COMPREHENSIVE RESEARCH PROGRESS REPORT FOR 1998

Submitted to SLV Research Center Committee
and the Colorado Potato Administrative Committee (Area II)

TITLE: **Characterizing and Overcoming Dormancy in Potato Minitubers**

PROJECT LEADERS: Cecil Stushnoff, Ann McSay, David Holm ,Susie Thompson Johns, Robert Davidson

PROJECT JUSTIFICATION: This proposal is based upon a need to better understand mechanisms which impart postharvest dormancy in minitubers, and to develop well-defined methods to overcome dormancy. Minituber producers and their customers have encountered problems when prolonged dormancy results in sporadic and unpredictable emergence. Recent research with normal tubers has shown that dormancy is cultivar specific, it is prolonged by exposure to low temperature, and it can be defined quantitatively in terms of storage temperature and duration. The emergence of late blight in production fields may restrict minituber seed production to non-infective seasons, thus further creating a need to understand and control minituber dormancy .

To the best of our knowledge, quantitative temperature requirements to maintain, or overcome, dormancy have not been reported for most modern potato cultivars and especially not for minitubers. Apparently, various chemical dormancy breaking agents have been tried on minitubers, but with little consistent success. This might be expected if there is a strong interaction with temperature and dormancy status. It would thus be essential to first characterize the role of temperature then optimize the potential use of growth regulating chemicals if temperature treatments alone are insufficient.

PROJECT DETAILS: (a) Tuber dormancy. Ten single tuber replications of medium-sized tubers for each of six cultivars and selections (AC83064-6, CO85026-4, Russet Norkotah, Russet Nugget, Nooksack, and Russet Burbank, obtained from the San Luis Valley Research Center right after harvest and field curing) were placed in perforated plastic bags, which were stored in cardboard cartons at 4, 8, 12, 16 and 20 C storage temperatures. Each tuber was examined, weekly from 16 and 20 C storage, biweekly from 12 C storage, every 3 weeks from 8C and monthly from 4C storage. Studies began Oct. 13, 1997 and ended June 22, 1998. Date and percent bud break was recorded until all buds broke at each temperature; alpha galactosidase enzymes assays were run, and separate samples were freeze-dried and stored for future soluble sugar analysis.

Storage characteristics of each cultivar are presented in Table 1. And Figures 1 to 6.. From these data one can detect the onset of tuber bud break or any % bud break from 10 to 100 for the duration of the storage study. Four C was the most effective storage temperature for all cultivars. AC83064 was the least responsive to 4C storage and broke bud the quickest at all temperatures. CO85026-4 was very similar to Russet Norkotah and Russet Nugget as with intermediate storage qualities. Nooksack and Russet Burbank were clearly the best storage cultivars.

(b) Minituber dormancy. Sub-lethal temperature stresses, both low and high temperatures, were tested on 600 minitubers from six cultivars (6-month-old FL1867, Shepody and Ute; 3-month old R. Nugget and R. Norkotah; and 2-month-old DT6063-IR). Details of procedures for these studies are enclosed as Appendices 1 to 5. Figures 7 to 10 illustrate % bud break for minitubers incubated at 18 and 23 C following the stress treatments. Tests using dormancy breaking agents including gibberellic acid (GA3), coumarin, o-coumaric acid, p-coumaric acid, calcium nitrate and red light exposure, in combination with alternating stratification have been initiated with AC88042-1 (obtained from David Holm).

Sub-lethal temperatures (lowest and highest temperatures permitting survival of minitubers) were determined. Minitubers survived freezing at 2C per hour as low as -4C, but not at lower temperatures. A few minitibers broke buds after exposure to -1 and -3C. However, inconsistent response suggested this was not likely to be a promising approach.

Minitubers exposed to heat shock treatments (25 to 70C for one hour) revealed a sub-lethal survival temperature of 55C. When six cultivars and selections were given heat shock exposures for one hour over a range of temperatures (33 to 39C), the highest level of bud break occurred after a 35C heat shock treatment and incubation for bud sprouting at 18C (64F) compared to incubation at 23C (74F). In all cases sprouting was reduced at 23C, suggesting incubation temperature needs further study, as well. Six, three, two and one-month old minitubers were tested. As one might expect the six-month old minitubers were most responsive. Six-month minitubers from one cultivar, FL1867, had the highest level of bud break, and the shortest incubation time (7 days) regardless of treatment. Six-month old Ute and Shepody also produced sprouts after 7 to 14 days incubation at 18C. Two-month old DT 6063-IR and three-month old Russet Norkotah also responded to 33 or 35C heat shock, but three-month old R. Nugget did not, and required 28 days incubation to produce sprouts. ∝Galactosidase enzyme activity was highest in non-dormant FL1867. Lengthening the heat shock up to 4 hours did not improve bud break.

In summary: (1) FL1867 required the least time and broke more buds than the other cultivars, regardless of the treatment; (2) incubation at 18C was far more effective than at 23C, in fact 23C could be considered inhibitory for bud break regardless of temperature stress treatments; (3) generally, as might be expected, six-month old minitubers stored at 4C were less dormant than two or three-month old tubers, but this effect is also confounded by cultivar response and needs further study; (4) postharvest temperature treatments, at best, have only a minimal effect on tuber dormancy.

OBJECTIVES FOR 1999:

1. **To continue studies to quantify storage temperatures required to break dormancy in selected cultivars of potato minitubers.**
2. **To determine if a rapid assay for α-galactosidase can be used to characterize dormancy in potato minitubers.**
3. **To continue testing minituber response to dormancy breaking agents.**
4. **To test the impact of MCP, an ethylene binding product in regulating potato bud dormancy.** A recent published report (Suttle, 1998), while not totally convincing, suggests other ethylene binding agents such as silver nitrate and 2,5-norbornadiene applied at early stages of development suppressed dormancy of potato microtubers. MCP is a new non-gaseous ethylene binder, presently approved for use to extend shelf- life of floral crops. Research procedures outlined in the 1998 proposal will be followed in these investigations.

Reference

Suttle, J.C. 1998. Involvement of Ethylene in Potato Microtuber Dormancy, Plant Physiol. 118:843-848.

Table 1. Days required to attain 50% bud break at five storage temperatures					
	20°C	16°C	12°C	8°C	4°C
Short Dormancy Group					
AC83064-6	35	42	43	62	130
CO85026-4	45	47	64	85	210
Intermediate Dormancy Group					
Russet Norkotah	57	63	72	91	200
Russet Nugget	61	74	82	97	210
Long Dormancy Group					
Nooksack	68	73	91	122	223
Russet Burbank	70	82	92	140	223

