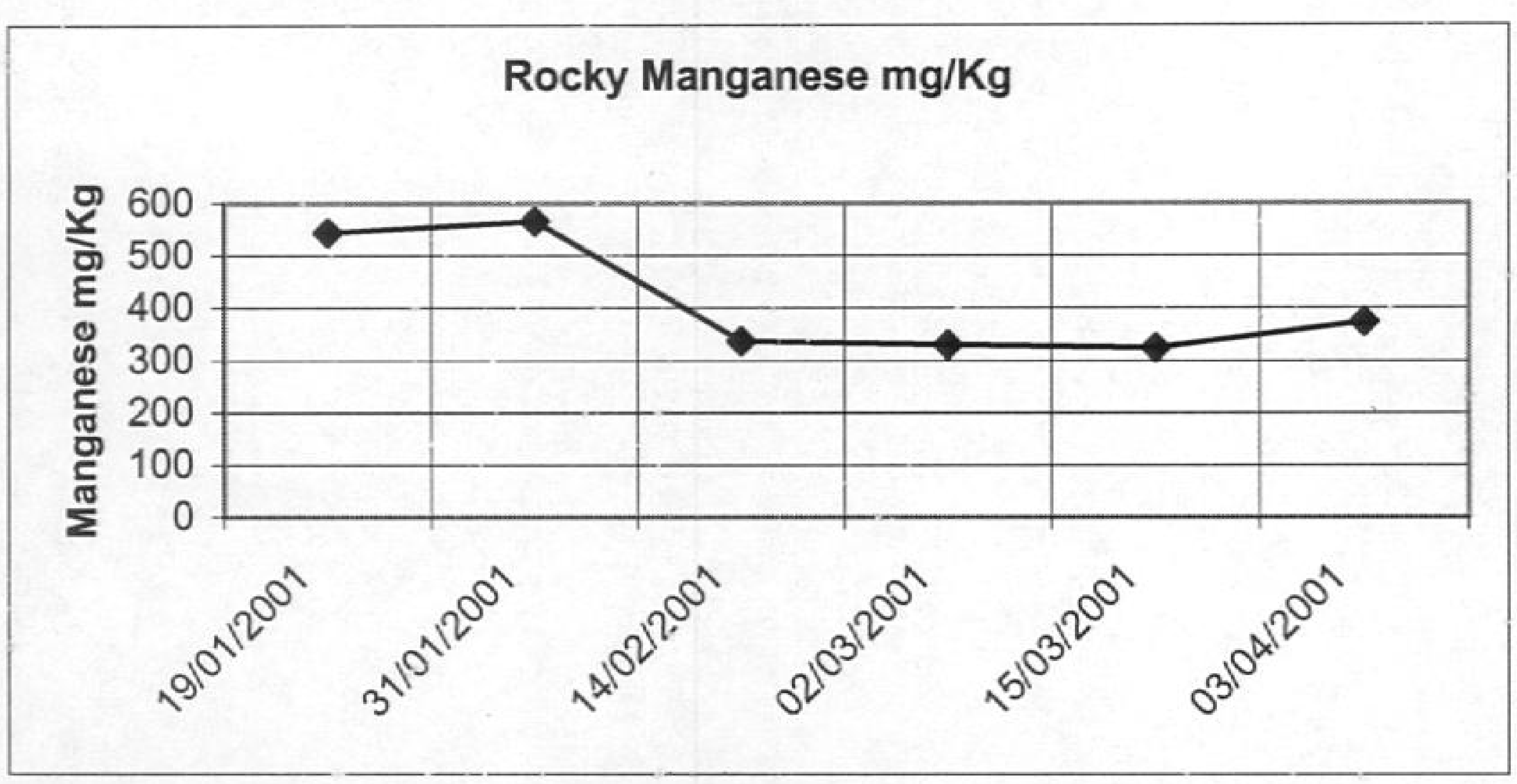

Rocky Calcium %
Calcium %
3.5
3
2.5
2
1.5
1
0.5
0
19/01/2001
31/01/2001
02/03/2001
15/03/2001
03/04/2001

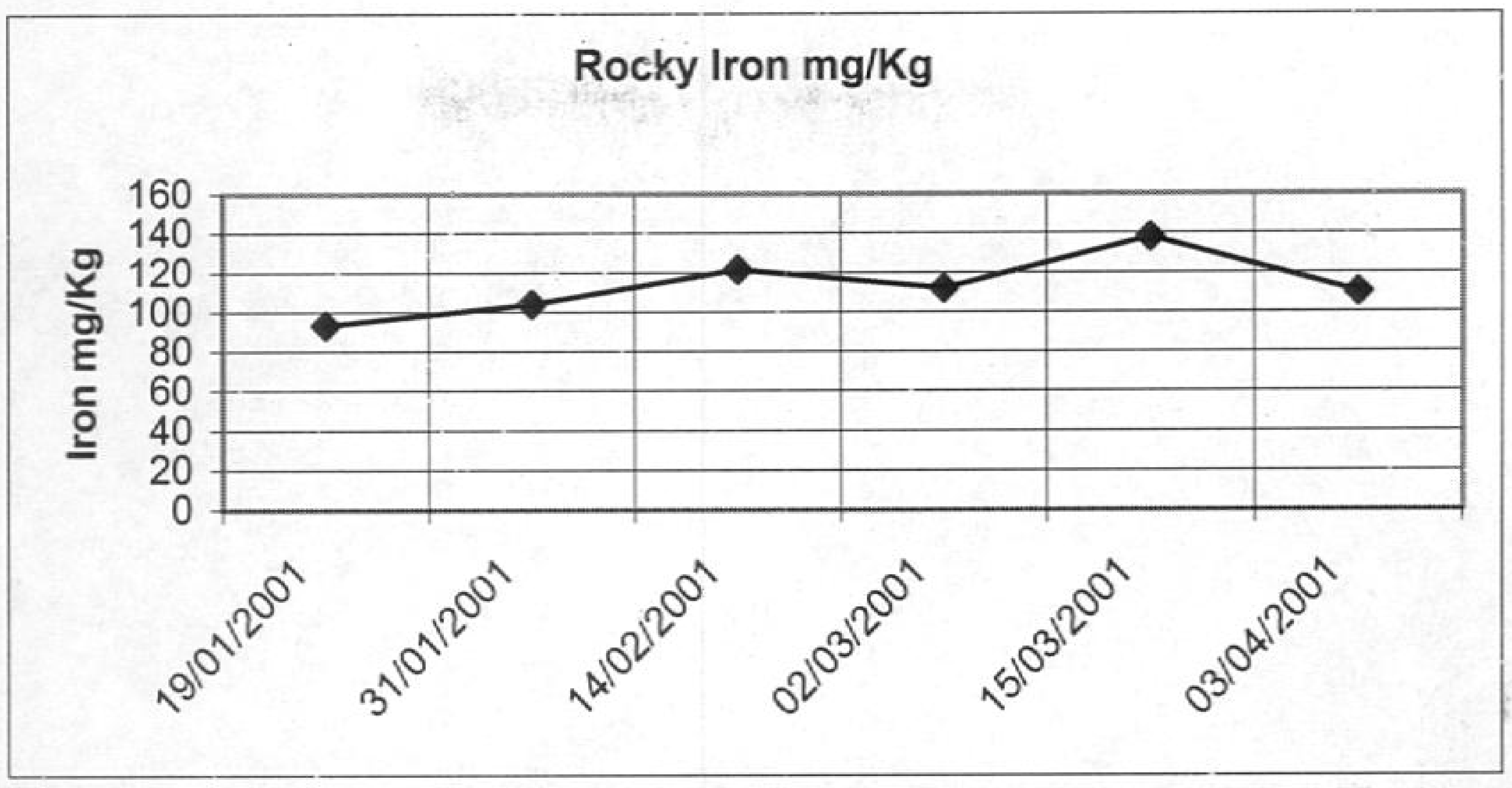

Rocky Magnesium %
Magnesium %
1.2
1
0.8
0.6
0.4
0.2
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

