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Internal Report No. 22

Effect of cooling asparagus on off-flavour and tip-rot.

A report on research conducted for the N.Z. Asparagus Research Council.

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CRD

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REPORT TO ASPARAGUS RESEARCH COUNCIL
EFFECT OF COOLING ON OFF-FLAVOUR AND TIP-ROT

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1. INTRODUCTION:

The aim of this experiment was to study the effect of cooling, using shading or irrigation, on the development of off-flavour and tiprot in four cultivars. The cultivars chosen were: Mary Washington, Rutgers Beacon, Limbras, Jersey Giant, and UC157. Jersey Giant and UC157 were used as controls. A breeder's line, 168x167, was also included in this study because it had proved susceptible to off-flavours in previous trials.

In previous studies at DSIR Crop Research it was observed that the environmental conditions prior to picking appeared to have an effect on the susceptibility of asparagus spears to tiprot development in storage. This effect was particularly noticeable in some cultivars and appeared to be connected with the development of off-flavour in fresh spears from these lines. To test the theory that hot, dry weather was contributing to this effect, it was decided to cool the spears in some way while they were growing and to observe the differences between cooled and un-cooled spears. Originally irrigation was to be used, but in consultation with DSIR agronomists it was decided that shading would give a better cooling effect considering the nature of the trial lay-out. At the end of the season when other experiments on the trial were completed, irrigation was applied and its effect studied.

2. METHOD:

Mary Washington (M.W.), Rutgers Beacon (R.B.), and Limbras (L), spears were harvested from a complete randomised block with four replications. Each plot of each cultivar within a replication was 18 m long. Each 18 m plot was divided into two 9 m sub-plots, one of which was shaded and the other left un-shaded. The shade cloth used gave a reduction of at least 50% in the solar radiation effect. Spears from all four reps. of each cultivar (shaded and un-shaded) were bulked together for tasting and storage.

This trial also contained the UC157 and Jersey Giant plots which were not shaded but kept as controls. Plots of the DSIR hybrid 168x167 in a nearby trial site were also evaluated.

This gave a total of ten samples in all:

1. M.W. - Mary Washington
2. M.W.S. - Mary Washington shaded
3. R.B. - Rutgers Beacon
4. R.B.S.- Rutgers Beacon shaded
5. L. - Limbras
6. L.S. - Limbras shaded
7. 168x167
8. 168x167.S. - 168x167 shaded
9. UC157
10. J.G. - Jersey Giant

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At the end of the asparagus season, when most picking had ceased, the shade covers were taken off all plots and all cultivars in the first trial (i.e. all cultivars excluding 168x167 which was in a separate trial site) were divided into two sub-samples with two reps of each cultivar in each sub-sample. Approximately 17 mm of irrigation was applied to one sub-sample each day for five days, while the other sub-sample was left un-irrigated. The asparagus was picked twice during this irrigation period, after 2 days' and 5 days' irrigation respectively. The amount of water used was low, as a cooling effect was required only. This irrigation was applied to the crop at the hottest part of the day from 12.00 pm to 2.00 pm. Irrigated and non-irrigated spears were kept separate and tasted and stored as such.

The entire experiment lasted from October 22 when the first spears were picked and tasted, through to December 7, a total of 8 weeks. During this time 9 taste panel sessions and 11 storage trials were conducted.

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2.1 Taste panels:

Ten trained panellists were used.
The taste panel evaluation form is included with this report. (See Appendix 1.) Panellists were asked to make a mark on a line to indicate the strength of each attribute. Each line was divided into five segments and scores given from 1-5 according to which segment the panellist's mark appeared in. In the case of off-flavour assessments a score of zero is the norm. Any score outside the first segment (i.e. with a mean of 1 or more) is of concern.

2.2 Storage trials:

For these trials spears with tight heads were chosen, labelled with the cultivar information and picking date and packed upright into asparagus boxes. The whole box was then placed in a high density poly-ethylene (HDPE) plastic bag with the end folded under, and kept in a chiller at 4 ± 2 °C for 3 or 4 weeks. The plastic bag was intended to reduce moisture loss and would also have slowed respiration by altering the free access of oxygen to the spears and allowing a certain accumulation of CO_2.

After the designated storage period, the whole bag was removed from the chiller and placed on a laboratory bench at 20°C for four days. Each day, starting from a zero point when the spears had just been taken out of the chiller, the spears were examined for numbers with tip rot, numbers with soft tips, and those which still had firm tips. These figures were recorded as percentages of spears with the designated defects at 0,24,48,72 and 96 hours. Other defects such as mouldy bases, or mould on the stem were ignored as tip rot development was the specific concern.

2.3 Ammonia samples:

Spears from the same days picking as were tasted and placed into storage trials were also set aside for ammonia tests. These spears were placed in perforated bags and kept at 20°C. After 24, 48 and 72 hours respectively 3-5 spears were removed, the top 3 cm cut off, weighed and blast frozen. The frozen spear tips were then freeze dried and sent to MAF Technology Levin for analysis of their ammonia content. The purpose here was to

establish a connection between ammonia build up in the spear tips and off-flavour or tip-rot development.
(Results for these ammonia measurements are not included with this report. See MAF Technology report.)