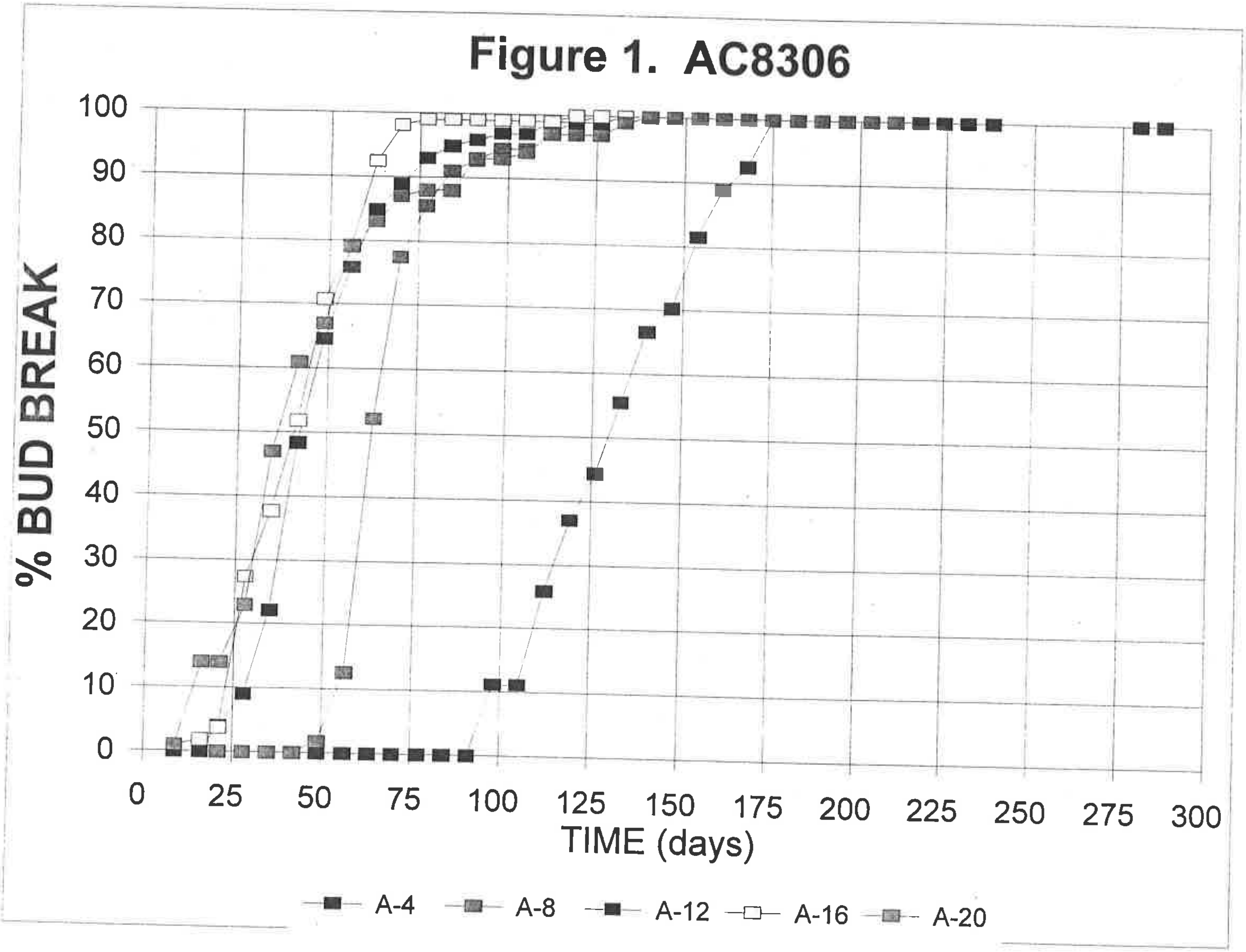


Figure 1. AC8306
% BUD BREAK
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
225
250
275
300
TIME (days)
A-4
A-8
A-12
A-16
A-20

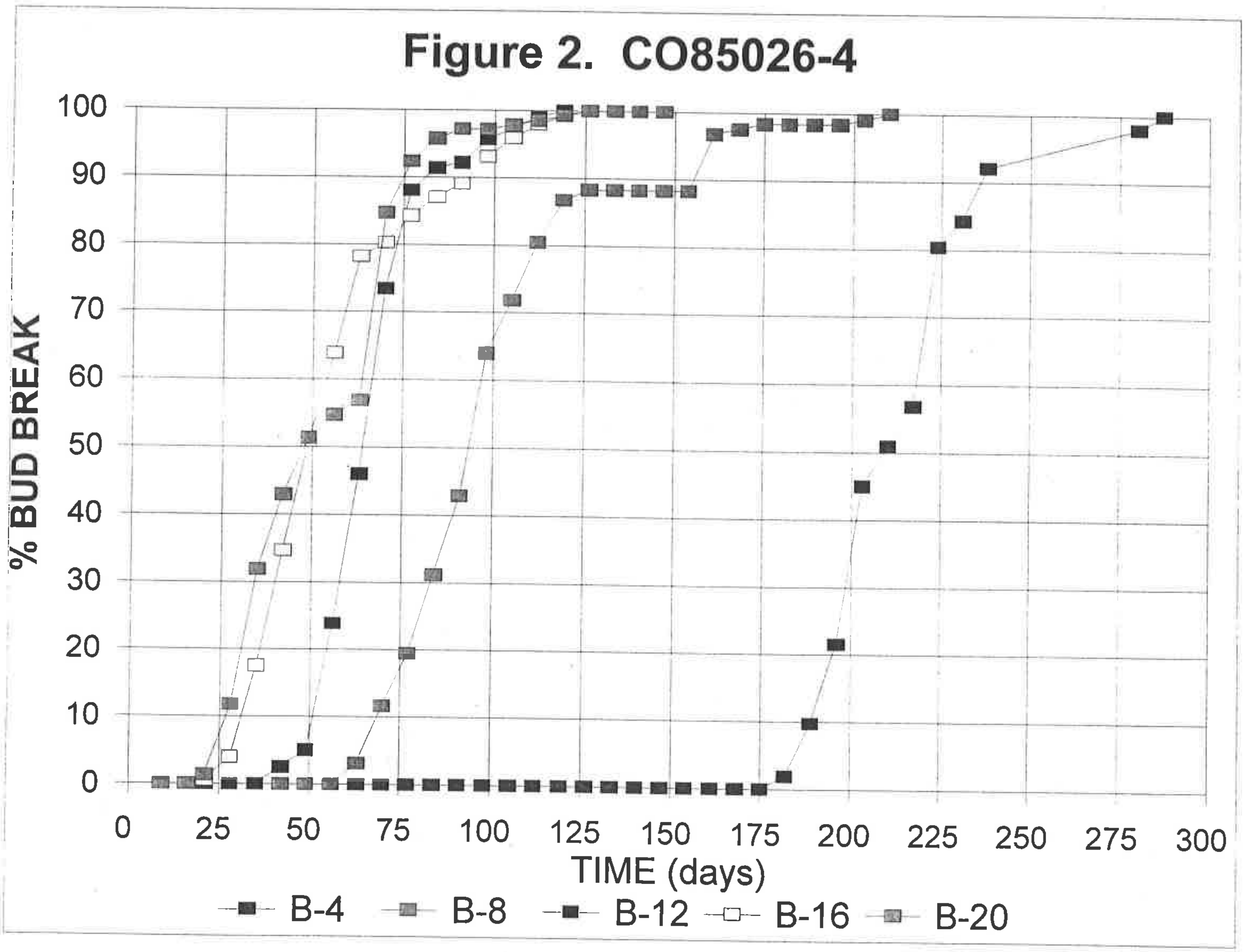


Figure 2. CO85026-4
% BUD BREAK
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
225
250
275
300
TIME (days)
B-4
B-8
B-12
B-16
B-20