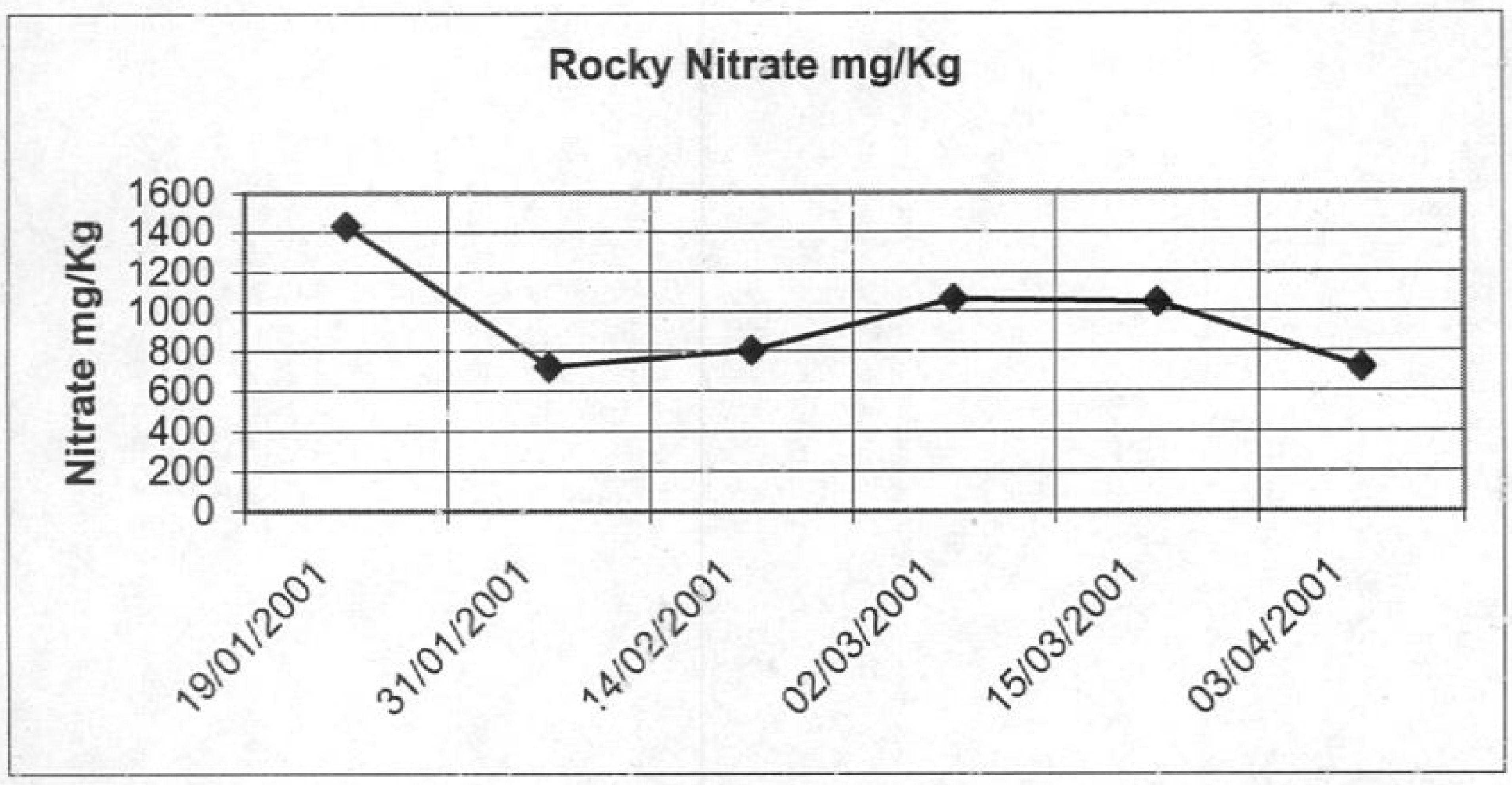

Rocky Chloride %
Chloride %
0.25
0.2
0.15
0.1
0.05
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

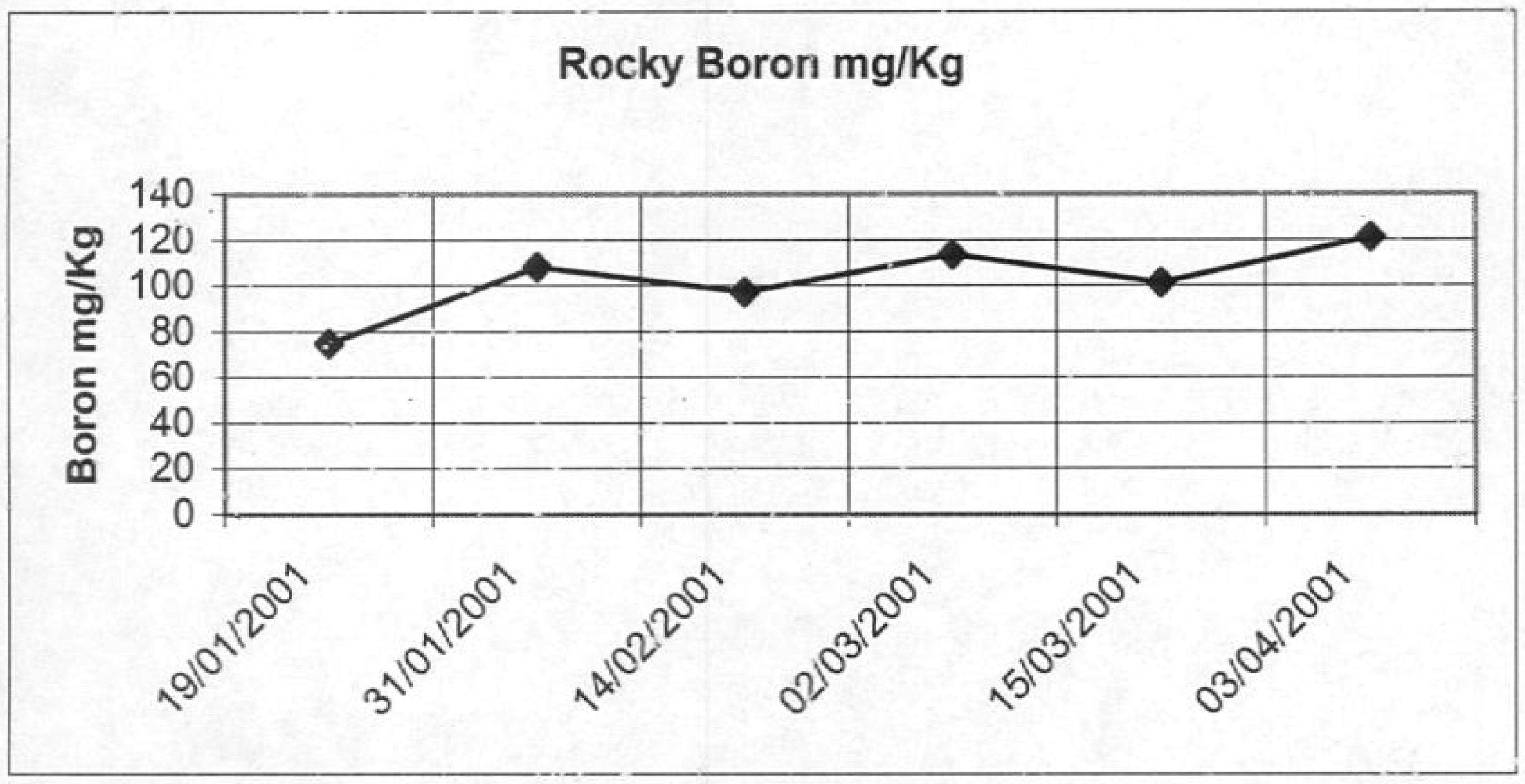

Rocky Copper mg/Kg
Copper mg/Kg
40
35
30
25
20
15
10
5
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

