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Grower Summary

Headline

- Translucency in stored onion bulbs can be induced by experimentally using high levels of CO^2 in a controlled atmosphere.
- Over the whole experiment bulbs stored at 0°C showed higher incidence of both watery skin and translucency than those stored at 5°C, but this was not consistent for all varieties.
- Penicillium was associated with most bulbs showing symptoms of both watery skin and translucency after storage at Kirton.

Background and expected deliverables

The causes of the conditions called “watery skin” and “translucency” in stored onions are not fully understood. This project aims to investigate the effects of pre-harvest moisture, variety, storage temperature, length of storage and CO_2 levels on the development of “watery skin” and “translucency” and to identify any disease organisms that might be associated with their development.

Watery Skin” is a deterioration and disease invasion of the outer scale of onions, which then become dark chocolate brown. “Translucency” has symptoms similar to bruising usually in the outer scales of onions thought to be due to high CO_2 levels causing breakdown. Both conditions seem to be worse in wet seasons in thick skinned bulbs after long storage. There are no current methods to detect “watery skin” and “translucency” prior to storage. If these disorders develop in storage not only will the packer or grower have difficulty in meeting the quality standards of his orders but he will also have spent money on storage which will be wasted. The aim of this project is to investigate the relation between growing environment, storage environment, genotype and the development of “watery skin” and “translucency”.

The expected deliverables are:

- for Growers: information on growing and storing conditions which might lead to the development of “watery skin” and “translucency” to add confidence to the quality of their produce and robustness to the onion supply chain for packing and processing.

- for Breeders: information on the genotypic characters which pre-dispose material to these problems.

Summary of the project and main conclusions

- Bulbs stored at 0°C had more severe symptoms for both watery skin and translucency than those stored at 5°C but this was not consistent across all varieties. Correlation with known varietal skin thickness was not good.

- Only Penicillium was present in damaged tissues after surface sterilisation.

- Storage of bulbs at 9-10% CO_2 produced translucency symptoms very similar to those seen in deteriorating bulbs with watery skin. The conclusion that thick skins reduce the ability of the bulb to respire and in extreme circumstances cause breakdown from accumulation of CO_2 has been supported by this work.

- In support of the above, onion bulbs in Controlled Atmosphere at 9-10% CO_2 showed a mean translucency score of 2.54 in July vs. 0.57 in May in normal atmosphere.

- In terms of watery skin / translucency differences between the varieties at 9-10% CO_2, there were large differences recorded (See Table 3) from external assessment.

  Internal translucency score (Table 4) however showed rather less difference.

  It was an overall conclusion when assessing the bulbs before and after storage that despite the (naturally) wet regime the incidence of "true" watery skin was not as high as expected. As a result of this the differences between varieties were not so conclusive as had been hoped.

- It was a commercial conclusion also that storability after the wet August was much better than anticipated, hence losses from watery skin were too low to attempt correlation with results from this project.

- It is clear from this initial study that with watery skin as a problem of variable / seasonal incidence that

a) Monitoring of varieties over several seasons would be necessary.
b) That more extreme / wet growing conditions seem to be needed for induction of watery skin on a sufficient scale to differentiate between varieties.
c) Larger plots providing commercial quantities would increase the possibilities of detecting low level varietal differences in practice and better relate to storage of sub lots at high CO_2.

Financial benefits

None yet as this is a preliminary investigation

Action points for growers

Storage temperature should not be below 0°C

Additional notes on action points

Indications are that storage temperatures slightly above 0°C (but not as high as 5°C) should minimise the incidence of watery skin and translucency.

Science Section

Introduction

The causes of the conditions called “watery skin” and “translucency” in stored onions are not fully understood. American studies have implicated both field (Clinton Shock et al 2001) and storage conditions (Purvis A 2002). This project investigated the effects of pre-harvest moisture, variety, storage temperature, length of storage and CO_2 levels on the development of “watery skin” and “translucency” and also identified the disease organisms that were present.