3. RESULTS:

The table (Appendix 2) shows the dates of picking, the taste panel number and the storage trial number which corresponds with asparagus picked on that date, and the meteorological conditions prevailing for the months of October, November and December.

The season was overall, cooler than the previous season (mean Tmax for the season was 17.6°C in 1990 compared with 19.7°C in 1989), and even the hottest spell in the second week of November was not as hot or as prolonged as that of the previous year, (from 6-12 November the mean Tmax was 21.1°C for 1990 and 24.1°C for 1989). This absence of extremely warm weather meant that the effect of the shade cloth was not as marked as had been hoped.

3.1 Effect of variety and cooling on off-flavour:

3.1.1 Shading as cooling

The following table shows the mean score for off-flavour for each cultivar over the first 6 taste panels (panels 1-6). (See method for scoring protocol.)

Sample No. (Cultivar & Treatment)	Number of times Tasted	Mean	Standard error
1. Mary Washington	52	0.73	.119
2. Mary Washington - shade	53	1.42	.164
3. Rutgers Beacon	54	0.77	.121
4. Rutgers Beacon - shade	54	0.81	.124
5. Limbras	52	0.985	.138
6. Limbras - shaded	52	0.83	.127
7. 168 x 167	53	0.987	.137
8. 168 x 167 - shaded	52	0.605	.105
9. UC157	47	0.78	.13

Only two cultivars gave mean off-flavour scores which were of concern. These were Mary Washington-shaded and 168 x 167. The higher mean for M. Washington - shaded occurred mainly because of the high off-flavour scores given to this cultivar on days 3 and 4. The DSIR hybrid 168 x 167 had bad off-flavour on day 6. In figures presented later in this

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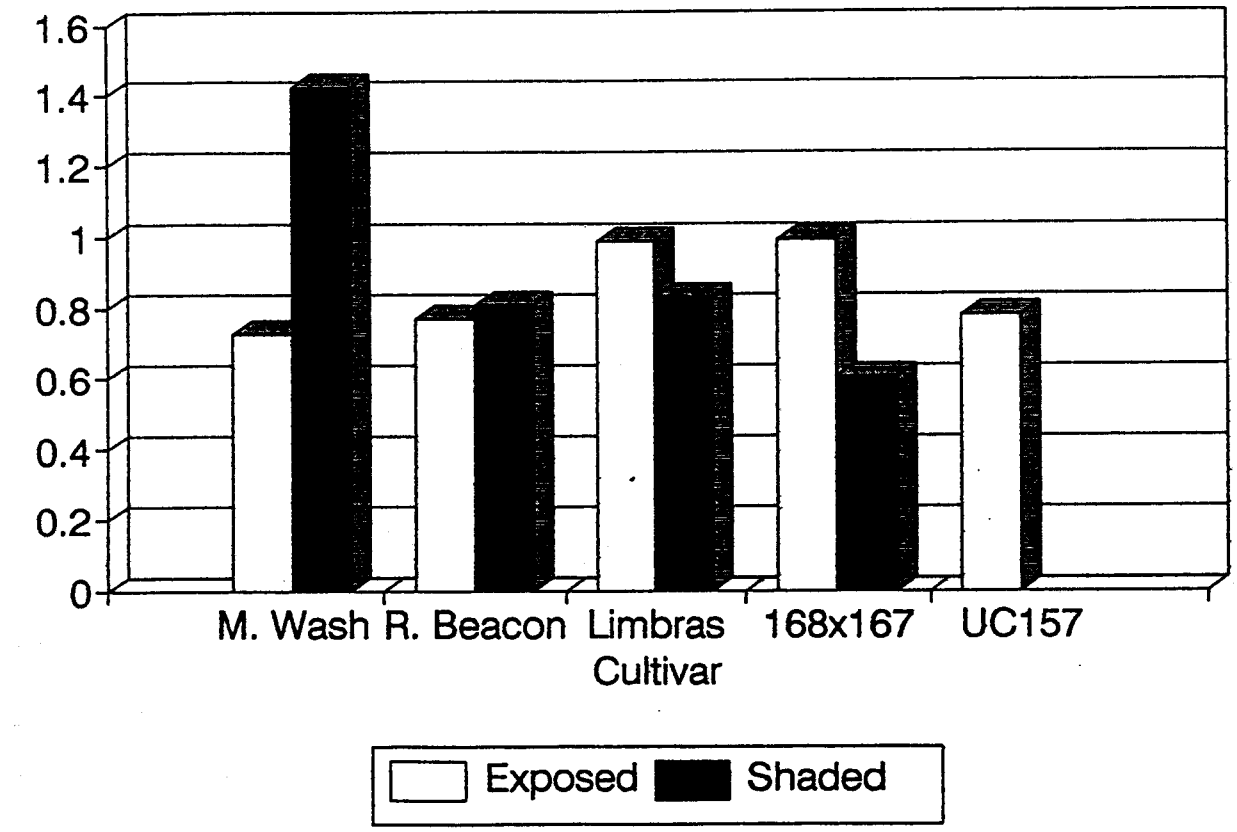
Effect of Shading on Off-flavour Development



report, in the irrigation trial, the un-irrigated R.Beacon is shown to have a higher off-flavour than all other cultivars.

