SPROUT SUPPRESSION 2020

Potato Council R&D: its role in developing sprout suppression best practice

Dr Mike Storey

Head of R&D

AHDB Potato Council

mike.storey@ahdb.org.uk

Ref	Title	Years
145	Optimising use of CIPC for sprout control	1992-1994
146	Airflow modelling to improve uniformity of CIPC	1992-1994
147	Alternatives to CIPC	1992-1994
159	Improving CIPC distribution in stores to minimise losses	1995-1997
S104	Optimum use of CIPC in sprout control	1998-1999
207	Optimisation of CIPC for stored potatoes and environmental issues	1999-2003
208	Detrimental effects of CIPC application on processing quality (CO2)	1999-2003
235	Review and development of CIPC application and its impact on potatoes for processing	2002-2005
243	CIPC application and evaluation of environmental issues	2003-2005
258	Use of modelling to predict vapour distribution and particulate CIPC	2004-2007
265	Modified storage practices – inverters	2005-2008
288	Use of CIPC vapour to control spouting in commercial stores	2007-2008
297	Timing of initial applications of CIPC	2007-2008
298	Effects of atmospheric compounds in potato stores on tuber quality	2007-2008
402	Inverter use, air delivery and crop quality	2007-2010
412	Understanding the role of ethylene	2008-2011
414	Residue variability	2008-2012
438	Reducing post-harvest losses and wastage due to sprouting (LINK)	2010-2013
438ext	Alternative sprout suppressants	2013-2014
441	Storage using CIPC and ethylene	2010-2012
450	CIPC vapour release	2011-2012
463	Low temperature CIPC recommendations	2012-2015
464	Ethylene best practice for processing crops	2011-2013
479	Controlling dormancy and sprouting in potatoes (HAPI)	2013-2017
483	CIPC in commercial stores	2013-2015
485	CIPC decontamination (PhD)	2014-2017
0009	CFD Storage modelling (PhD)	2015-2018

R&D and Best Practice

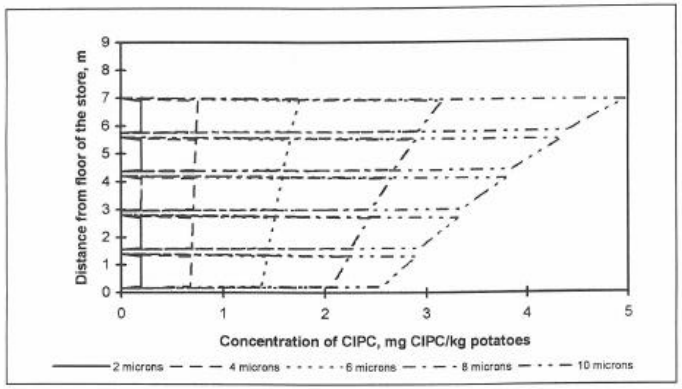
- CIPC
- Bulk and box stores
- Ethylene
- Alternative suppressants
- Delivery of best practice

Critical CIPC levels

Initial CIPC levels (ppm):	30%	50%
Maris Piper	1.20	1.15
Record	1.45	2.05

Sprouting not observed until CIPC residues dropped below *c.*0.3 - 0.5 ppm

- Sprout control very effective at the reduced rates
- Sprout growth may not be sustained
- Control tubers had some sprout inhibition



Predicted effect of particle size on the distribution of CIPC after one application of a fog containing 2, 4, 6, 8 or 10µm particles.

CIPC deposits after application

Romano tubers placed in store prior to fogging and recovered 24hr after CIPC application

Chlorproham (mg kg^{-1})

Box	Centre	Bay no	wall
Top	2.41	8	4.50
Bottom	1.81		4.60
Top	5.52	7	8.34
Bottom	1.97		2.52
Top	6.22	6	6.23
Bottom	1.94		6.44
Top	7.35	5	6.32
Bottom	5.46		3.03
Top	5.41	4	8.34
Bottom	2.34		3.24
Top	9.05	3	6.74
Bottom	4.70		3.16
Top	4.77	2	3.44
Bottom	4.68		3.67
Top	7.86	1	8.73
Bottom	5.94		–

Bay number: not significant

Aisle v wall: not significant

Top v bottom box: * * *

Top = 6.3 mg/kg

Bottom = 3.7 mg/kg

CIPC distribution model

- predictions generally agree with store data
- particle size has a significant effect
  - ⇒large (10 micron): high deposits and variable
  - ⇒small (less than 2 micron): slow to sediment and leakage from store
- small temperature differences in air around and within boxes important
- gas flow rate has little effect on CIPC distribution
- uniformity of deposits of larger particles may be improved by forced ventilation systems