Watery Skin” is a deterioration and disease invasion of the outer scale of onions, which then become dark chocolate brown. “Translucency” has symptoms similar to bruising usually in the outer scales of onions thought to be due to high CO_2 levels causing breakdown. Both conditions seem to be worse in wet seasons in thick skinned bulbs after long storage. There are no current methods to detect “watery skin” and “translucency” prior to storage. If these disorders develop in storage not only will the packer or grower have difficulty in meeting the quality standards of his orders but he will also have spent money on storage which will be wasted.

Materials and Methods

a) Field

12 varieties of spring sown bulb onions from seven breeders were drilled in replicated plots at P.G Rix Farms Ltd in a commercial crop at Little Horkesley near Colchester, Essex.

The varieties were: **Barito** (Seminis)**, Boston** (Advanta)**, Friso** (Nickersons)**, Hyfort** (Bejo)**, Hysam** (Bejo)**, Julia** (Agriseeds)**, Marco** (Nickersons)**, Rolex** (Advanta)**, Sherpa** (Advanta)**, Sprinter** (Syngenta)**, Sunskin** (Syngenta) **and TEX 2095** (Takii).

The plots were grown in the same way as the commercial crop except that a stand pipe irrigation system was laid out with the intention of keeping the trial at a soil moisture deficit of not less than 1" of field capacity throughout the later part of the growing season. In practice the irrigation was only applied once, as August 2004 was exceptionally wet.

b) Storage at Kirton

Samples from each of the 36 plots were harvested and dried at NIAB, Cambridge. 200 bulb samples were then stored at HRI-Kirton at both 0°C and +5°C until 16th May. A sub sample of bulbs from Kirton showing translucent scale and watery skin were grown on agar plates after surface sterilisation

c) Storage in Poland

A further 10Kg sample from each plot was sent to Poland and stored at 0°C but with elevated CO_2 levels. Air temperature in refrigerated storage rooms was maintained at level 0°C, within ± 0.2°C. Relative humidity in the chambers was maintained at 75-85% by placing inside each chambers anhydrous calcium chloride. On 10 November 2004 onions were placed in gastight steel chambers and the desired level of oxygen and carbon dioxide were established within 24 hours by flushing with compressed nitrogen or added carbon dioxide from cylinders when required. During the storage period controlled atmosphere was monitored and maintained automatically by OXYSTAT 200. Each storage chamber had a temperature probe connected to a DATAGEM Controller.

All of the onion samples were kept from 10 November 2004 until 26 April 2005, in a controlled atmosphere of 3 % O_2 – 9% CO_2, and then from 27 April 2005 until 15 July 2005 at 3 % O_2 – 10 % CO_2. After storage onions were sorted into 4 following groups:

- Class 1(bulbs very good quality, firm without skinning),
- Class 2 (bulbs <33% of skinning), onion with shrinkage and skinning outer dry skin,
- Soft bulbs (mostly with watery skin),
- Rotten bulbs (rots caused by neck rot or other fungal diseases),
- Weight loss in percentage to initial weight of onion placed into store.

Internal assessment of Translucency

For watery scale observation 25 bulbs from each replicate (each variety has a 3 replicates) was used. Each onion was cut and observation of cross section were made according to following rating scale:

1 – no translucency,
2 – slight damage – one fleshy scale,
3 – medium – 2-3 fleshy scales,
4 – severe – 3 – 4 fleshy scales,
5 – very severe – more than 4 fleshy scales.

The results were analysed by standard analysis of variance test. Means were compared using Newman-Keuls test at significance level $\alpha + 0.05$.

Results and Discussion

General

Overall the levels of Watery skin and Translucency recorded after storage at Kirton were not high despite the wet growing season with only 8% bulbs showing any external (watery skin) symptoms and 17% bulbs showing any internal (translucency) symptoms. The elevated CO^2 storage in Poland did not increase the incidence of watery skin (6%) by weight but did succeed in increasing the severity of translucency (mean 0.57 at 0°C at Kirton, mean 2.34 at 0°C in Poland).