1. From the above figures, off-flavour in Mary Washington increased significantly with shade. All other treatments have mean scores of < 1.0 for off-flavour which is within the acceptable level.
2. Off-flavour in 168 x 167 decreased significantly with shade.
3. Overall mean for off-flavour had a range of 0.5 between taste-days, being significantly higher on 5 November (day 3) which was the day when Mary Washington - shaded was particularly bad.

3.1.2 Irrigation as cooling

The following table shows the mean off-flavour scores over the two days of picking after irrigation. (See method for scoring protocol.)

Sample No. (Cultivar and Treatment)	No. of Times tasted	Mean	Standard error
1. Mary Washington	20	0.5	.22
2. Mary Washington-irrigated	20	0.4	.22
3. Rutgers Beacon	20	1.8	.33
4. Rutgers Beacon-irrigated	20	0.35	.21
5. Limbras	19	0.74	.24
6. Limbras-irrigated	19	0.26	.17
9. UC157	19	0.36	.14
10. Jersey Giant	39	0.28	.13
11. Jersey Giant - irrigated	10	0.4	.22
12. UC157 - irrigated	9	0.11	.11

Spears from the non-irrigated Rutgers Beacon plots had significantly more off-flavour than spears from the irrigated plots. Limbras also shows a significant difference between the irrigated and non-irrigated off-flavour scores.

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3.1.3 Effect of variety and cooling on off-flavour:

1. Variety.

Off-flavour occurred in only three cultivars to any extent. These were:
Mary Washington (in the shaded treatment)
Rutgers Beacon (in the un-irrigated treatment)
168x167 (in the un-shaded treatment)
(See off-flavour scores above)

2. Cooling.

These results were as predicted in that the shading and irrigation decreased the off-flavour development in some cultivars. The weather this season was not as hot as other years reaching 24°C on only a few occasions (see Appendix 2). On these few occasions off-flavour did develop but the surprising result was for Mary Washington where it was the shaded treatment which developed the off-flavour. The weather was hot during the irrigation period and this resulted in increased off-flavours in R. Beacon and Limbras. (168x167 was no longer in the trial at this stage.) This increased off-flavour did not occur where the plants were irrigated.

3.2 Storage Trials

Figures for these storage trials were analyzed in two sets: four weeks of storage and three weeks of storage. The four week trials were very severe and the deterioration of spears after removal from cool storage was so rapid as to cover any effects which may have been caused by the variables used (Cultivar and shading).

3.2.1 Four Week Storage Trials:

Graphs 1 and 2 show how the percentage of spears soft or rotten increased with hours at the shelf temperature of 18-20°C. The graphs show this for each cultivar, in the exposed blocks and in the shaded blocks.

In the exposed blocks, J. Giant stored significantly better than R. Beacon and Limbras. R. Beacon gave the fastest deterioration but by 48 hours after removal from cool storage all cultivars had deteriorated equally.

In the shaded blocks R.Beacon was much improved and 168 x 167 shows a slower deterioration than the other cultivars.

3.2.2 Three Week Storage Trials:

As with the above results for the four-week storage trials, graphs 3 and 4 show the percentage of spears soft or rotten at 0, 24, 48, 72 and 96 hours after removal from cool storage.