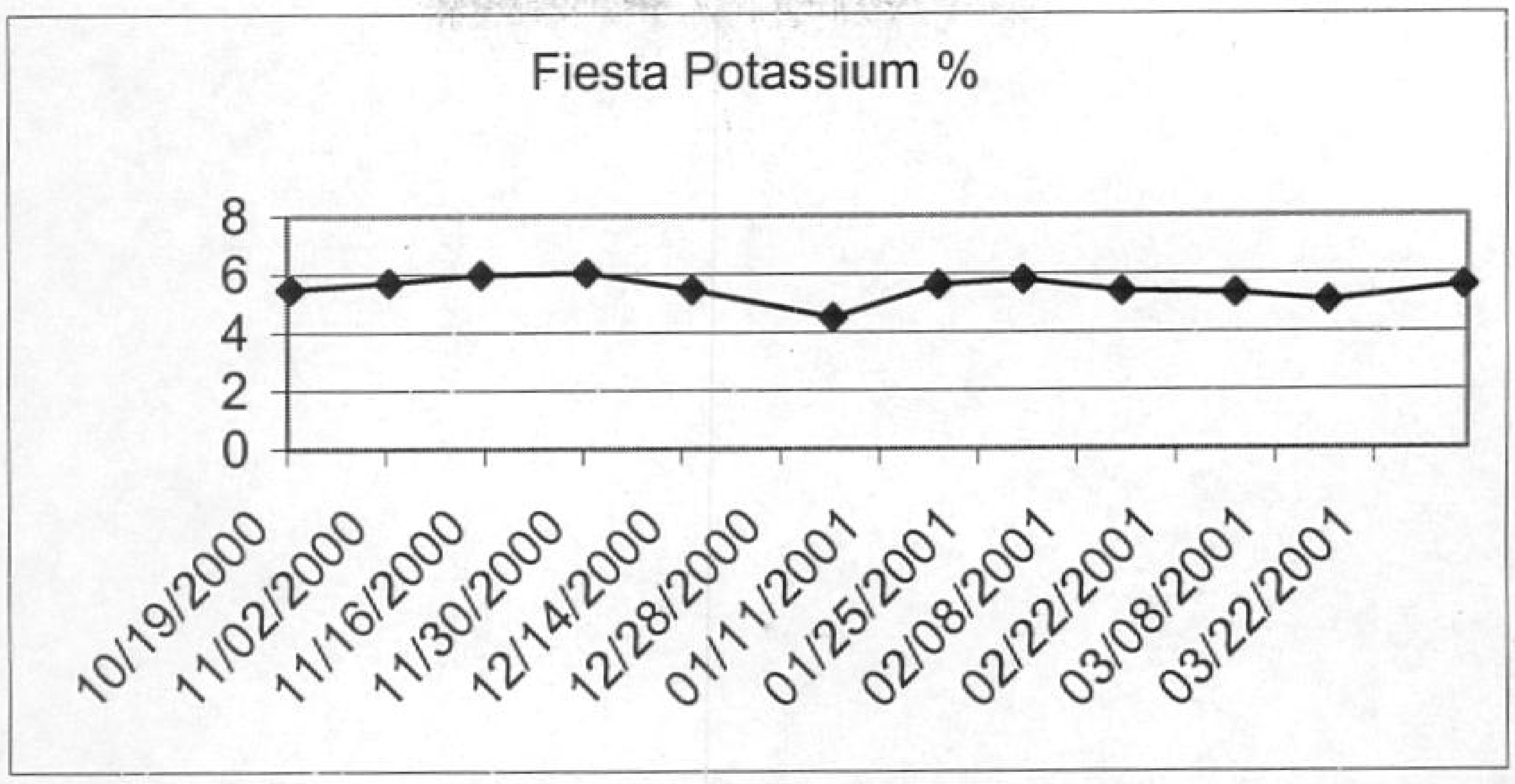

Rocky Zinc mg/Kg
Zinc mg/Kg
70
60
50
40
30
20
10
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

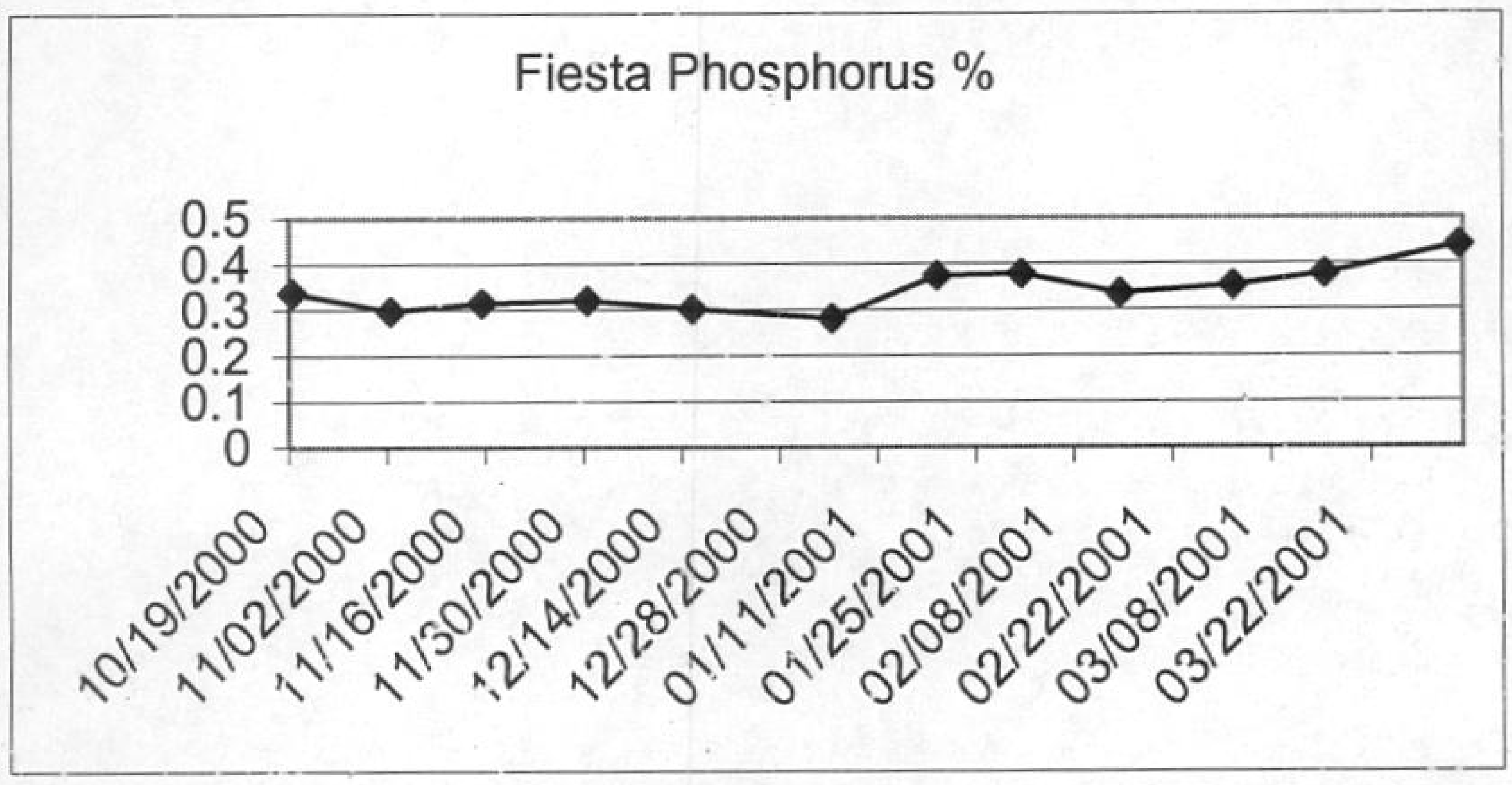

Rocky Manganese mg/Kg
Manganese mg/Kg
600
500
400
300
200
100
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

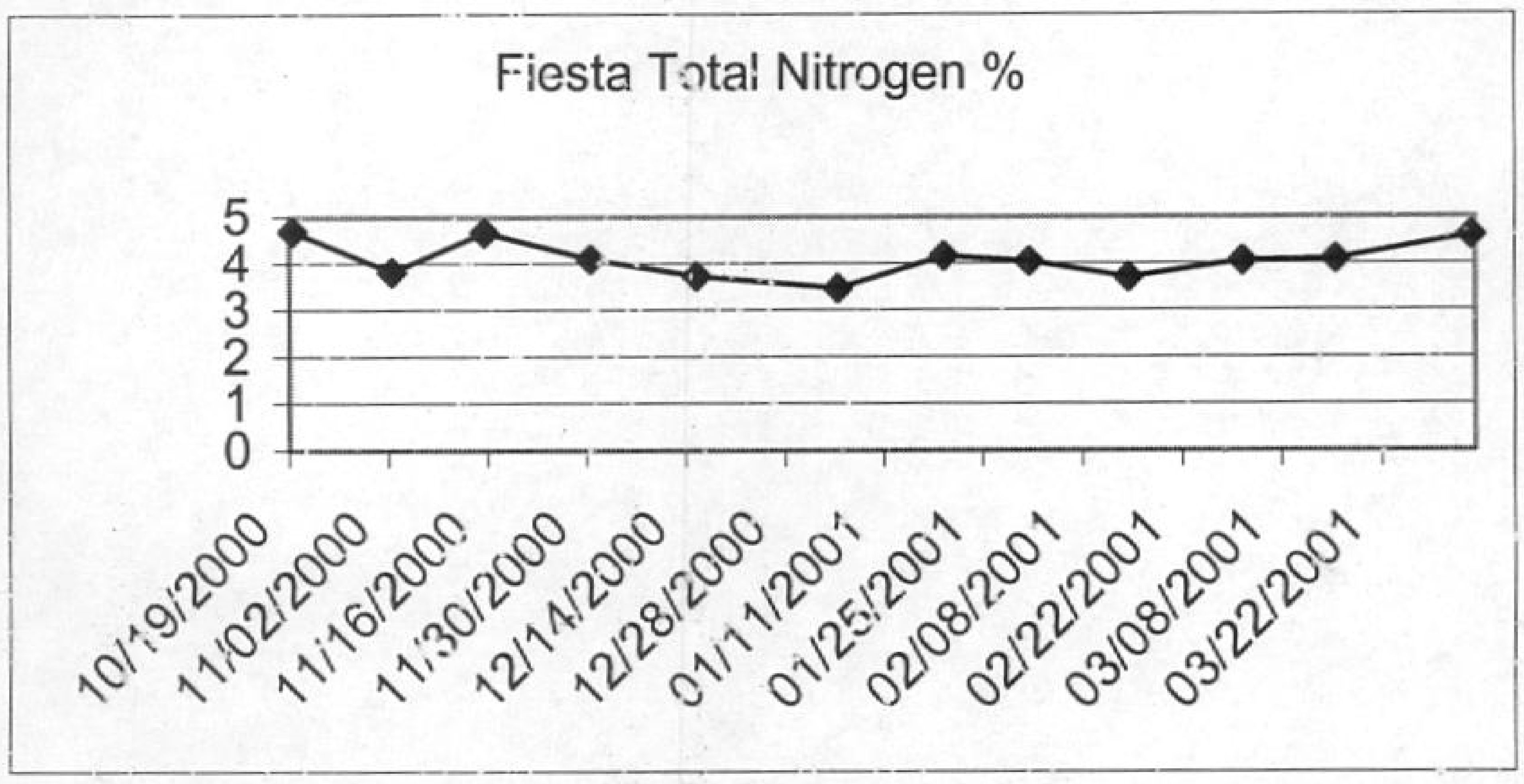

Rocky Iron mg/Kg
Iron mg/Kg
160
140
120
100
80
60
40
20
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