1. The Effect of Storage temperature

Table 1. Temperature effects on Watery skin & Translucency ex Kirton

Severity of symptoms (0-5) 0= none, 5=severe

Storage temperature	mean watery scale score (0-5)	mean translucency score (0-5)
0°C	0.378	0.570
5°C	0.267	0.381
lsd (P=0.05)	0.075	0.080

Table 1 shows the mean incidence of both external (watery skin) and internal (translucency) symptoms across all 12 varieties stored at Kirton at 0°C and 5°C. Both internal and external symptoms are significantly higher at 0°C when comparing the mean of all varieties. Tables 2 and 3 show that this was not consistent for each individual variety.

2. The Effect of Variety

Table 2. Variety x Temperature effects on Watery skin and Translucency ex Kirton

Severity of symptoms (0-5) 0= none, 5=severe

In order of severity of mean watery skin

	Watery skin (0-5)			Translucency (0-5)		
Variety	0°C	5°C	variety means	0°C	5°C	variety means
Sunskin	0.540	0.613	0.557 e	0.580	0.707	0.644 def
Sherpa	0.967	0.140	0.554 e	1.193	0.260	0.727 ef
Barito	0.740	0.193	0.467 de	1.253	0.413	0.833 f
Julia	0.373	0.313	0.343 cd	0.660	0.487	0.574 cde
Friso	0.400	0.273	0.337 bcd	0.633	0.340	0.487 bcd
Sprinter	0.513	0.147	0.330 bcd	0.640	0.253	0.447 abcd
Hyfort	0.180	0.413	0.297 abcd	0.247	0.447	0.347 ab
Marco	0.340	0.193	0.267 abc	0.433	0.340	0.387 abc
Hysam	0.147	0.340	0.244 abc	0.207	0.313	0.260 a
TEX 2095	0.180	0.167	0.174 abc	0.400	0.247	0.324 ab
Rolex	0.080	0.232	0.156 ab	0.287	0.336	0.312 ab
Boston	0.073	0.180	0.127 a	0.307	0.427	0.367 abc
means	0.378	0.267	0.322	0.570	0.381	0.475
lsd (P=0.05)	0.260	0.260	0.184	0.278	0.278	0.197

means followed by the same letter do not differ significantly at (P=0.05)

Table 2 shows that were significant differences between some varieties. **Barito, Sherpa** and **Sunskin** were worse for both watery skin and translucency. **Boston, Rolex** and **TEX 2095** had least watery skin and **Hysam, Rolex, TEX 2095** and **Hyfort** least translucency. Some varieties performed relatively better at one temperature than the other e.g. **Sherpa** performed badly at 0°C but much better at 5°C while **Hysam** and **Sunskin** performed relatively better at 0°C.

3. The Effects of High Carbon Dioxide Storage

Table 3. Storage ability of onions kept at 3 % O_2 – 9% CO_2 and then 3 % O_2 – 10 % CO_2. ex Poland

(temperature 0°C; period of storage 10 Nov. 2004 – 15 July 2005 – 247 days)

Variety	Marketable onions		Outgrades			
	Class 1 (no skinning)	Class 2 (< 33% skinning)	Shrinkage and skinning	Soft bulbs (watery scale)	Rotten bulbs	Weight loss
	In percentage of initial weight; average from 3 replicates					
Barito	55.0 ab	30.8	0.5	2.0	0.3	11.4
Boston	61.8 ab	21.5	0	4.5	2.8	9.4
Friso	74.0 ab	13.8	0.7	0.5	0	11.0
Hyfort	77.7 a	13.8	0.8	1.5	0.8	5.5
Hysam	72.4 ab	8.3	2.0	6.2	1.5	9.6
Julia	63.0 ab	15.7	4.0	9.2	1.8	6.3
Marco	55.1 ab	26.2	4.8	2.5	0.7	10.7
Rolex	67.2 ab	19.0	2.0	2.8	0.2	8.8
Sherpa	51.7 b	17.0	0	16.1	1.0	14.2
Sprinter	65.2 ab	18.7	2.5	3.3	1.2	9.1
Sunskin	72.0 ab	11.7	1.2	7.3	2.1	5.7
Tex 2095	23.1 c	36.0	6.7	16.2	4.3	13.7
		ns	ns	ns	ns	ns

Means followed by the same letter do not differ significantly at $\alpha = 0.05$ (Newman-Keuls test)