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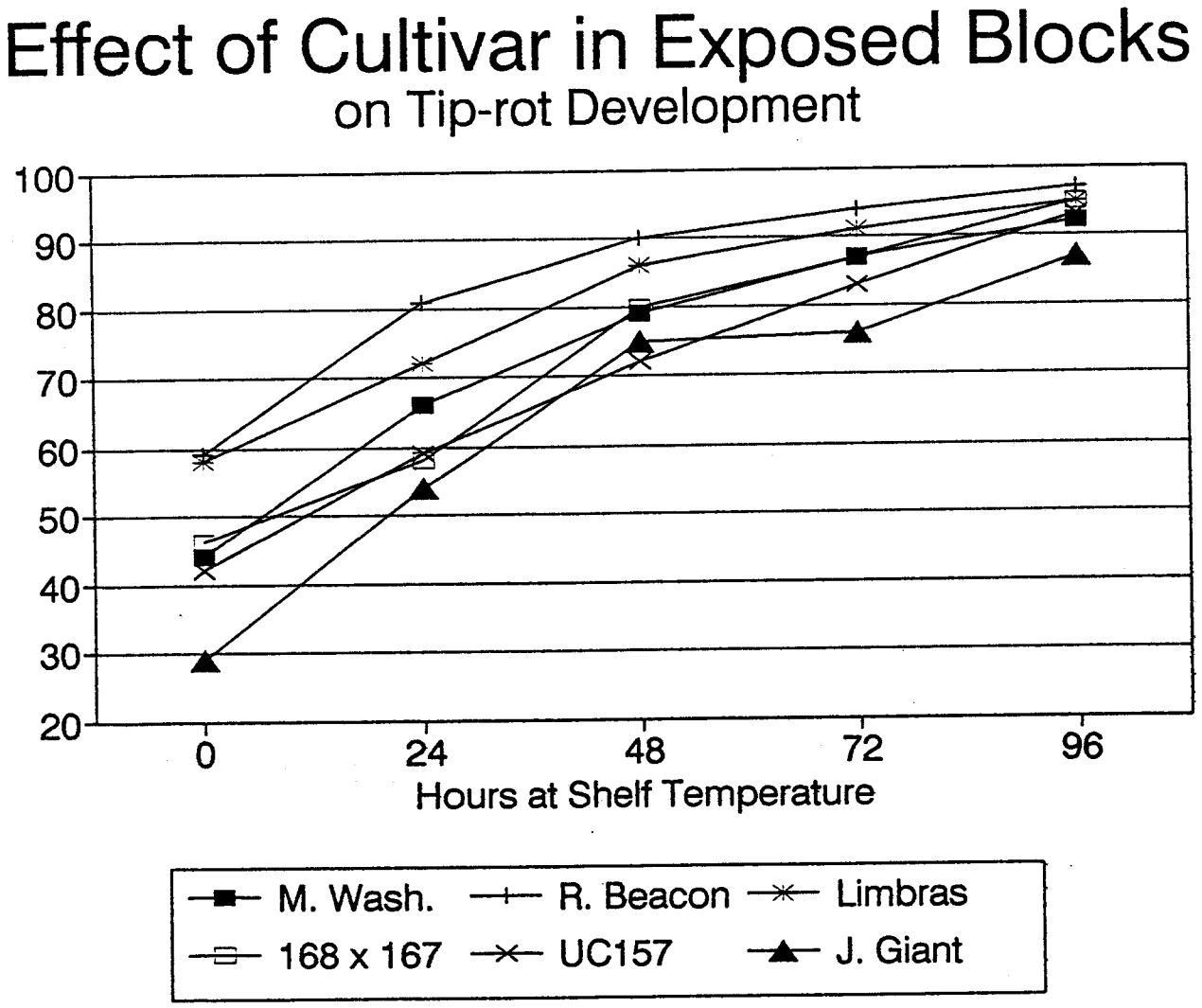
Graph 1



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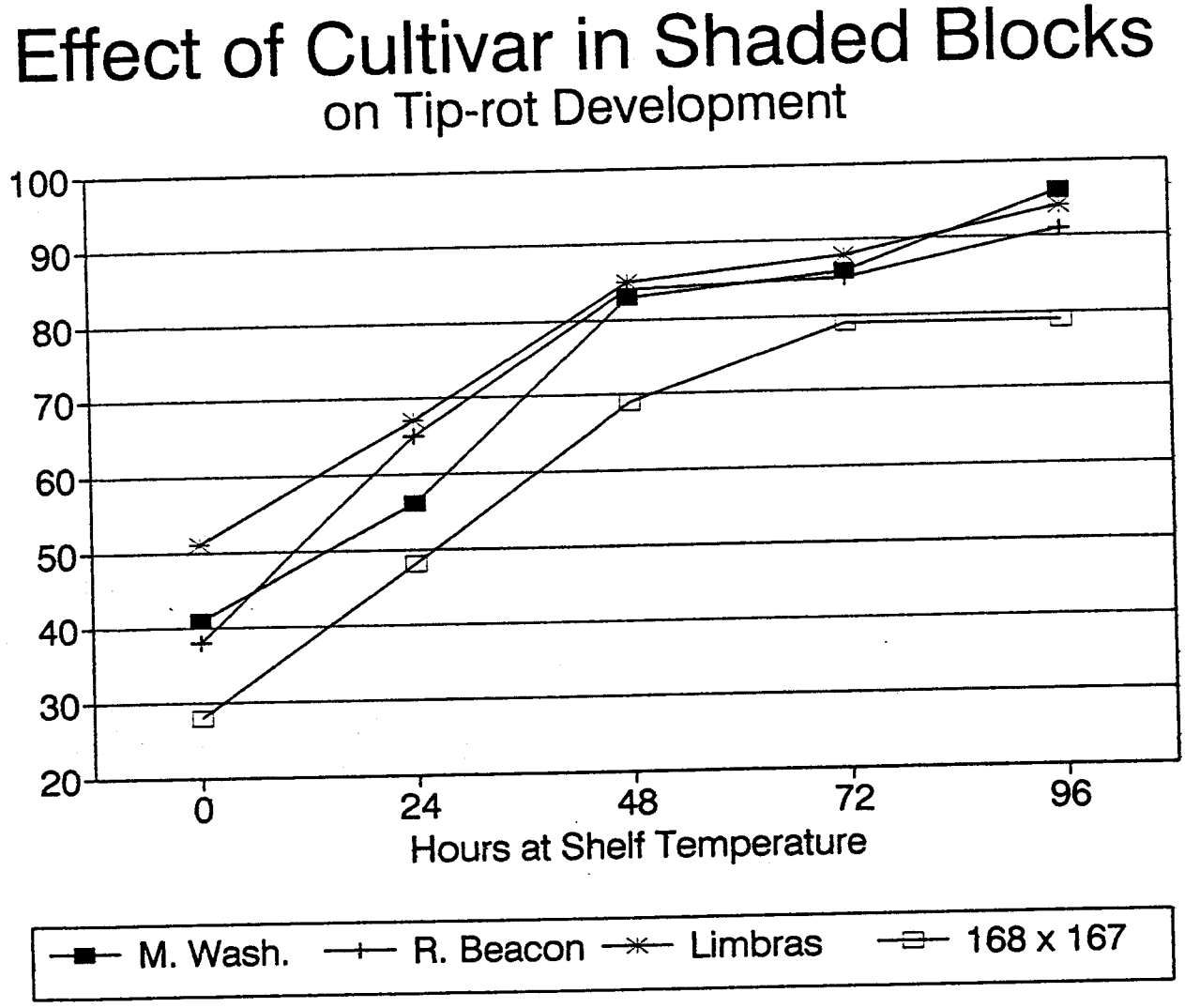
Graph 2