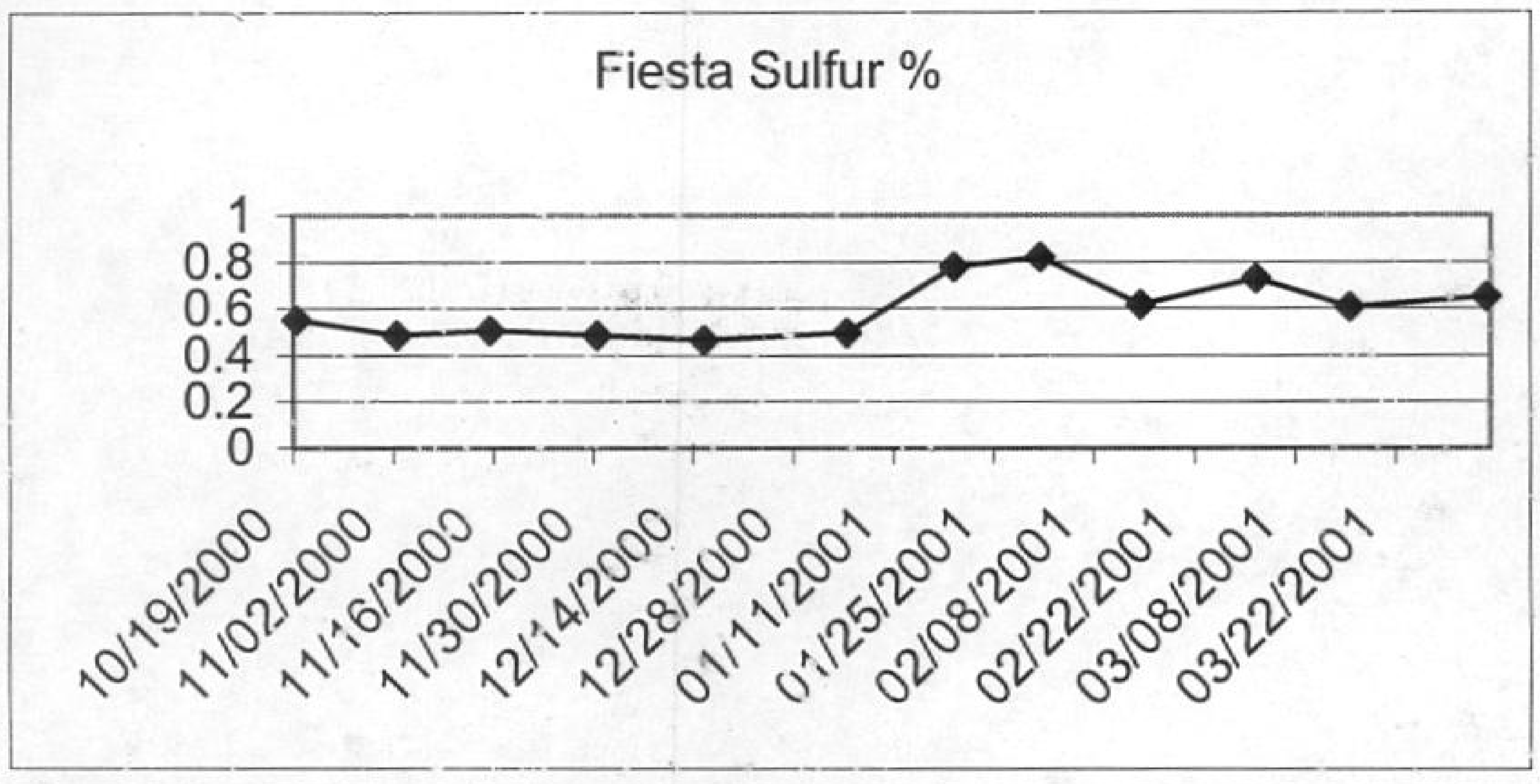

Rocky Nitrate mg/Kg
Nitrate mg/Kg
1600
1400
1200
1000
800
600
400
200
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

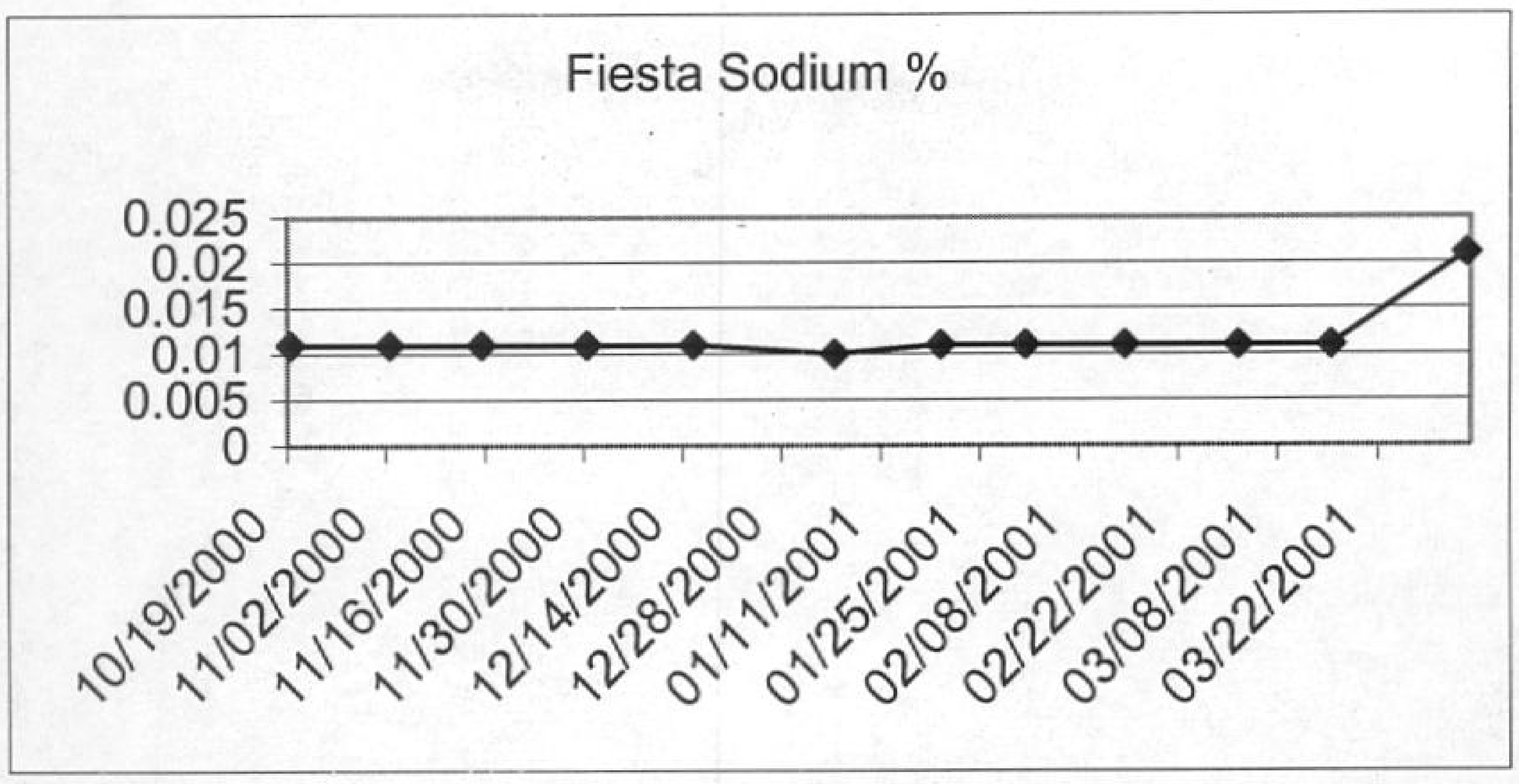

Rocky Boron mg/Kg
Boron mg/Kg
140
120
100
80
60
40
20
0
19/01/2001
31/01/2001
14/02/2001
02/03/2001
15/03/2001
03/04/2001