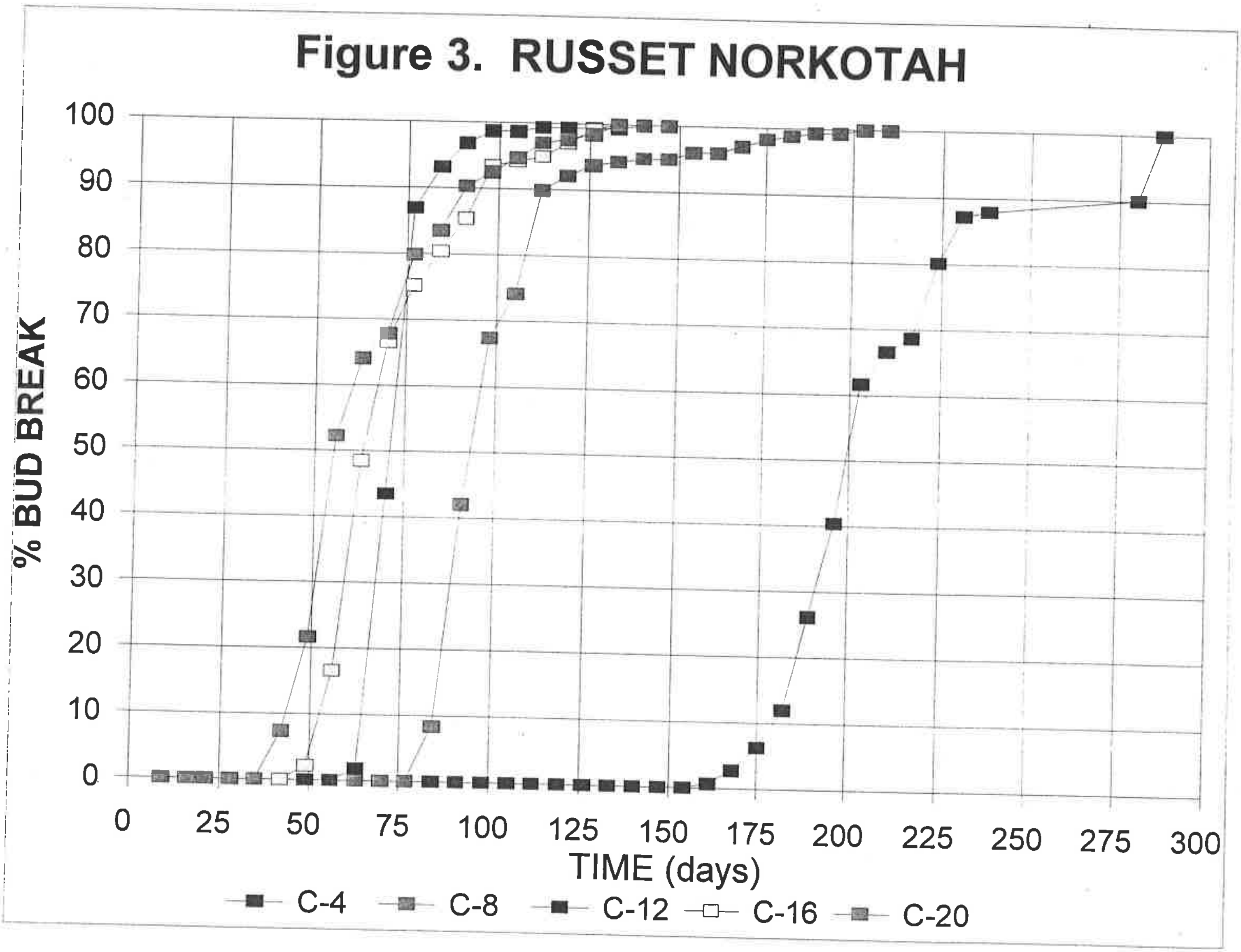


Figure 3. RUSSET NORKOTAH
100
90
80
70
60
50
40
30
20
10
0
% BUD BREAK
0
25
50
75
100
125
150
175
200
225
250
275
300
TIME (days)
C-4
C-8
C-12
C-16
C-20

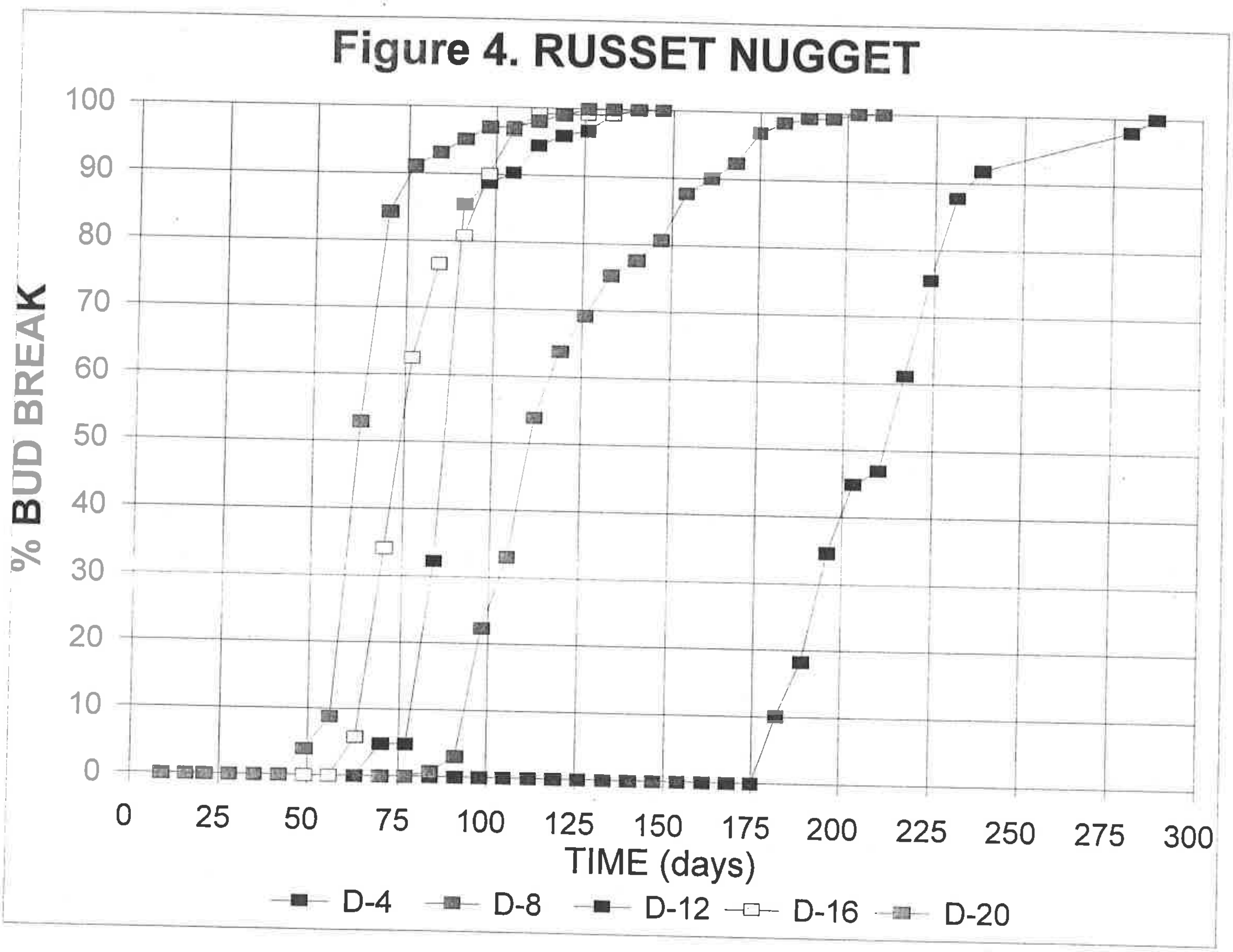


Figure 4. RUSSET NUGGET
% BUD BREAK
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
225
250
275
300
TIME (days)
D-4
D-8
D-12
D-16
D-20