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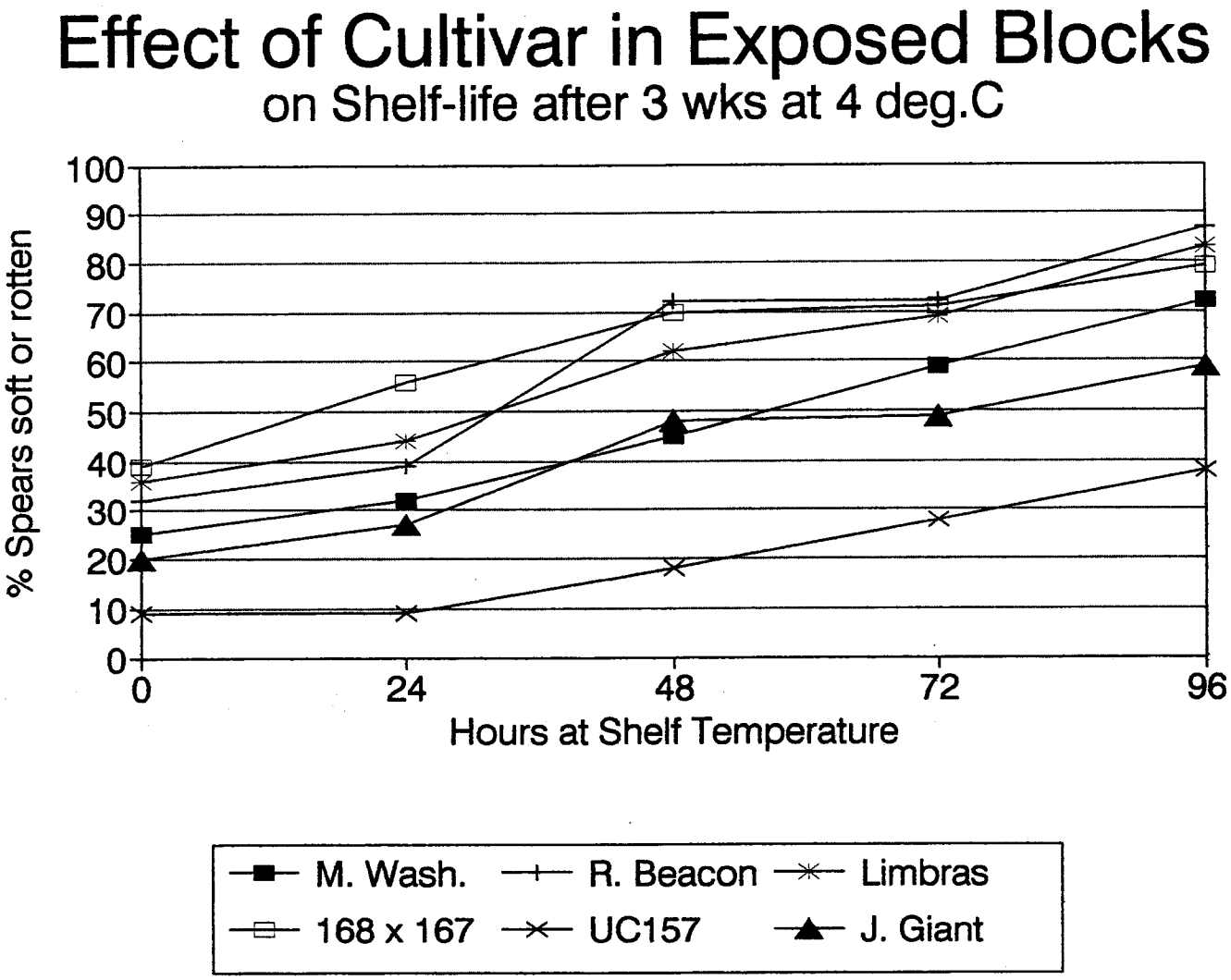
Graph 3