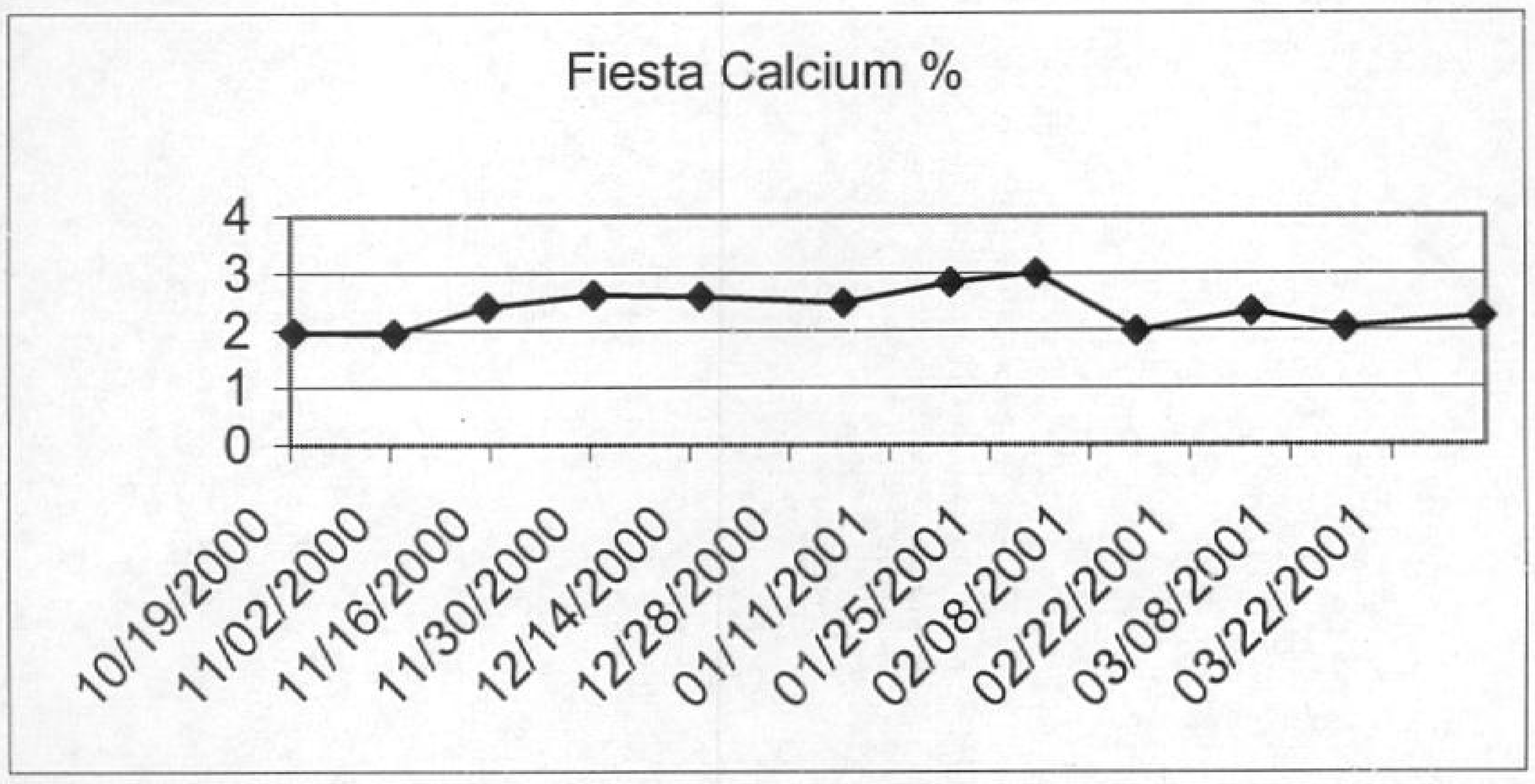

Fiesta Potassium %
8
6
4
2
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001

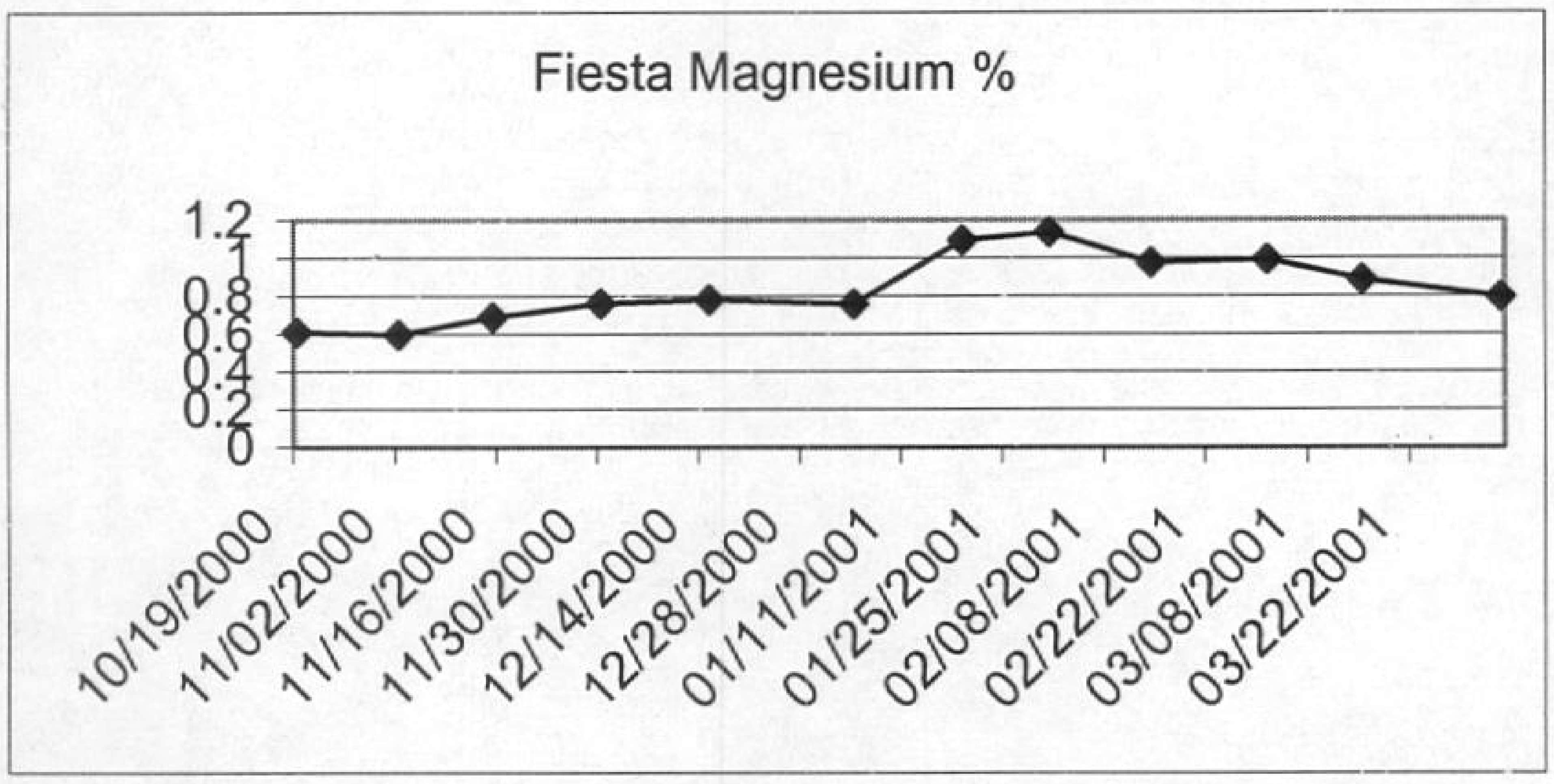

Fiesta Phosphorus %
0.5
0.4
0.3
0.2
0.1
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001