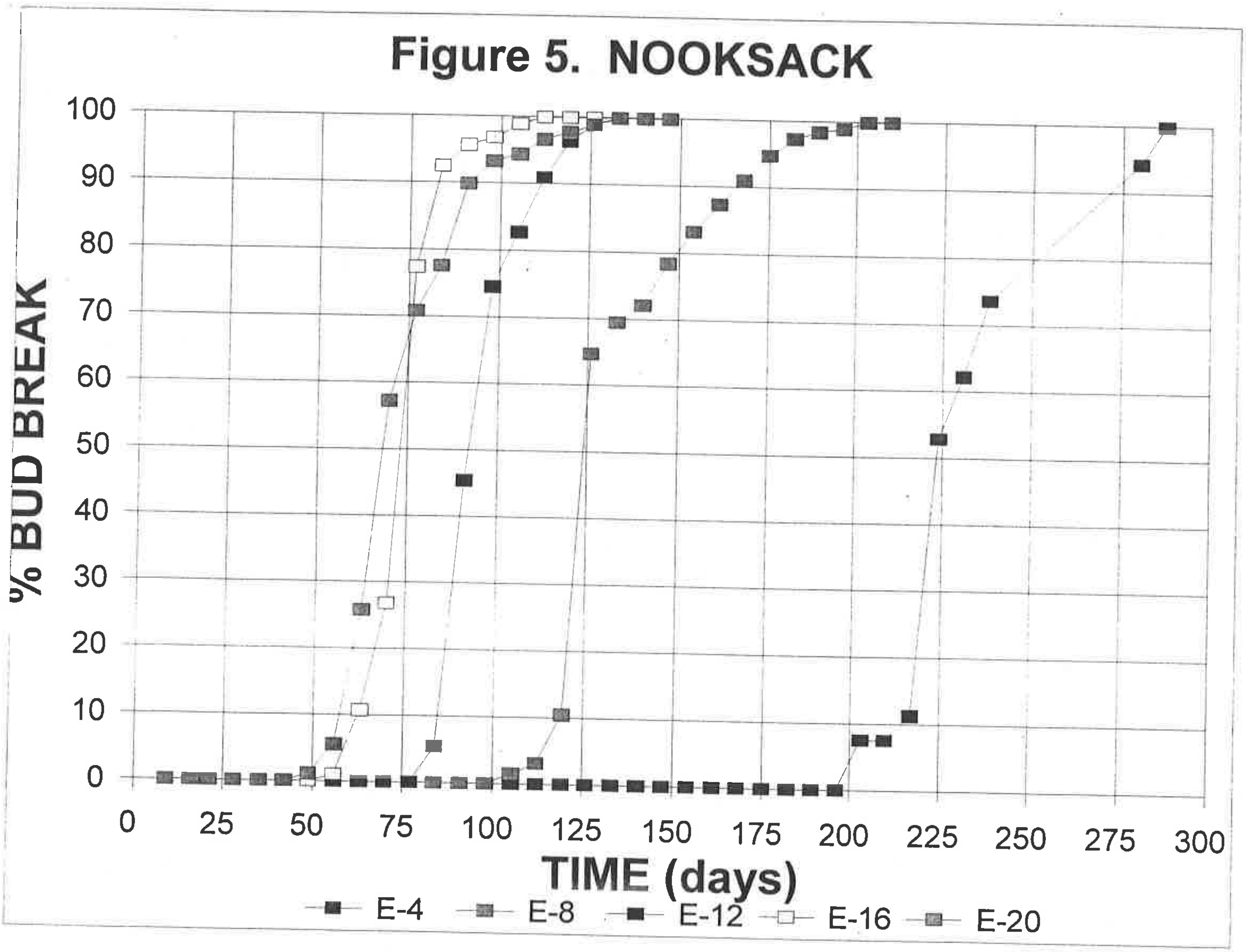


Figure 5. NOOKSACK
% BUD BREAK
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
225
250
275
300
TIME (days)
E-4
E-8
E-12
E-16
E-20