Glasgow University, Silsoe RI and SuttonBridge

CIPC vapour

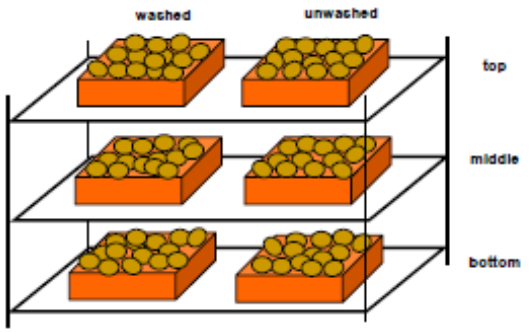
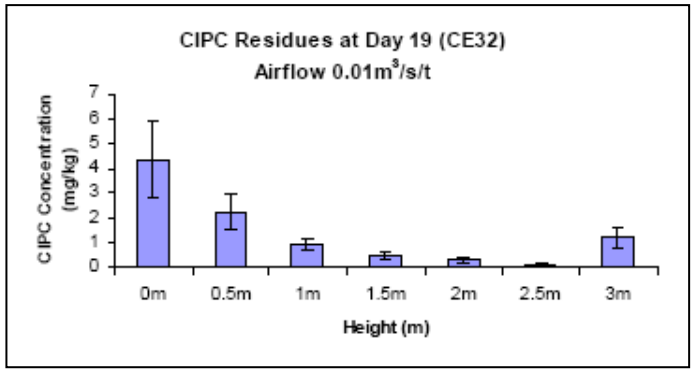
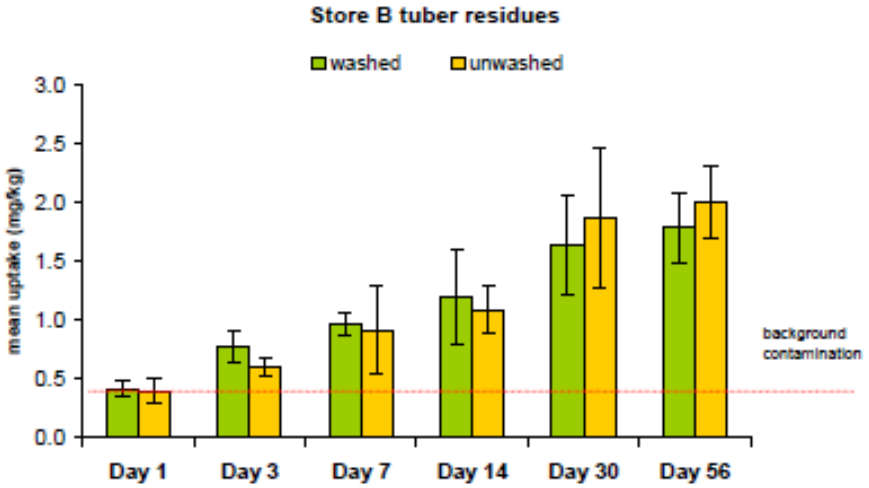
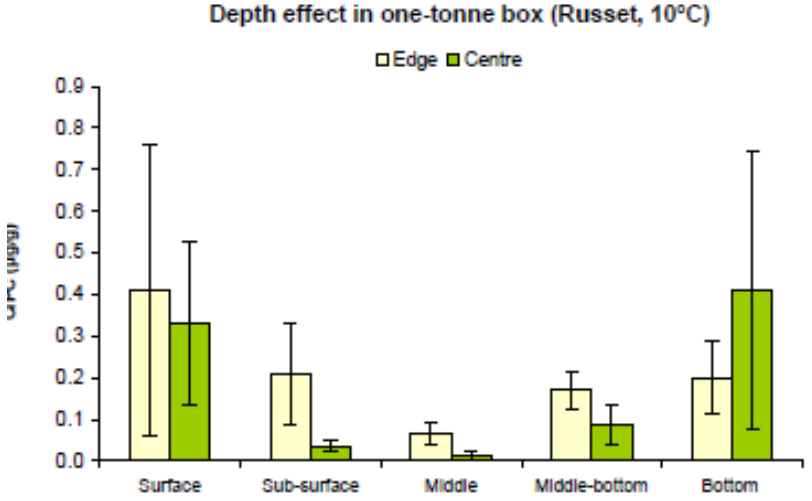