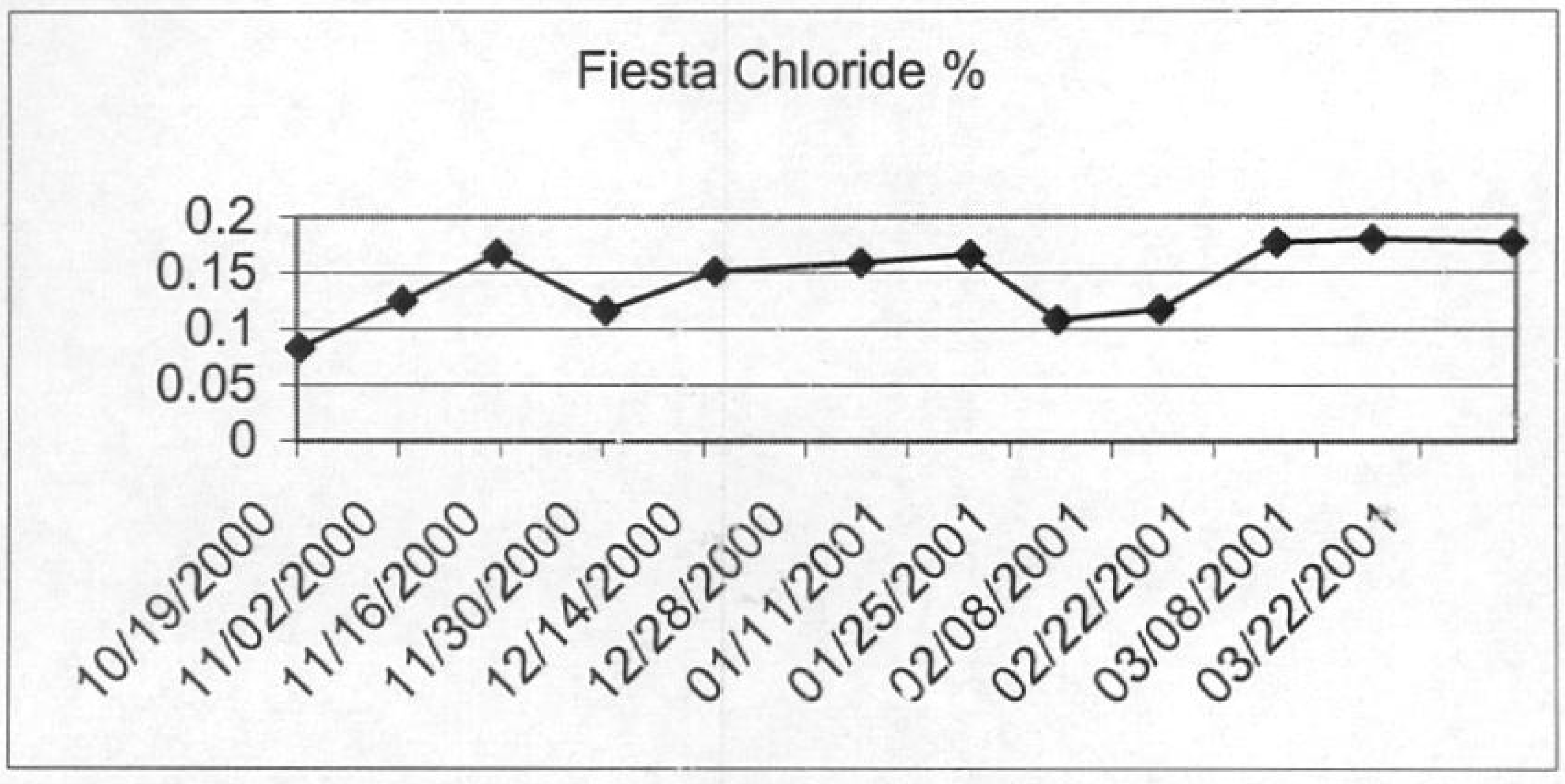

Fiesta Total Nitrogen %
5
4
3
2
1
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001

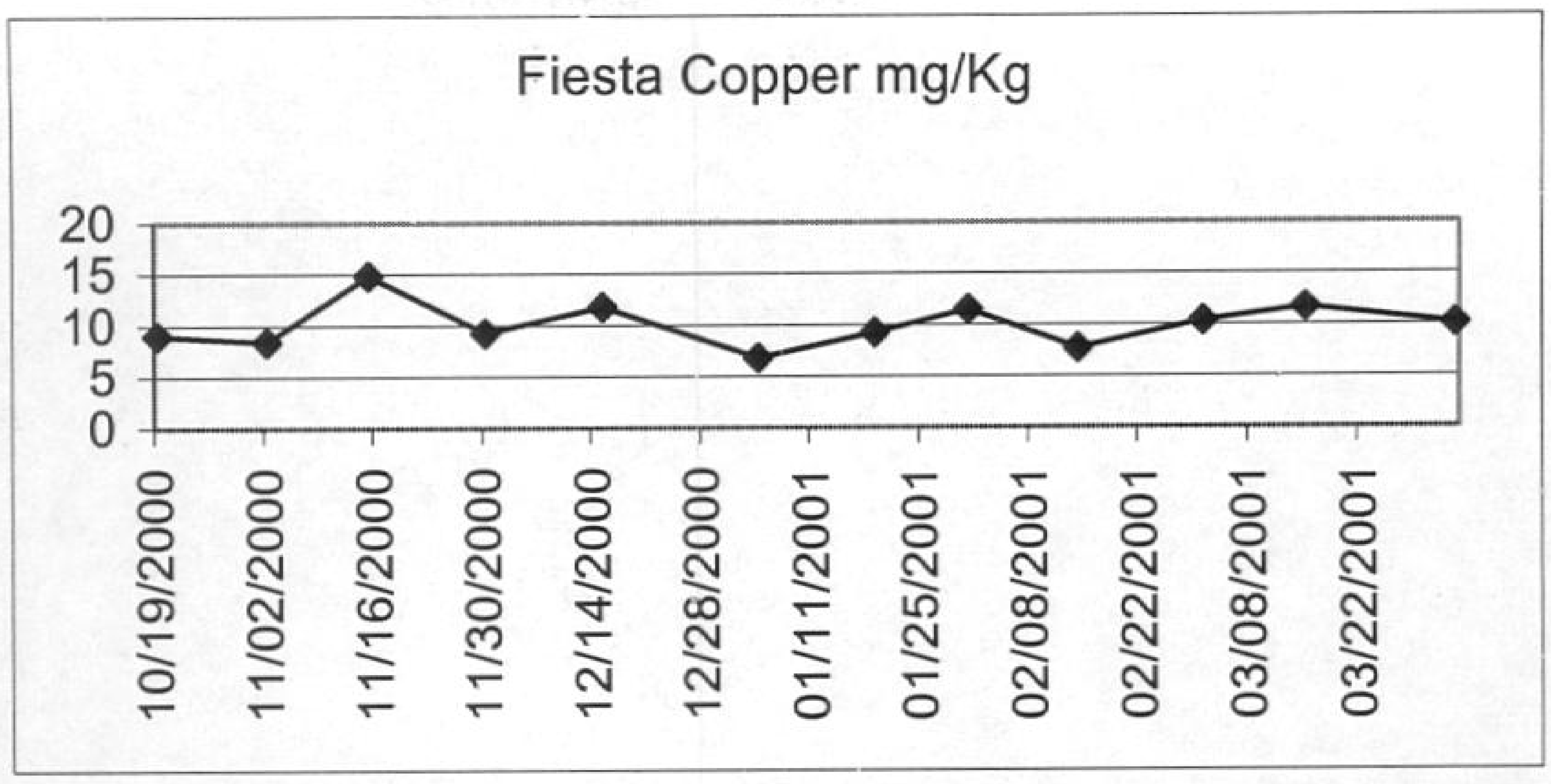

Fiesta Sulfur %
1
0.8
0.6
0.4
0.2
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001