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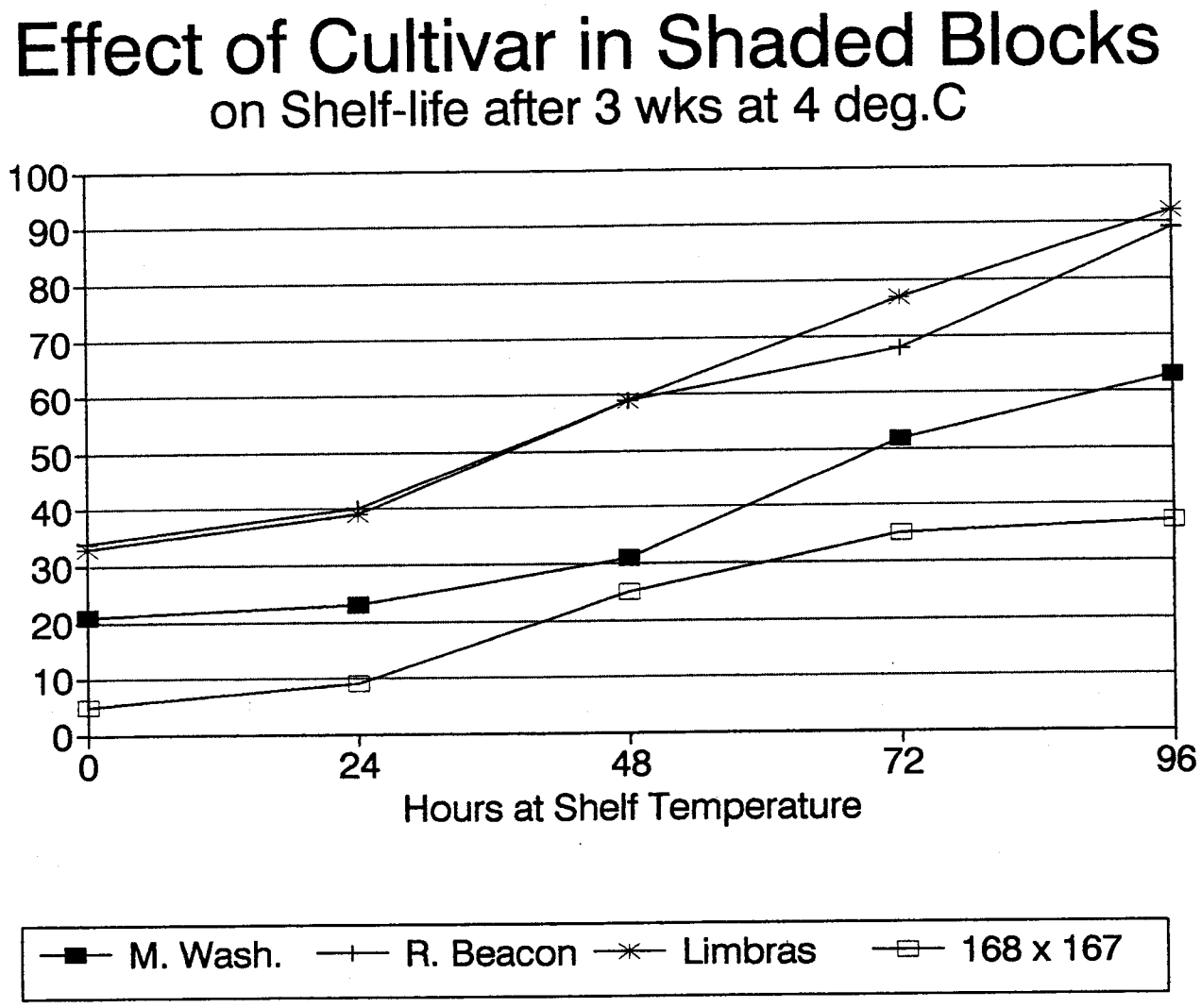
Graph 4



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For spears from the exposed blocks, UC157 had the least soft or rotten spears. Comparing the graph for the exposed blocks with that for the shaded blocks, it can be seen that 168x167 improved dramatically with shading.

When the exposed trials are considered alone, and individual storage days looked at, there is a difference in the mean % rotten over all cultivars between 13% on the first two storage trials(21/11/90 and 23/11/90) and 51% for the third trial(26/11/90) when they were first taken out of cool storage. This effect is still noticeable 24 hours later. (See table below.) The weather for the first two trials was cool and wet with very high humidity, whereas the temperatures were higher (20°C) around the time that the third trial was picked. (See Appendix 2.)