FIGURE 1: LAYOUT OF TRAYS IN SAMPLED STORES



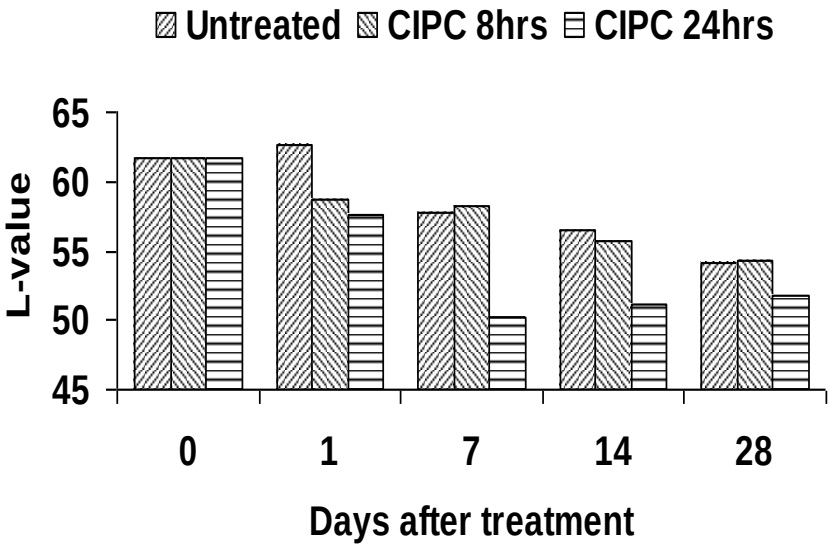


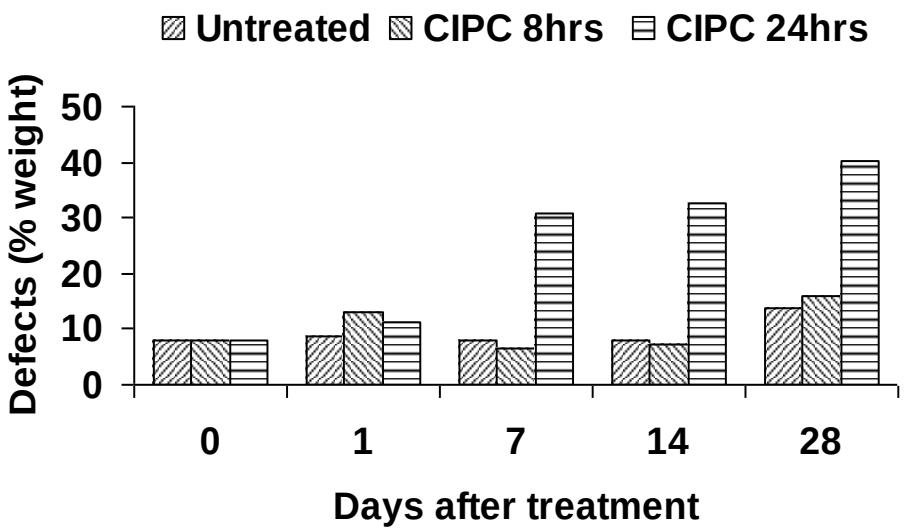


8: MEAN CIPC CONTENT OF UNTREATED POTATOES AT DIFFERENT DEPTHS IN A ONE-TONNE BOX AFTER STORAGE IN A CIPC CONTAMINATED STORE AT 10°C FOR 35 DAYS.

Ventilation post-CIPC application

Fry colour and fry defects cv Saturna ventilated
8 or 24 hours after CIPC application





Early ventilation of stores is now on all CIPC labels.

Box and Bulk Potato stores

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

SPROUT SUPPRESSION 2020

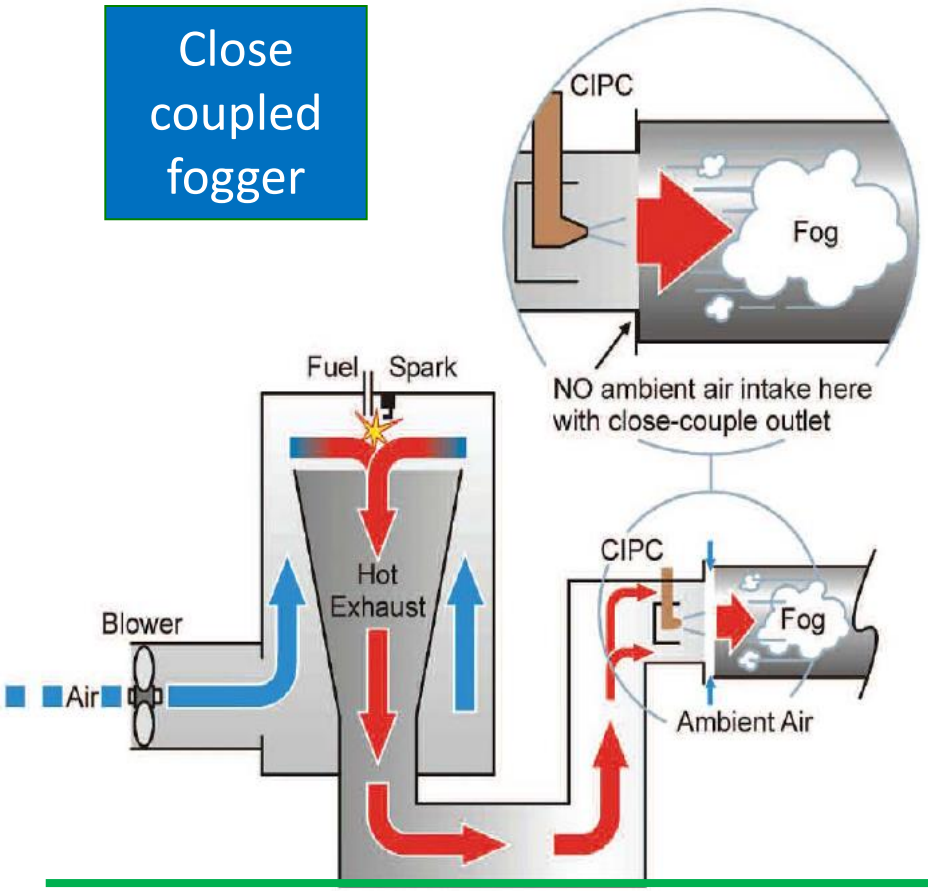
Evaluating modified storage practices

- Modified application process
  - Recirculation using fans fitted with VFD's
  - Closed couple at the fog head
  - Solvent-free CIPC
- Control application
  - No recirculation
  - Open couple at the fog head
  - 50% CIPC in methanol