Figure 6. RUSSET BURBANK

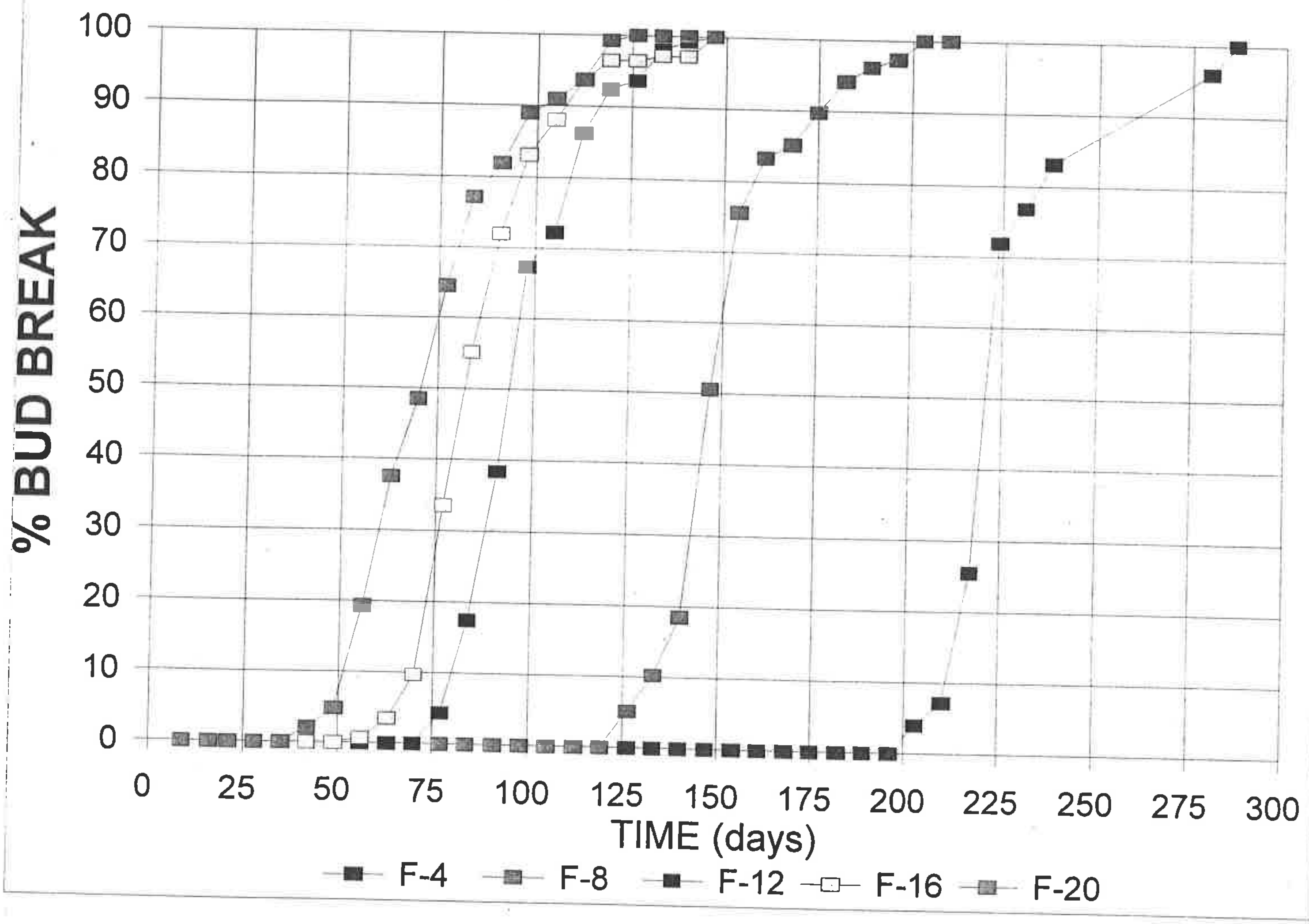
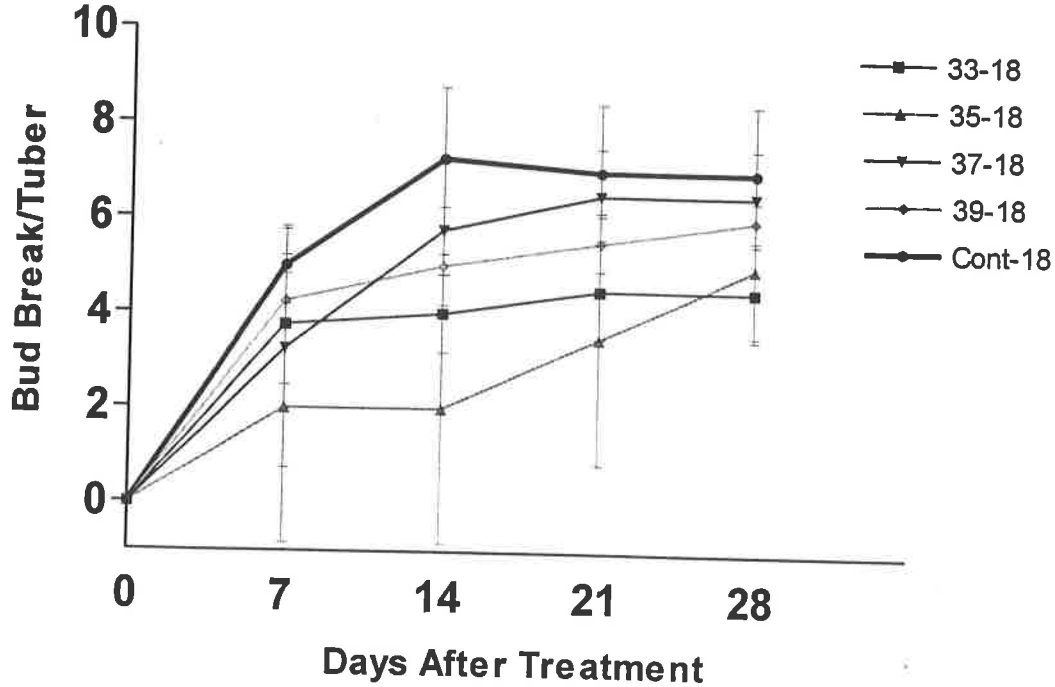


Figure 7.

Six-month-old FL 1867 after 1 Hour Heat Shock, Grown at 18C



Six-month-old FL1867 after 1 Hour Heat Shock, Grown at 23C

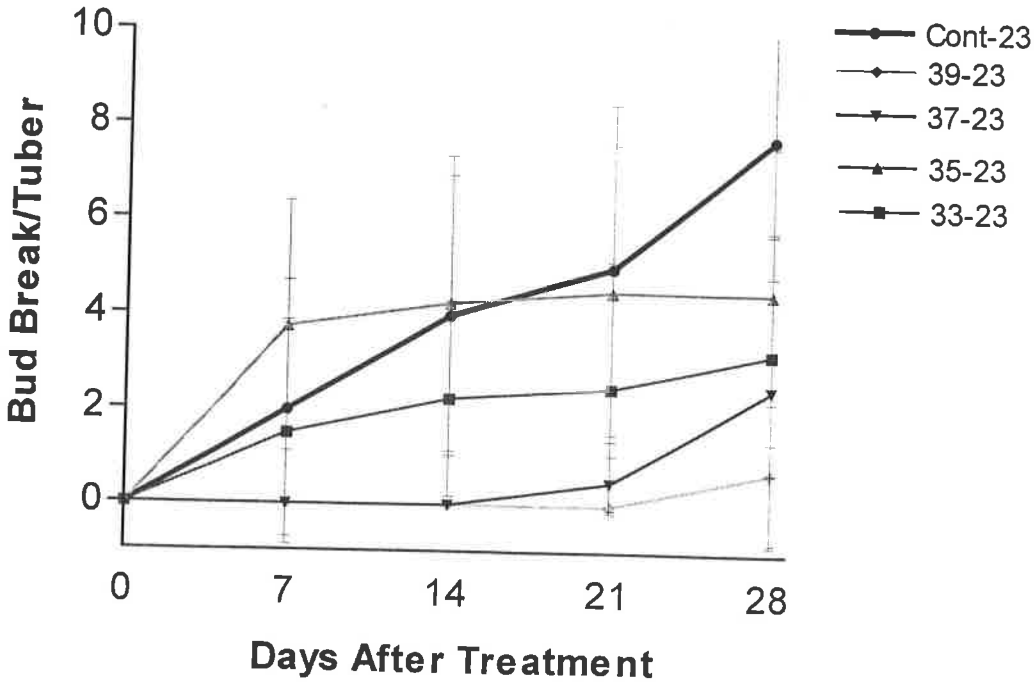
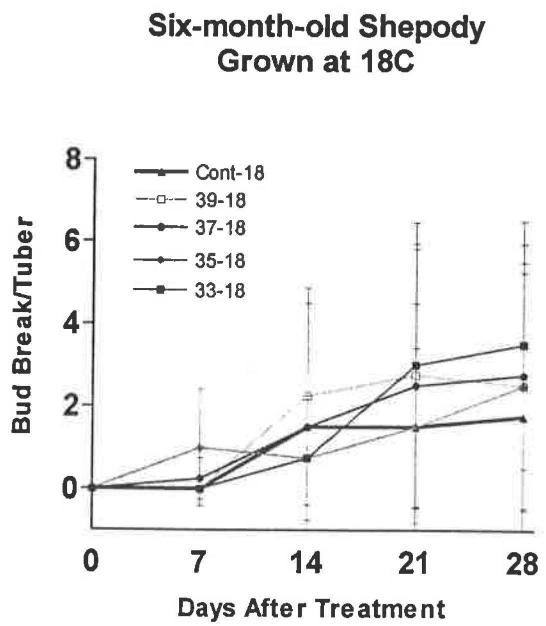
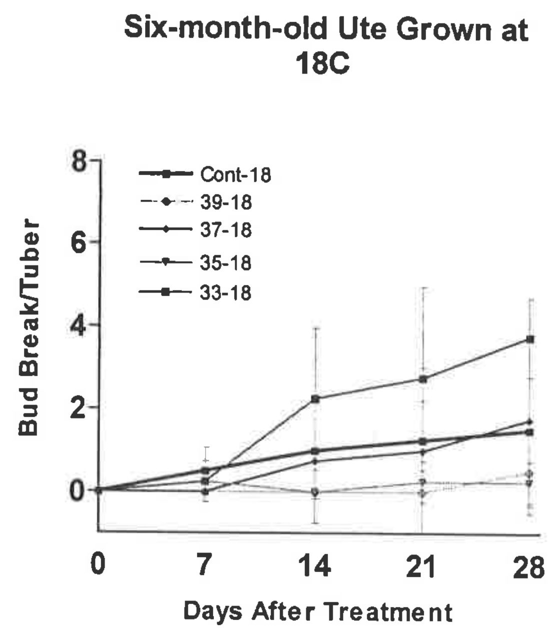
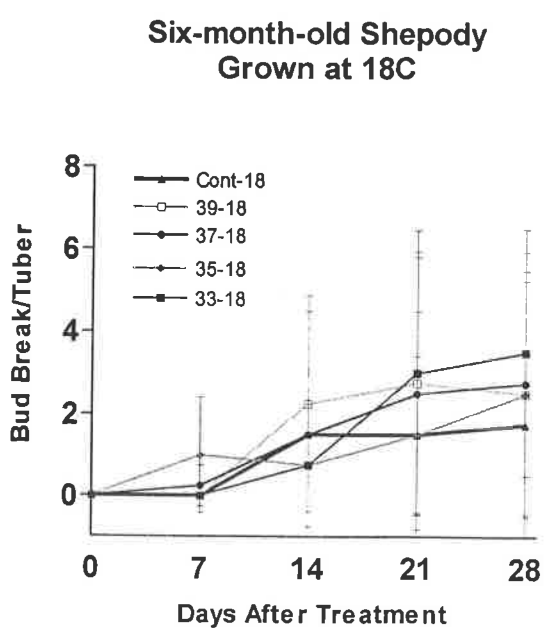