Pick-day	Mean % rotten 0 h	Mean % rotten 24h	Mean rain for 3 days	Mean temp for 3 days
21 Nov	13	12	9.1	12.3
23 Nov	13	22	4.5	11.2
26 Nov	51	65	0.6	18.86

3.2.3 Effect of variety and cooling on tiprot:

Shading did appear to reduce tip rot in the CRD hybrid 168x167 which had been included in these experiments because of a tendency to produce off-flavours during hot, dry weather. UC157 produced less tiprot in storage than other cultivars.
In the four week trials where spears were kept at 2-6°C for four weeks before a shelf-life trial at 18-20°C, Rutgers Beacon shows a shade versus exposed difference at first but the length of the cool storage caused rotting in all treatments after 48 hours of shelf-life.
Jersey Giant performed better than other cultivars during the 4 week cool storage period and after one days "shelf" storage.
There were large effects caused by pick-day, especially in the three week storage trial. (It is possible that these pick-day differences would have shown up more in asparagus stored for 4 weeks had they had been stored for a shorter period.) The pick-day effects are presumed to be the result of season and environmental effects. As the season progresses the reserve of nutrients in the crown decreases, with a resultant decrease in sweetness of spears. (Sweetness was another attribute judged by taste panels, the results appearing in a Crop Research Internal Report.) Also, hotter weather could cause spears to grow faster with a possible depletion in sugars to the tip.
It was unfortunate that the season (1990) was not as hot as usual (see Appendix 2), and so the effect of shading in hotter drier weather was not able to be measured. However, from the differences observed, the theories above are more confirmed than disproved.

The number of spears soft or rotten was too high to be acceptable for any exporter. Three or four weeks of storage followed by several days of "shelf" temperatures would appear to be too severe a treatment for asparagus under the conditions used.

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4. CONCLUSIONS:

The fact that off-flavour was observed in Rutgers Beacon and 168x167, that this off-flavour was more pronounced in the exposed and non-irrigated plots, and that these two cultivars showed differences in their resistance to tiprot when shaded or irrigated indicates a connection between:

conditions during the growing period, variety,
early off-flavour in spears and tip rot development.

Also, although the season was not hot the large difference in the number of rotten spears over all cultivars between those picked in cool weather and those picked in hotter weather (see three week storage trial results) indicates that hotter weather does pre-dispose the asparagus to tiprot.

The off-flavour in the shaded plots of Mary Washington is, however, an unexplained anomaly of this experiment. Perhaps this cultivar prefers the heat.

The most important consideration for the industry in this area must be the improvement of the distribution system for fresh, air-freighted, export asparagus. If this system is good and asparagus is picked, cooled and kept cool from the farm to the retail store then this would take care of the bulk of the tiprot problem. The gains to be made with better cultivars and with understanding the effects of pre-harvest conditions are real but are small compared with the effect of good cool chain management.

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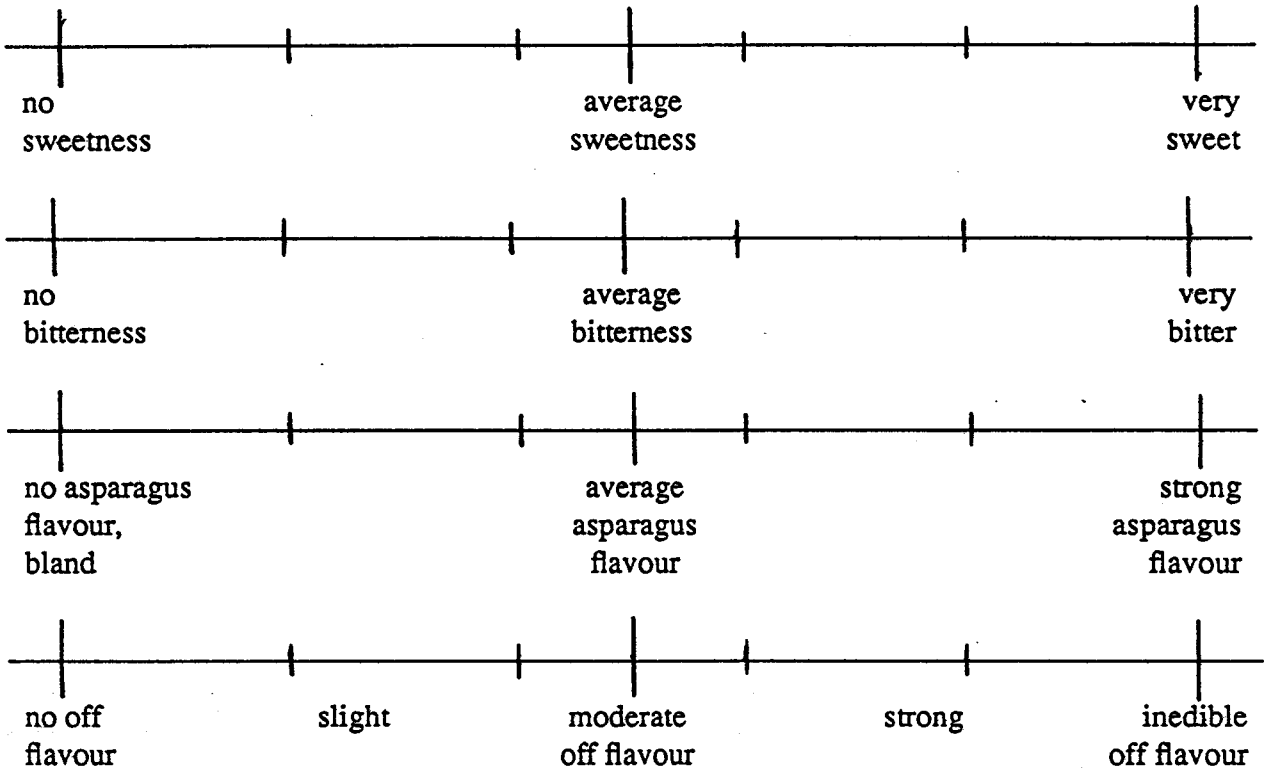
ASPARAGUS SENSORY EVALUATION - 1990

NAME : _____ TIME : _____

DATE : _____ BOOTH : _____

Please evaluate each sample by eating the entire spear. Use the half spear for flavour evaluations and the whole spear for texture evaluations. Place a ✘ on the scale to indicate the level of each characteristic and label with the appropriate sample number.