Sutton Bridge S265

Reducing risk of MRL exceedance in bulk stores

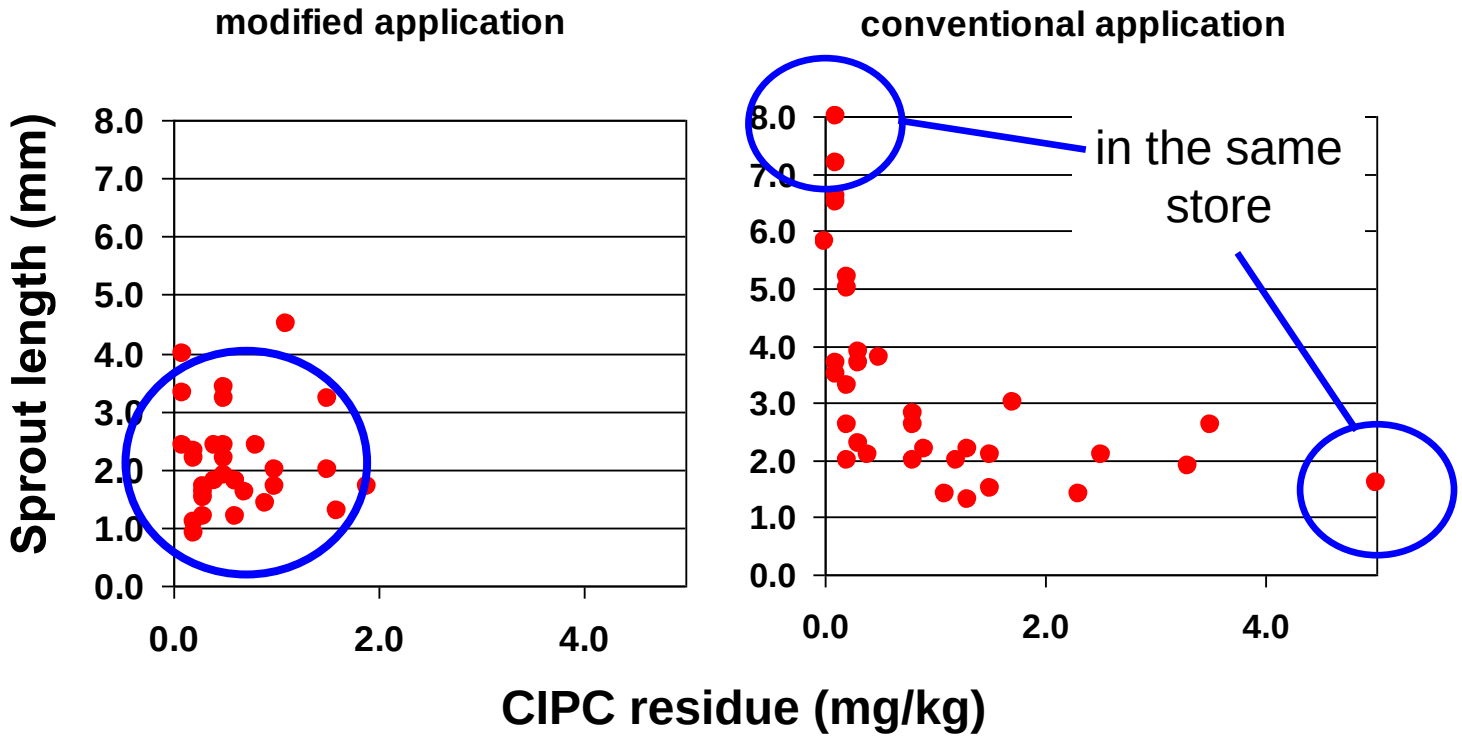
Close coupled fogger



Inverter

Improved ventilation management

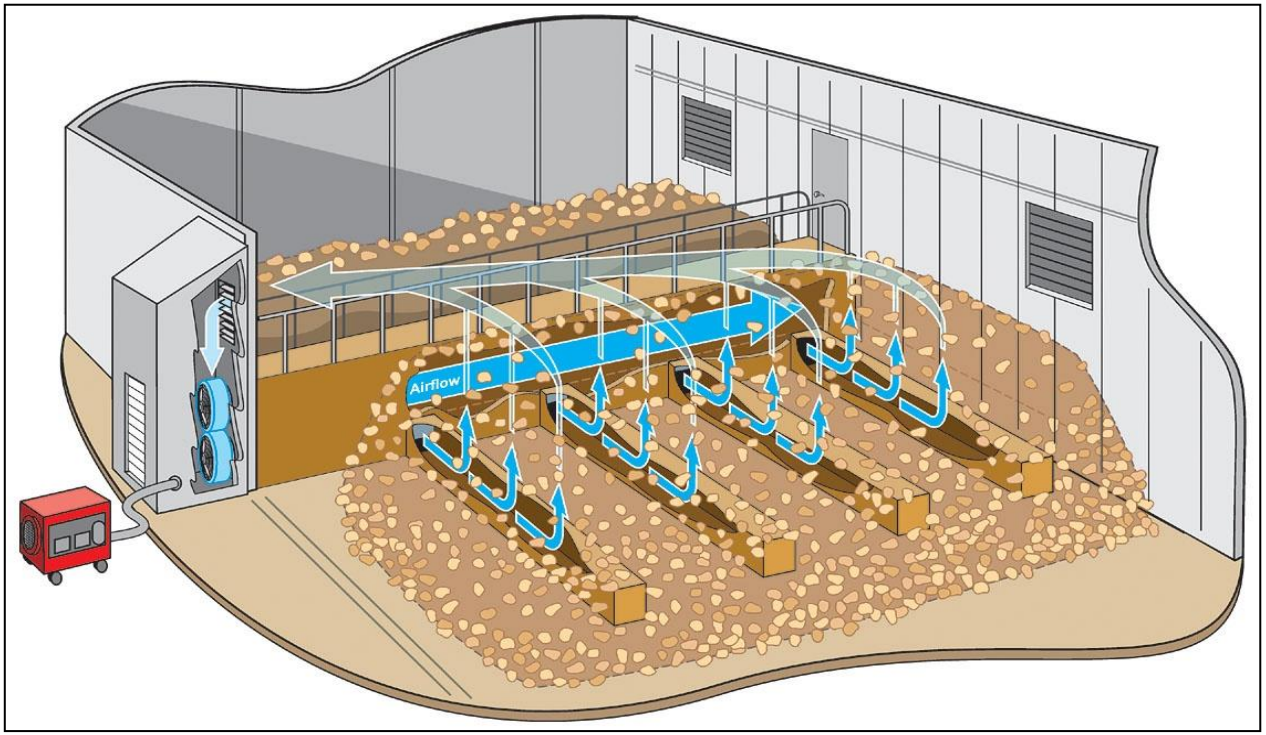
Best Practice in bulk stores



Modified treatment: MSS SproutNip, Close-coupled fogger. VFD operated fans

University of Glasgow & SBCSR

Improved airflow & bulk store temperature control



Achieving uniform air distribution for CIPC application also improves ventilation management for better crop temperature control **– and less variability in fry colour**