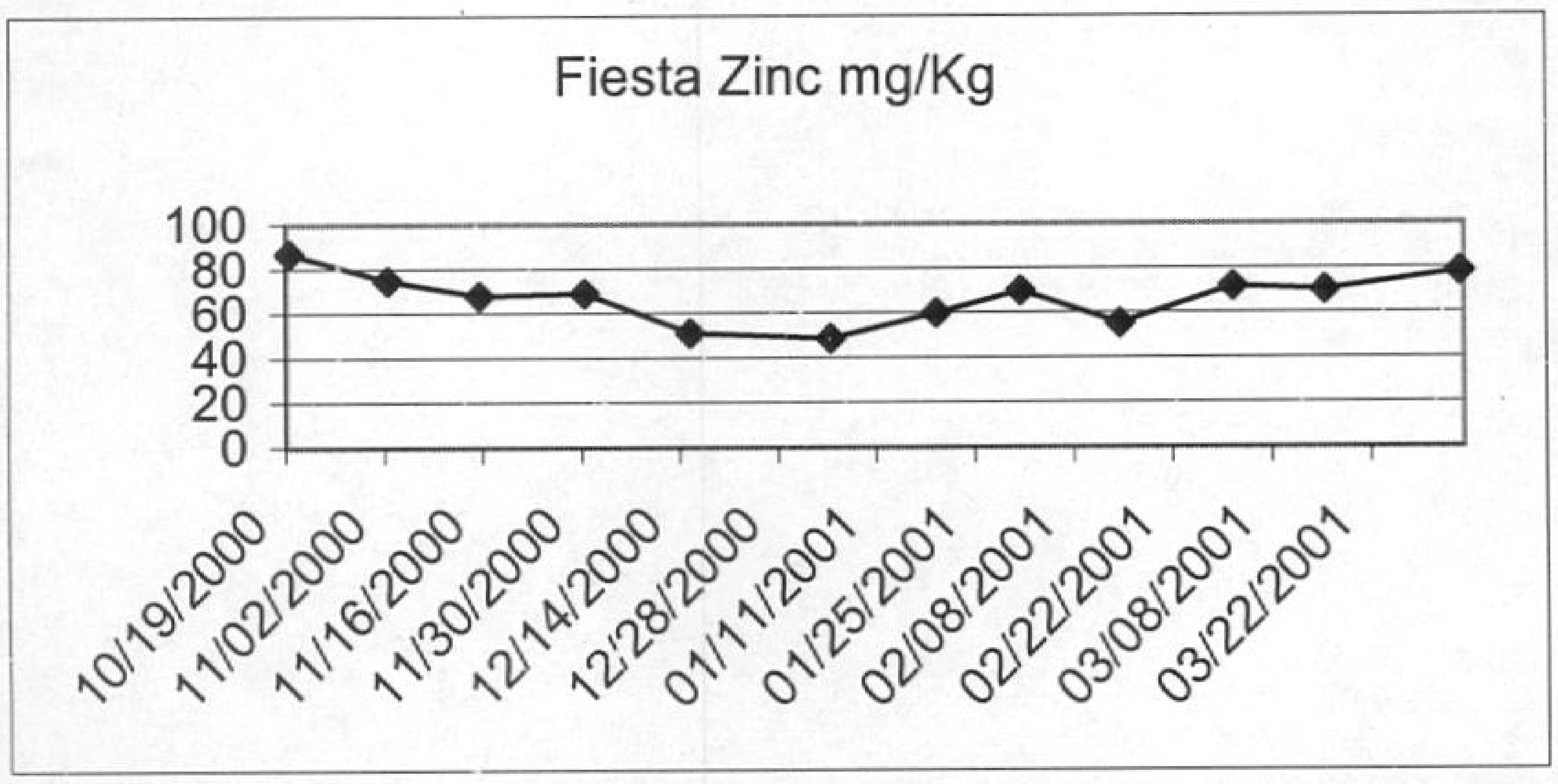

Fiesta Sodium %
0.025
0.02
0.015
0.01
0.005
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001