Figure 8.


Six-month-old Shepody Grown at 18C
Cont-18
39-18
37-18
35-18
33-18
Bud Break/Tuber
Days After Treatment


Six-month-old Ute Grown at 18C
Cont-18
39-18
37-18
35-18
33-18
Bud Break/Tuber
Days After Treatment


Six-month-old Shepody Grown at 18C
Cont-18
39-18
37-18
35-18
33-18
Bud Break/Tuber
Days After Treatment

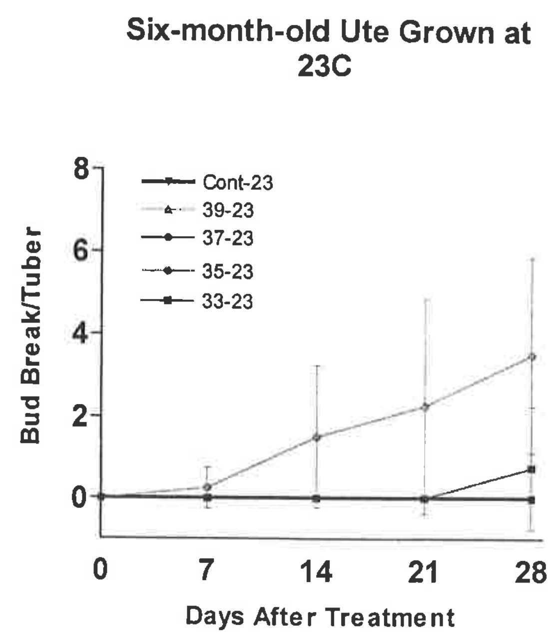

Six-month-old Ute Grown at 23C
Cont-23
39-23
37-23
35-23
33-23
Bud Break/Tuber
Days After Treatment

Figure 9.