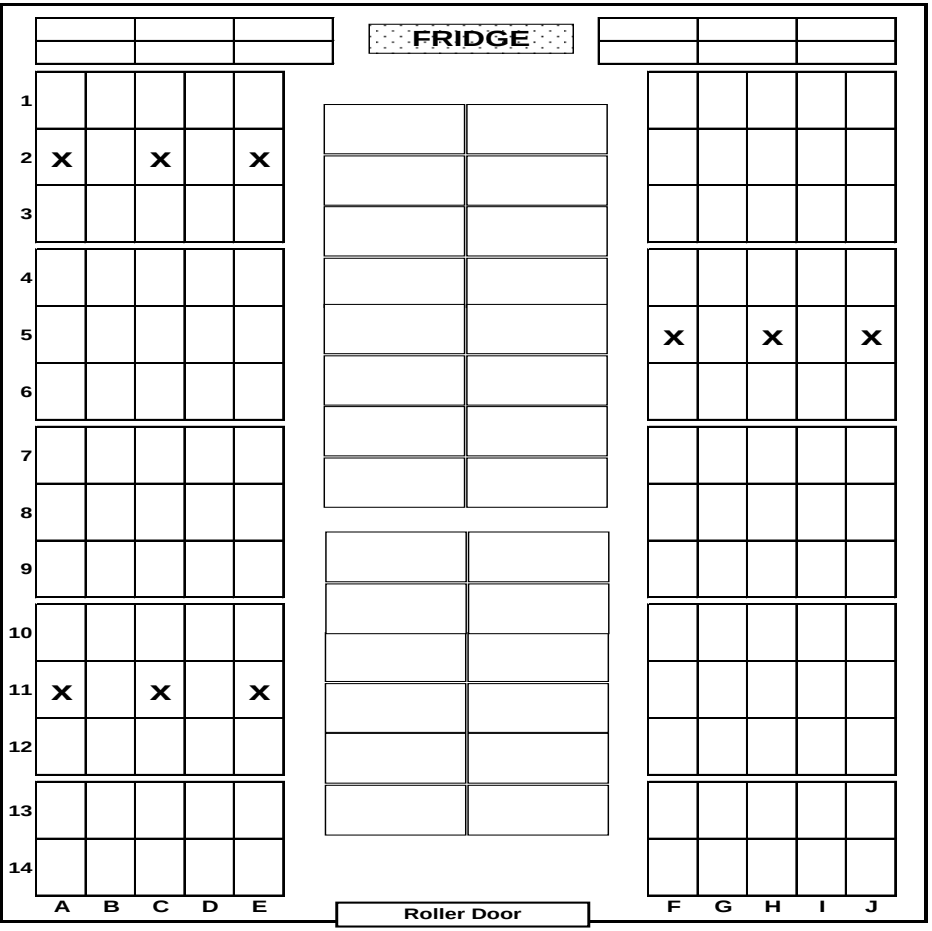
Improving CIPC use in box stores

- Modify box stacking to create a plenum
- Plenum acts as main duct
- Pallet slots/apertures act as lateral ducts

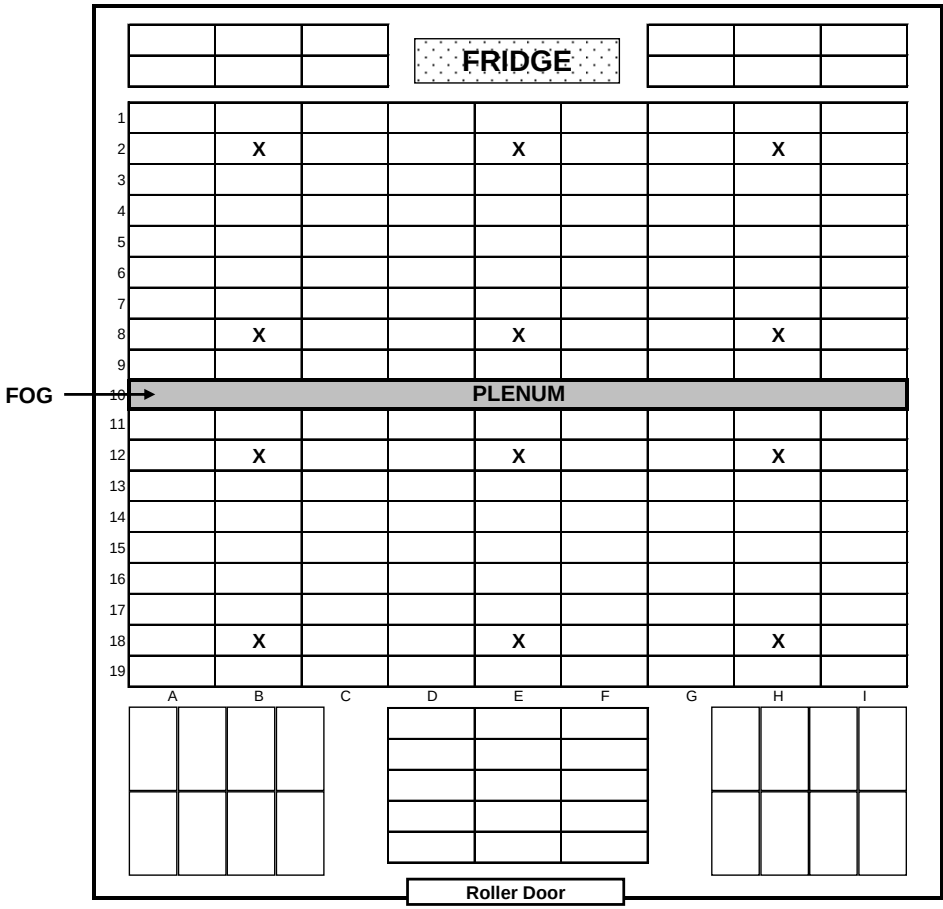
AHDB Agriculture & Horticulture DEVELOPMENT BOARD