Table 4. Assessment of Translucency after storage at high CO^2 ex Poland

Variety	Mean Translucency scores (1-5) 1=none, 5=severe)
Barito	2.11
Boston	2.27
Friso	1.94
Hyfort	2.10
Hysam	2.45
Julia	2.26
Marco	2.37
Rolex	2.10
Sherpa	2.92
Sprinter	2.60
Sunskin	2.46
TEX 2095	2.50
means	2.34
lsd	ns

Tables 3 and 4 summarise the results from Poland where bulbs were stored in high CO^2 concentration.

a) on Watery skin

Table 3 shows results of external assessments. Two varieties, **Hyfort** and **Friso** had the highest percentage of Class 1 onions but differences were not significantly higher than for 8 other varieties. **TEX 2095** had the lowest amount of Class 1 onions, significantly lower than all other varieties, **Sherpa** was the next lowest but only significantly lower than **Hyfort**. Both those varieties had the highest percentage of soft bulbs, with watery scale.

The percentage of marketable onions post - CA storage ranged from 59.1 % for **TEX 2095** to 91.5 % for **Hyfort**. Overall, the percent marketable onions after 247 days of storage in CA was very good with two third of the varieties having more than 80% marketable.

Julia, Sunskin and **Hysam** also had a high percentage of soft bulbs after CA storage in high concentration of CO_2. The percentage of rotten bulbs was low, rotting was mostly due to Botrytis neck rot.

Weight loss ranged from 0.7 % to 1.7 % per month. Highest weight loss was found for **Sherpa** and **TEX 2095.**

b) on Translucency

Overall the differences in Translucency were not significant however there were a range of scores. The highest levels of Translucency were recorded for **Sherpa** – 2.92, **Sunskin** – 2.60 and **TEX 2095** – 2.50 (Table 4). Two or three fleshy scales and sometimes more were affected by translucency. The following varieties had the lowest scores: **Friso, Hyfort, Rolex, Barito** and **Boston**. The majority of bulbs had only one fleshy scale affected, with the rest of scales sound.

4. Disease organisms

Tissue samples were taken from bulbs stored at Kirton showing symptoms of either watery skin or translucency. Sections of affected tissue approximately 1 cm^2 were either surface sterilised with sodium hypochlorite or left unsterilised. Sections were macerated gently in sterile saline and the resulting solution streaked onto semi-selective media for estimation of bacterial infestation, or placed intact onto potato dextrose agar for estimation of fungal infestation. Plates were examined for consistent colony types, and the results are summarised in Table 5.

Table 5. Summary of mycological tests (bulbs stored at Kirton)

Pre-treatment	Symptom	Incidence of possible causal agents (% of onion bulbs tested)		
		Pseudomonas	Erwinia	Penicillium
None	Translucent	43	14	79
	Watery skin	20	0	80
5 mins	Translucent	0	0	33
	Watery skin	0	0	50

Pseudomonas and Erwinia were the most common bacterial species found. However, none were seen in material, which had been surface sterilised, which suggests that they were superficial contaminants from the storage environment, and not consistently associated with watery skin or translucent scale development. However, a relatively high proportion of bulbs showing symptoms were infected with *Penicillium* spp, even after surface sterilisation, and it is possible that Penicillium might be implicated in symptom development, though equally possible that bulbs with watery skin are pre-disposed to secondary infection by Penicillium. Further tests using a controlled inoculation and storage would be necessary to determine whether Penicillium has any role in watery skin development.

Samples stored in Poland were not tested for disease organisms but Penicillium symptoms were not visually obvious.

Technology Transfer
NIAB open days and Onion steering group meetings
HDC News

Glossary
"Watery Skin" is a deterioration and disease invasion of the outer scale of onions, which then become dark chocolate brown.
"Translucency" water soaking symptoms usually in the outer scales of onions

References
Clinton C Shock et al 2001. Effects of Onion Plant Damage and Field Heat Stress on Translucent Scale in Onion Bulbs. Oregon State University, Malheur Experimental Station Annual Report 2001
Purvis A 2002 Storage Losses in CA Stored Vidalia Onions. The University of Georgia College of Agricultural and Environmental Sciences Impact Statement

Appendices
Photos of scales for Watery skin and translucency (Separate file)