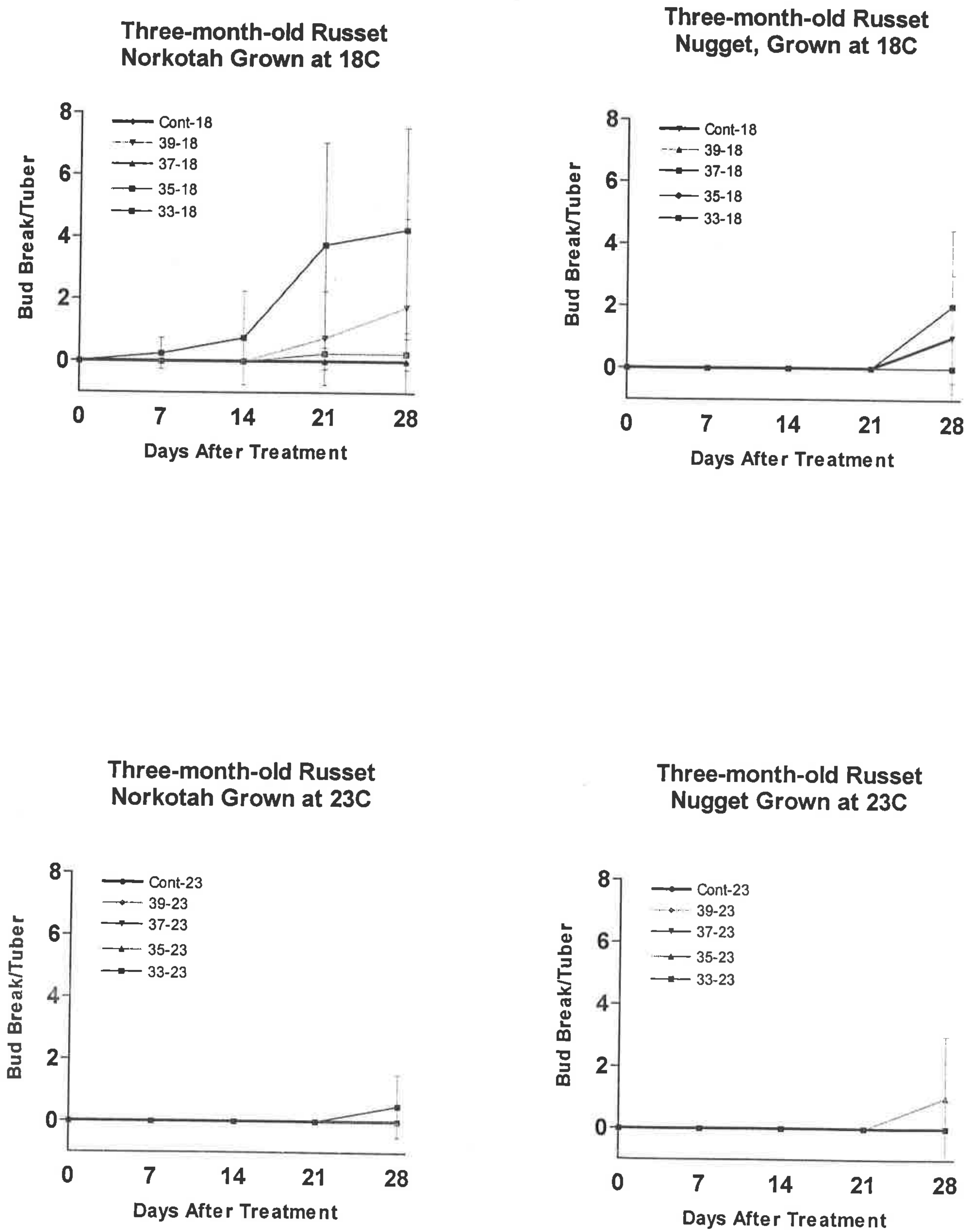
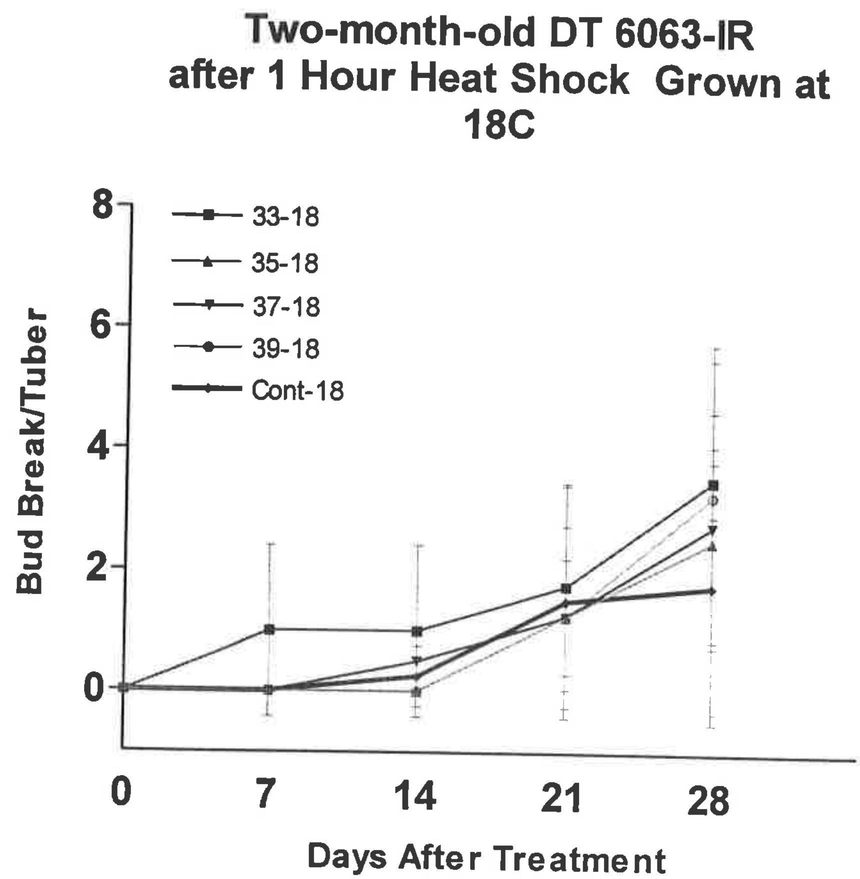
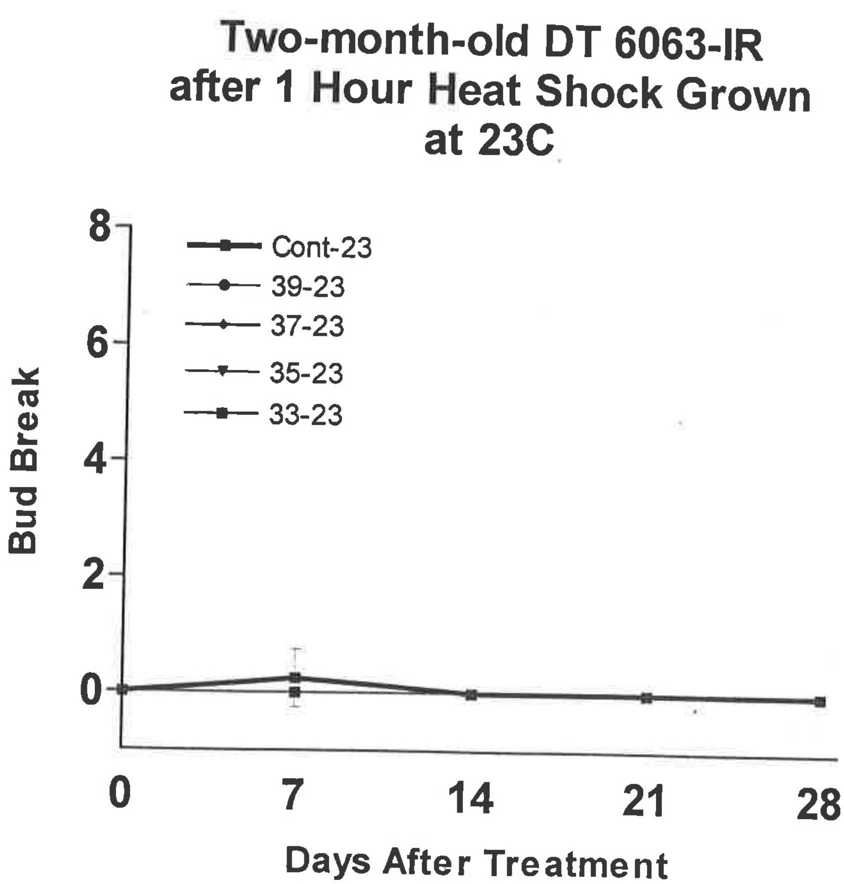

Three-month-old Russet Norkotah Grown at 18C
Bud Break/Tuber
Cont-18
39-18
37-18
35-18
33-18
Days After Treatment
Three-month-old Russet Nugget, Grown at 18C
Bud Break/Tuber
Cont-18
39-18
37-18
35-18
33-18
Days After Treatment
Three-month-old Russet Norkotah Grown at 23C
Bud Break/Tuber
Cont-23
39-23
37-23
35-23
33-23
Days After Treatment
Three-month-old Russet Nugget Grown at 23C
Bud Break/Tuber
Cont-23
39-23
37-23
35-23
33-23
Days After Treatment

Figure 10.


Two-month-old DT 6063-IR
after 1 Hour Heat Shock Grown at
18C
33-18
35-18
37-18
39-18
Cont-18
Bud Break/Tuber
8
6
4
2
0
0
7
14
21
28
Days After Treatment


Two-month-old DT 6063-IR
after 1 Hour Heat Shock Grown
at 23C
Cont-23
39-23
37-23
35-23
33-23
Bud Break
8
6
4
2
0
0
7
14
21
28
Days After Treatment

APPENDICES

Appendix I.

12/4/98

Minituber potato experiment–Heat Shock component–preliminary
Will a heat shock break dormancy?