Standard ‘Over Head Throw’ vs ‘Plenum’

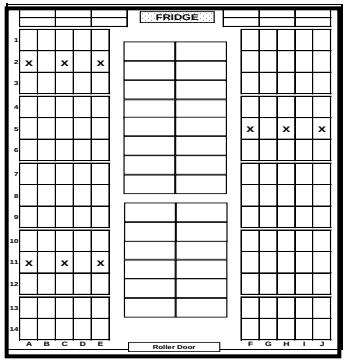
Control-store A – ‘OHT’

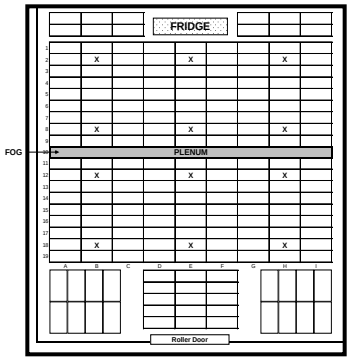


Plenum (passive) store B



Standard ‘Over Head Throw’ vs ‘Plenum’





Control - OHT

12x

4x

Mean values		
	sprout length (mm)	CIPC concentration (mg/kg)
Top	1.72	2.00
Middle	29.11	0.17
Bottom	13.94	0.26

Plenum

Mean values		
	sprout length (mm)	CIPC concentration (mg/kg)
Top	2.37	0.97
Middle	2.64	0.24
Bottom	1.96	0.23

Commercial store trials

Fogger: reduced volume, solvent free formulation
Store: modified airflow/stacking patterns
plenums, low speed recirc, suction wall

5 commercial stores

- control
- passive plenum
- positive plenum
- negative plenum
- suction wall

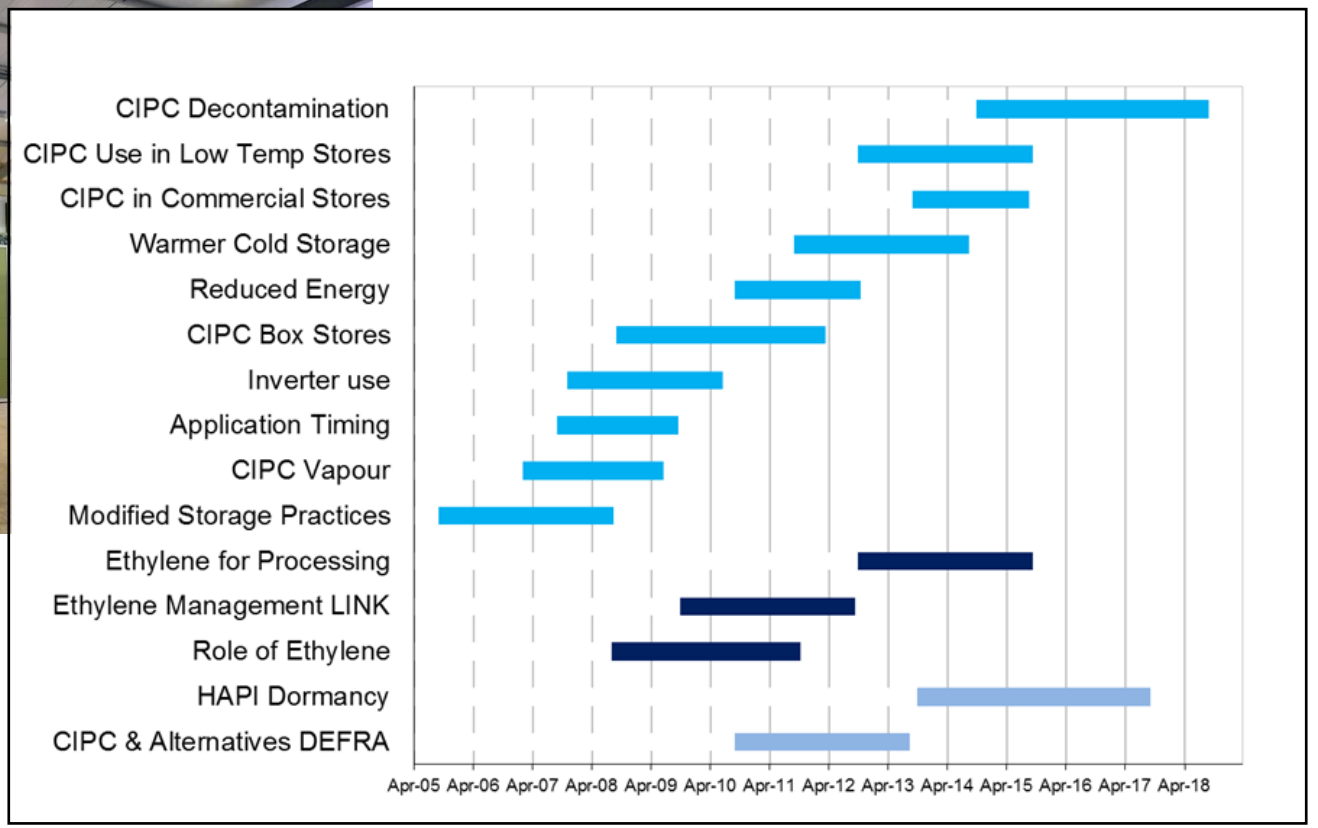
Commercial store trials – yr 1 summary

store	treatment	CIPC mean	CIPC max	CIPC min	CIPC CV%	CIPC eff	CIPC max/min
W3	Passive plenum	2.9	9.3	0.4	57	24%	23x
H36	Positive plenum	2.7	5.3	0.3	48	10%	18x
W1	Suction wall	3.0	9.7	0.9	54	25%	11x
L2	Separator, foam & VFD	3.2	7.7	0.5	58	23%	15x
C6	Separator & VFD	1.1	3.3	0.1	47	5%	33x