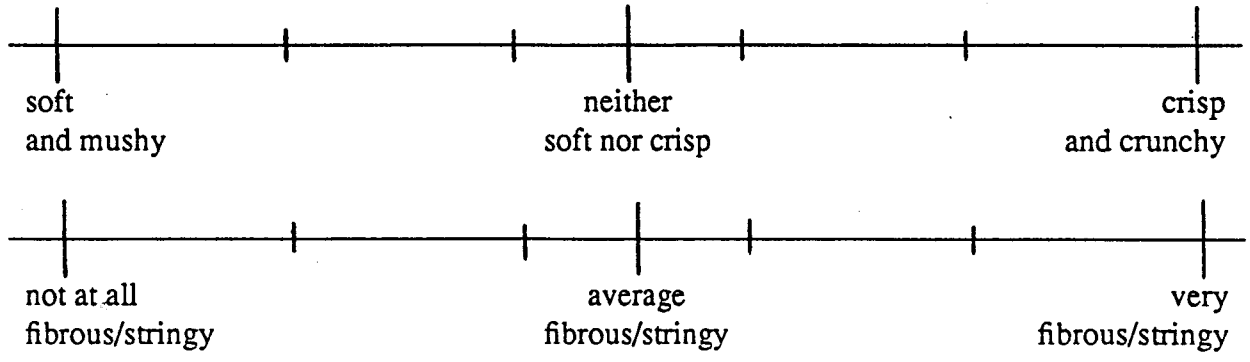
Flavour



If off flavours were detected please describe: _____

_____

Texture



Comments

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DATE	TASTE NO.	STORAGE NO.	RAIN	Tmax	SOLAR RAD.	RELATIVE. HUMIDITY. (at
19/10			7.8	18.5	21.0	47.9
20/10			0.0	16.1	22.6	72.2
21/10			0.0	23.5*	19.3	42.5
22/10	1	1	0.4	18.2	23.7	64.1
23/10			0.0	13.9	18.3	75
24/10			0.0	19.0	25.5	44.2
25/10			0.0	17.7	25.0	55.3
26/10			0.0	17.9	25.8	54
27/10			0.2	21.6	12.9	46.5
28/10			0.0	13.9	19.6	60.5
29/10	2		0.0	24.1*	21.1	28.3#
30/10			3.8	16.9	21.5	51.4
31/10			1.0	12.9	14.8	74
1/11			0.0	14.5	17.7	62.4
2/11			0.0	18.0	21.9	46.6
3/11			0.2	22.6	25.7	36.8#
4/11			0.4	18.0	20.0	58.65
5/11	3	2	0.8	14.5	19.5	79.4
6/11			0.0	13.3	25.0	66.8
7/11			0.0	20.1	27.3+	36.6#
8/11			0.0	24.6*	27.8+	33.6#
9/11			0.0	24.1*	28.0+	42
10/11			0.0	25.4*	28.7+	39.5#
11/11			0.2	23.9*	19.2	45.2
12/11	4	3	9.0	16.5	5.6	58.1
13/11			0.0	15.3	21.9	82.3
14/11			0.0	16.6	26.8	58.8
15/11			0.0	16.8	16.1	56
16/11	6	4	0.0	15.9	27.9+	69.2
17/11			0.4	19.8	8.5	53.7
18/11			14.8	15.1	13.3	75.2
19/11	5	8	6.2	10.6	11.1	93.9
20/11			6.2	11.3	18.2	81.4
21/11		5	5.5	10.2	9.4	70.8
22/11		6	1.8	12.2	8.5	65.5
23/11			0.0	14.8	24.9	63
24/11			0.4	21.6	19.4	45
25/11			1.4	20.2	23.4	54.5
26/11	7	9	0.6	20.1	25.0	43.4
7/11			1.8	17.2	18.3	50
28/11		7	1.0	15.3	19.8	57
29/11			0.0	13.8	15.3	73.6
30/11			0.2	18.3	30.8+	51.4
1/12			0.0	22.5	31.4+	41.8
2/12			0.0@	16.9	26.4	64.4
3/12			0.0@	24.3*	26.6	40.5
4/12	8	10	9.4@	19.1	24.2	58.8
5/12			0.0@	15.3	31.8+	61.6
6/12			0.0@	21.9	16.4	33.9#
7/12	9	11	0.0	24.3*	23.7	32.9#
8/12			0.0	26.1*	24.3	35.2#

For the above table: * = Days with high maximum temperature; + = Days with high solar radiation; # = Days with low relative humidity; @ = Days irrigated

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