Procedure:

wash tubers
store dry at room temp until they are put in for respective temp trts
weigh tubers–put into respective tubes
use rubber band(?) To attach thermocouple to tuber
put in water in tubes (10ml?)/ plus tubes with no water
use water bath (yellow in 311)
Put tubes in bath–leave at desired temp for 1 hour–be sure tubes in water bath are being slowly agitated
Record thermocouple temperature just prior to removing tubers from bath

Potatoes will be held for 1 hour in water bath at the following temperatures (each temp will have 2 tubers –one in water in test tube and one in air in test tube)=10 temps

25C
30
35
40
45
50
55
60
65
70

When tests complete put tubers on moist paper as before put in 25C in dark for growth check
Save water for leakage tests in screw cap vials

Experiment to be done week of 12/7/98

Appendix II.

12/30/98

Minituber Potato Experiment- Heat Shock Component –Will Heat shock break dormancy?

1. Use Russet Norkotah mini tubers
2. Wash with de ionized water
3. Air dry
4. Quick dip in 70% ETOH
5. Air dry
6. Store at room temp until respective treatments
7. All tubes will have 10 ml of water (tuber will be submerged)
8. Weigh tubers
9. Put in water bath for 1 hour for each treatment
10. Check temp with thermocouple – use rubber band to attach thermocouple
11. Save water in screw cap vial for leakage tests
12. Put tubers in tray between layers of cotton for growth check i.e. bud break

TREATMENTS

TEMPERATURE (HEAT SHOCK) = 10 tubers per temp

31C
33C
35C
37C
39C

RECOVERY = 5 tubers per temp

18C
23C

Appendix III.

1/12/99

Minituber Potato Experiment- Heat Shock Component –Will Heat shock break dormancy?
CONSTANT TIME VARY TEMPS

1. Use mini tubers from 307Shep 4C cooler (upper shelf on right hand side) x 6 cultivars
2. Wash with de ionized water
3. Air dry
4. Quick dip in 70% ETOH
5. Air dry
6. Store at room temp until respective treatments
7. All test tubes (25x150mm with kaput caps) will have 10 ml of ultrapure water (tuber will be submerged)
8. Weigh tubers, put in water in test tubes just prior to water bath treatment
9. Put test tubes with tubers in water into water bath for 1 hour for each treatment–caps on test tubes
10. Check temp with thermocouple – use rubber band to attach thermocouple to tuber–record twice (about 30 minutes and just prior to removal)
11. Save water in screw cap vial for leakage tests–put in fridge in 305 w/labels
12. Put tubers in tray between layers of cotton for growth check i.e. bud break
    (I used about 100ml ultrapure water for each layer of cotton)

TREATMENTS

TEMPERATURE (HEAT SHOCK) = 10 tubers per temp/variety–Yellow water bath in 311 is good–takes about 15 minutes to increase temp between treatments–be sure water level is adequate to be higher than water in test tubes.

Control (these will have no heat treatment i.e. they will be removed from 4C, left at room temp, put in water in test tubes for 1 hr (save water for leakage) at room temp,(steps 1-7)

33C
35C
37C
39C

RECOVERY (GROWTH CHECK) = 5 tubers per temp/variety wrapped in foil or in the dark
18C===Chamber 1 room 304
23C===Chamber 2 hallway

CULTIVARS	**QUANTITY**	**HARVESTED**	**SHIPPED**
Ute	100	7/21/98	10/19/98
Shepody	100	7/21/98	10/19/98
FL1867	100	7/21/98	10/19/98
Norkotah	200	10/20/98	10/23/98
R. Nugget	100	10/22/98	10/23/98
DT6063	100	11/23/98	11/30/98

Appendix IV.

1/12/99

Minituber Potato Experiment- Heat Shock Component –Will Heat shock break dormancy?
CONSTANT TEMP VARY TIME

1. Use mini tubers from 307Shep 4C cooler (upper shelf on right hand side) x 6 cultivars
2. Wash with de ionized water
3. Air dry
4. Quick dip in 70% ETOH
5. Air dry
6. Store at room temp until respective treatments
7. All test tubes (25x150mm with kaput caps) will have 10 ml of ultrapure water (tuber will be submerged)
8. Weigh tubers, put in water in test tubes just prior to water bath treatment
9. Put test tubes with tubers/water into water bath for 1 hour for each treatment–caps on test tubes
10. Check temp with thermocouple – use rubber band to attach thermocouple to tuber–record twice (about half way and just prior to removal)
11. Save water in screw cap vial for leakage tests-put in fridge in 305 w/labels
12. Put tubers in tray between layers of cotton for growth check i.e. bud break
    (I used about 100ml ultrapure water for each layer of cotton)

TREATMENTS----TEMPERATURE TO BE USED =

TEMPERATURE (HEAT SHOCK) = 10 tubers per time/variety–Yellow water bath in 311 is good—be sure water level is adequate to be higher than water in test tubes.

Control (these will have no heat treatment i.e. they will be removed from 4C, left at room temp, put in water in test tubes for same time period as treatment (save water for leakage) at room temp,

30 MINUTES
60 MINUTES—currently used for temp variation expts
120 MINUTES
240 MINUTES

RECOVERY (GROWTH CHECK) = 5 tubers per time/variety wrapped in foil or in the dark
18C===Chamber 1 room 304
23C===Chamber 2 hallway

CULTIVARS	**QUANTITY**	**HARVESTED**	**SHIPPED**
Ute	100	7/21/98	10/19/98
Shepody	100	7/21/98	10/19/98
FL1867	100	7/21/98	10/19/98
Norkotah	200	10/20/98	10/23/98
R. Nugget	100	10/22/98	10/23/98
DT6063	100	11/23/98	11/30/98

Appendix V.

2/11/99

Potato Minituber Experiment
Minitubers being used are AC88042-1 (98B 2/3/99) from David Holm (SLV)

CALCIUM NITRATE

1. Use concentrations of:
   0
   100
   300
   600 ppm
2. Temperatures of :
   Diurnal fluctuation of 10C and 30 C –12 hours each no light
   Constant temperature of 18C

Procedure:

1. Wash minitubers with deionized water
2. Air dry
3. Put in respective nitrate solutions–leave in aerated solution for 16 hours
4. Remove from solution, air dry, 70% ETOH spray/dip
5. Position in trays (5 reps each treatment)

Requires 4x5x2 = 40 tubers

Appendix VI.

2/11/99

Potato Minituber Experiment
Minitubers being used are AC88042-1 (98B 2/3/99) from David Holm (SLV)

GROWTH COMPUNDS

1. Coumarin
2. O-coumaric acid
3. P-coumaric acid
4. Gibberellic acid

1. Use concentrations of:
   0
   10-3
   10-4
   10-5

2. Temperatures of :
   Diurnal fluctuation of 10C and 30 C –12 hours each no light
   Constant temperature of 18C

Procedure:

1. Wash minitubers with deionized water
2. Air dry
3. Put in respective nitrate solutions–leave in aerated solution for 16 hours
4. Remove from solution, air dry, 70% ETOH spray/dip
5. Position in trays (5 reps each treatment)

Requires 4x5x2 = 40 tubers /growth compound x 4 =160