Highest residues and greatest retained proportion of dose in low temperature stores

Ongoing R&D investment

New experimental stores at Sutton Bridge (£600k)



LINK collaborative research

Sprout control under 10 ppm ethylene

Variety	2 months storage		4 months storage		6 months storage	
	Length (mm)	sd	Length (mm)	sd	Length (mm)	sd
Desiree	**1.2**	1.50	**7.0**	5.20	**11.0**	7.35
Innovator	**1.7**	1.15	**7.8**	3.09	**8.8**	4.04
Lady Claire	**3.8**	4.80	**19.8**	3.85	**25.8**	6.05
Maris Piper	**5.5**	5.69	**8.1**	6.18	**13.5**	8.04
Markies	**0.9**	2.12	**1.3**	1.54	**3.1**	2.78
Ramos	**0.1**	0.34	**1.1**	0.50	**3.1**	3.13
Rooster	**3.2**	2.74	**20.6**	6.68	**25.4**	5.96
Russet Burbank	**0.0**	0.00	**1.1**	0.81	**2.3**	1.27
Saturna	**0.4**	0.72	**9.1**	4.26	**19.9**	4.84

The James Hutton Institute

Natural Resource Institute

PEPSICO INTERNATIONAL UK & Ireland

CYGNET PB Cygnet Potato Breeders Ltd

SUTTON BRIDGE Crop Storage Research

POTATO COUNCIL

Greenvale AP

Landseer LIMITED

Effects of 10 ppm ethylene on French fry colour

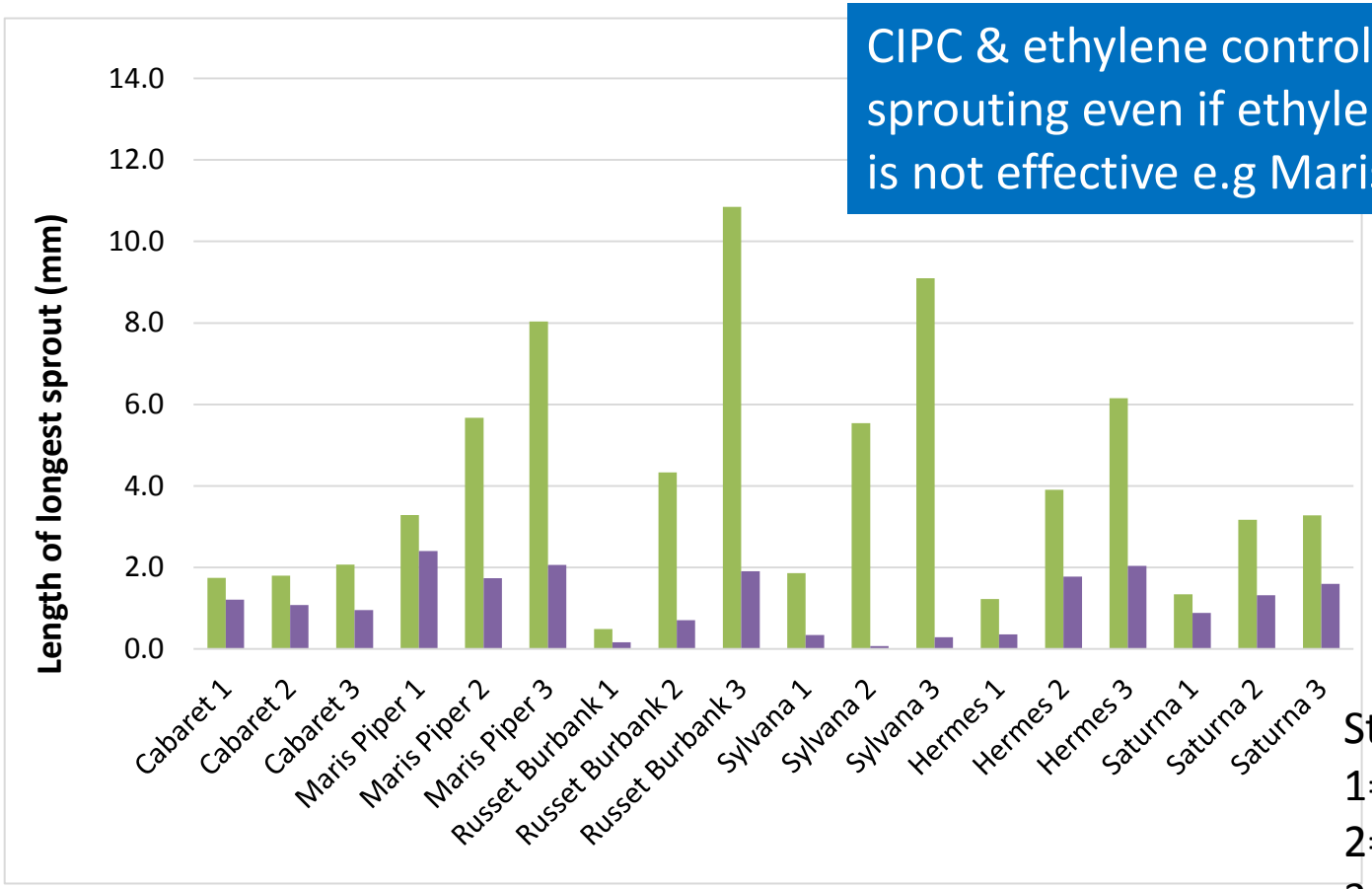
	Intake		2 months		4 months		6 months	
	Score	sd	Score	sd	Score	sd	Score	sd
Desiree	**3.2**	0.64	**4.9**	0.52	**4.5**	0.87	**5.6**	0.69
Innovator	**2.9**	0.36	**2.9**	0.49	**3.4**	0.62	**4.1**	0.72
Maris Piper	**2.9**	0.67	**3.5**	0.65	**3.3**	0.90	**4.0**	0.96
Markies	**2.9**	0.52	**3.0**	0.34	**3.2**	0.52	**3.4**	0.58
Ramos	**1.8**	0.49	**1.6**	0.65	**1.8**	0.87	**4.4**	0.84
Rooster	**1.9**	0.28	**2.6**	0.53	**1.8**	0.72	**2.3**	0.52
Russet Burbank	**2.9**	0.45	**3.2**	0.46	**3.4**	0.48	**3.7**	0.66