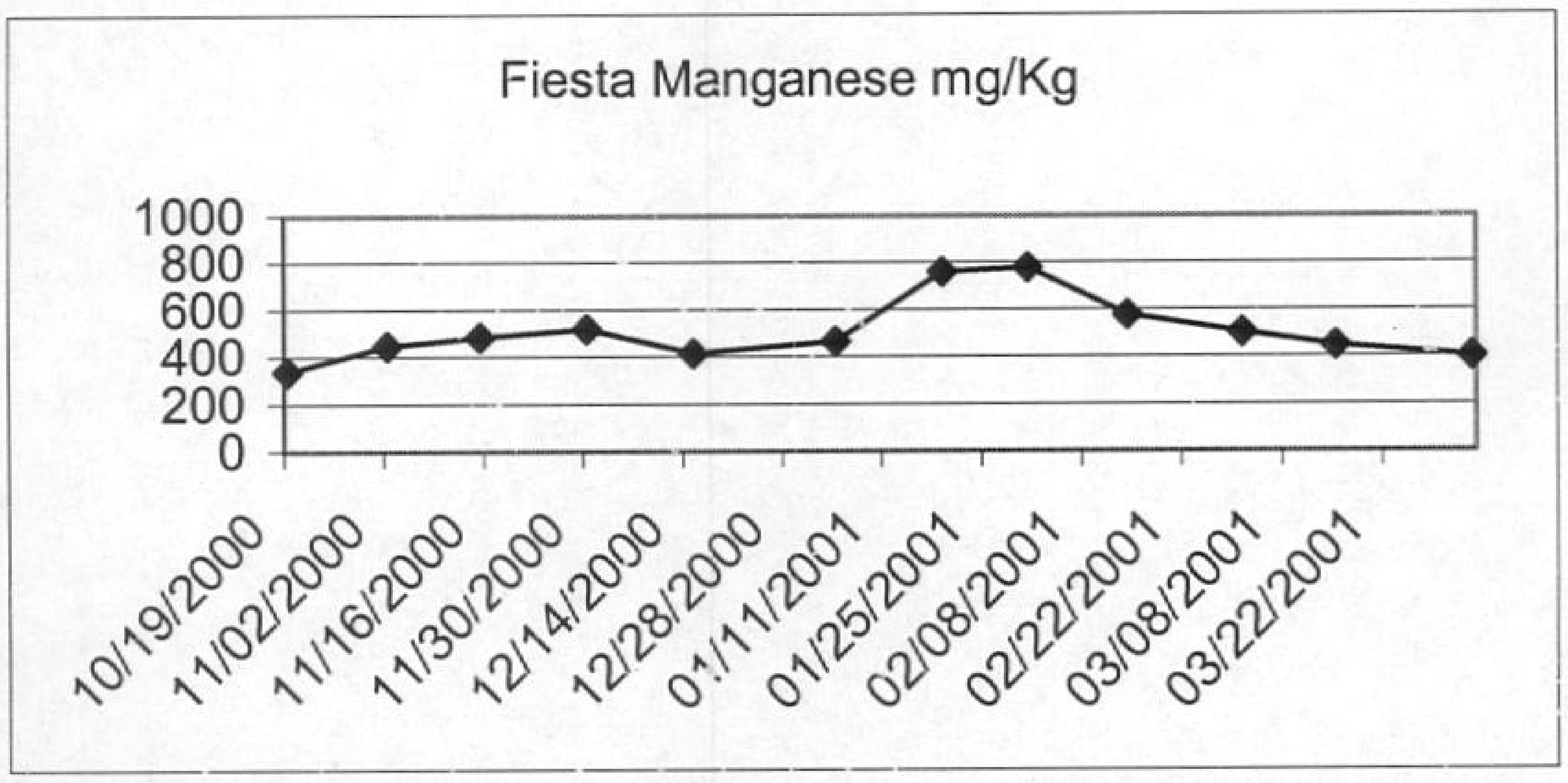

Fiesta Calcium %
4
3
2
1
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Magnesium %
1.2
1
0.8
0.6
0.4
0.2
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Chloride %
0.2
0.15
0.1
0.05
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Copper mg/Kg
20
15
10
5
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Zinc mg/Kg
100
80
60
40
20
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Manganese mg/Kg
1000
800
600
400
200
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
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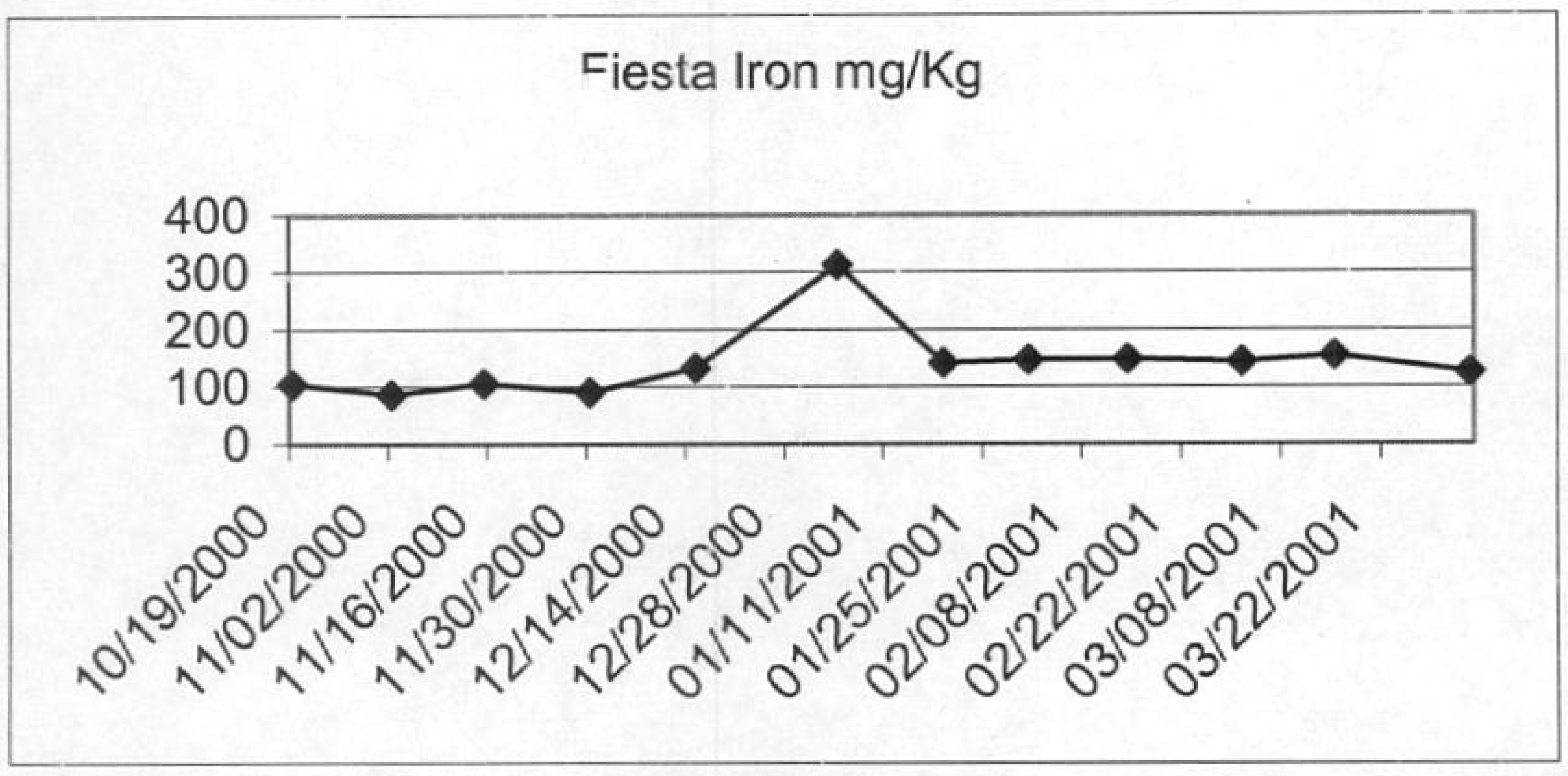
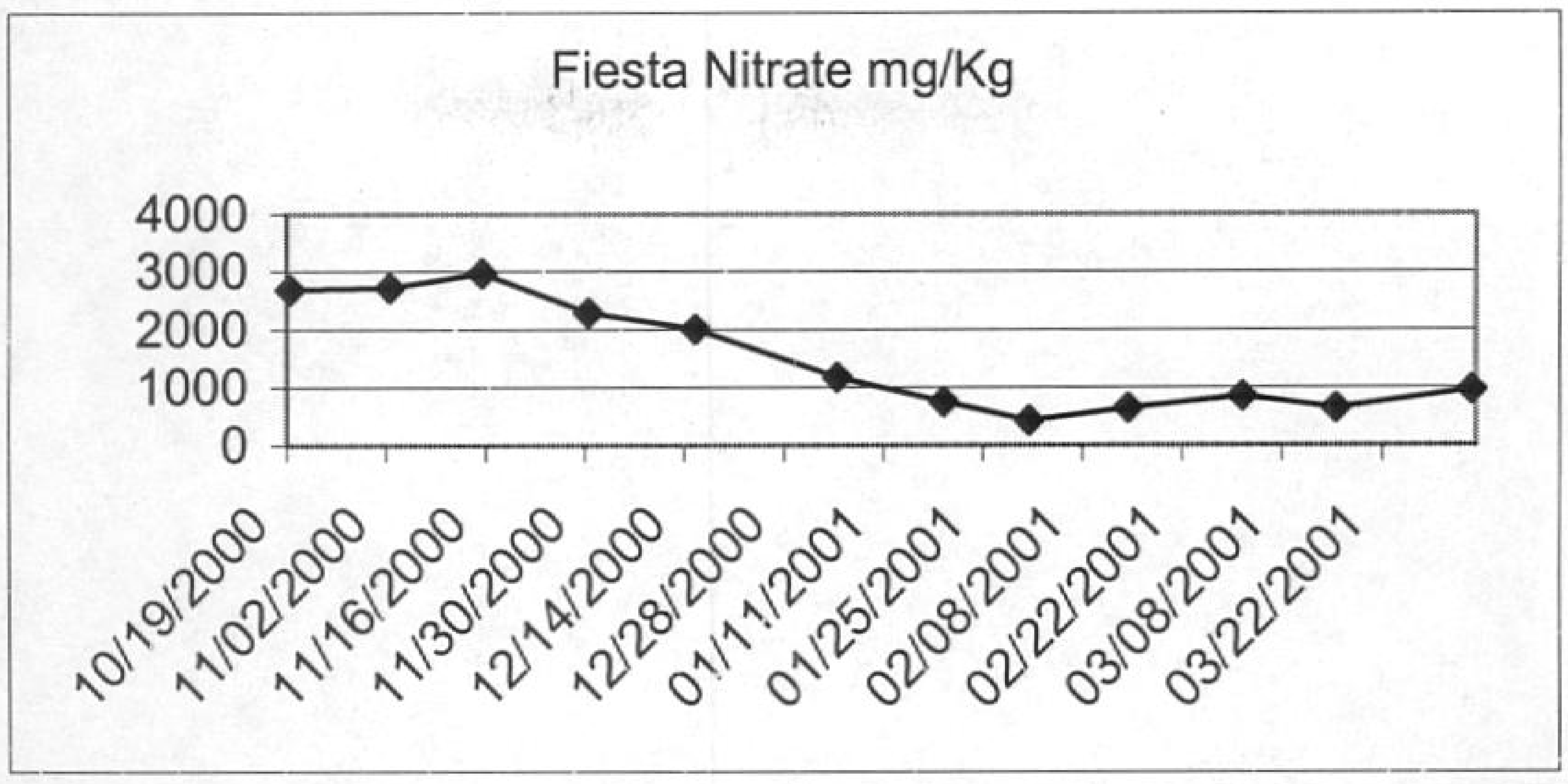
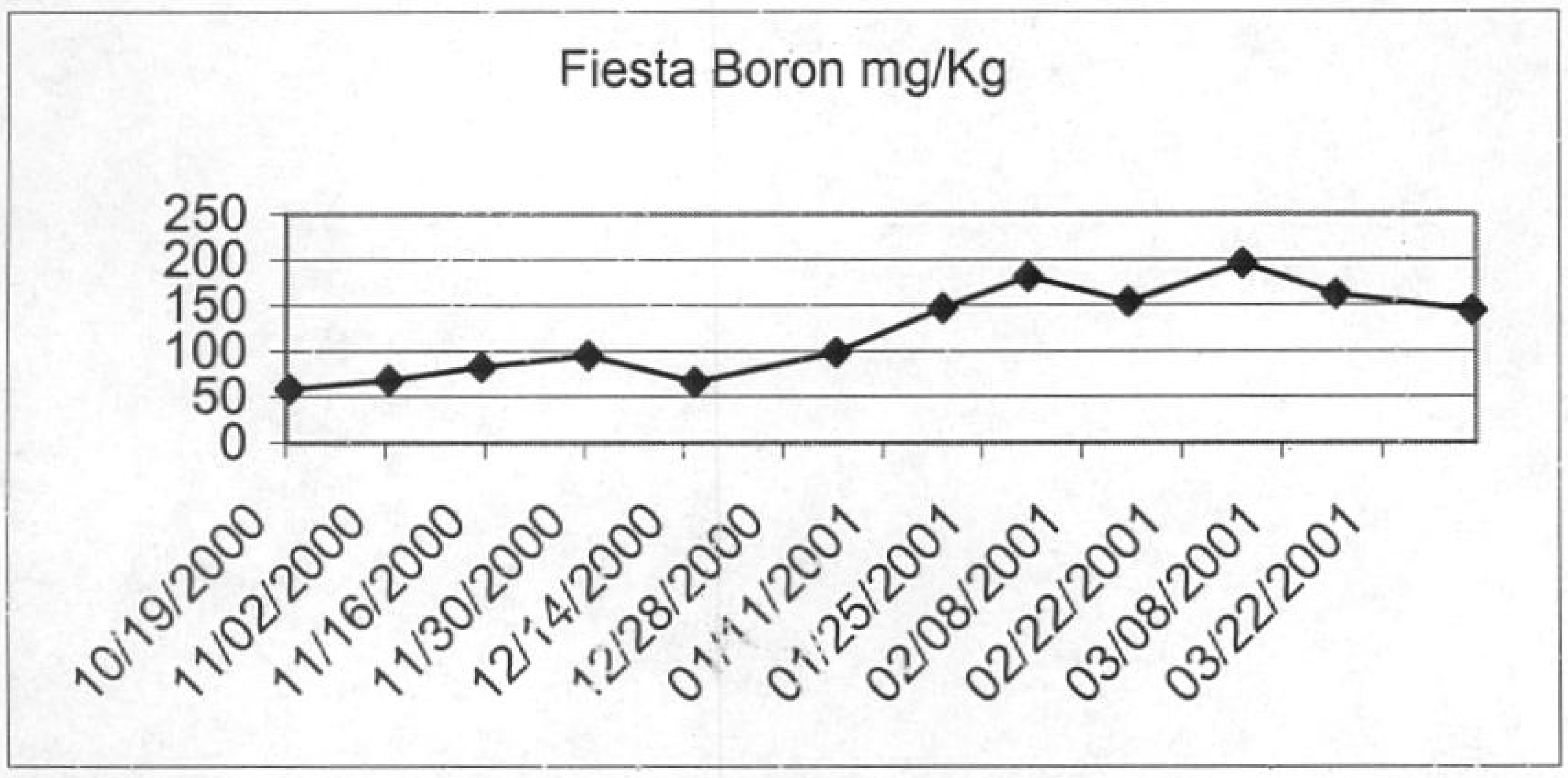
02/22/2001
03/08/2001
03/22/2001


Fiesta Iron mg/Kg
400
300
200
100
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Nitrate mg/Kg
4000
3000
2000
1000
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001


Fiesta Boron mg/Kg
250
200
150
100
50
0
10/19/2000
11/02/2000
11/16/2000
11/30/2000
12/14/2000
12/28/2000
01/11/2001
01/25/2001
02/08/2001
02/22/2001
03/08/2001
03/22/2001