SBCSR	1	2	3	4	5	6	7
USDA	000	00	0	1	2	3	4

Summary ethylene treatment

- Pronounced varietal response to ethylene
- Ethylene decreases sprouting in all varieties compared to untreated but only to commercially acceptable standards with a few varieties
- Effect of ethylene on chip fry colour generally small
- Large effects on crisp fry colour in some varieties

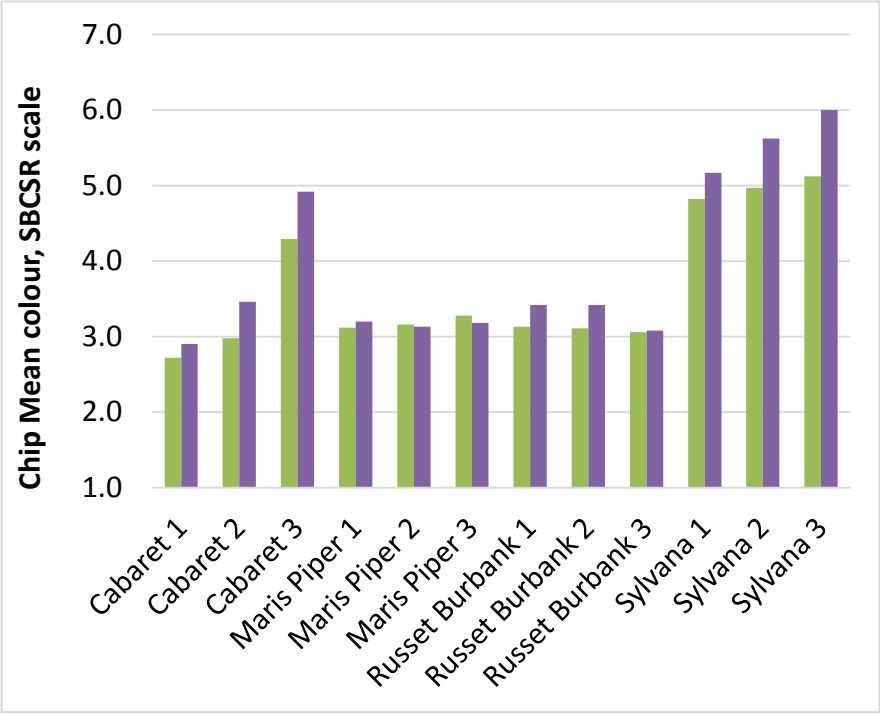
Integrating sprout suppressants

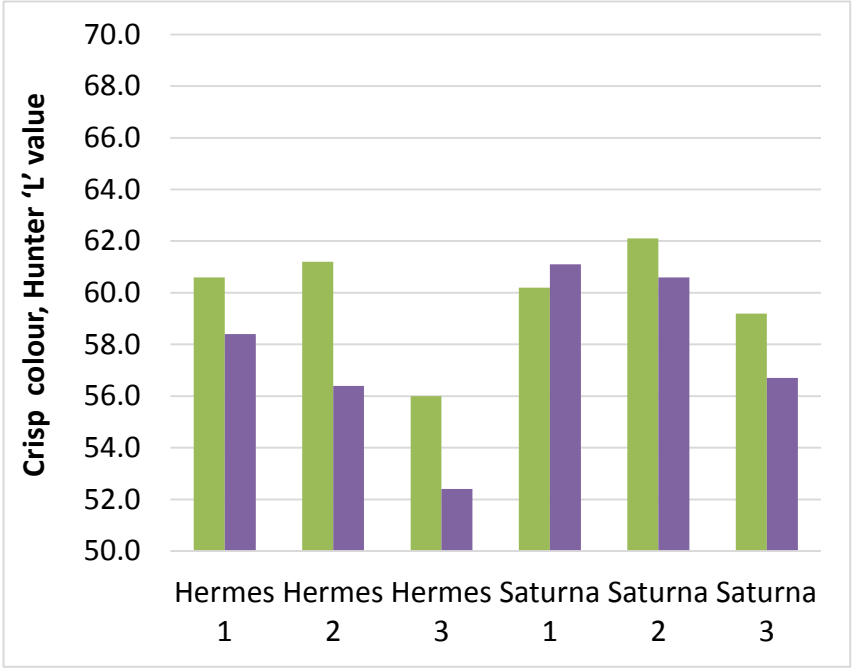


CIPC & ethylene control of sprouting even if ethylene alone is not effective e.g Maris Piper

Storage period
1=2mths
2=4mths
3=6mths

Effects on fry colours





SBCSR score	1	2	3	4	5	6	7
USDA score	000	00	0	1	2	3	4

Effects of ethylene on fry colour evident – but (at 9oC) small and acceptable for chips, can be more significant for some crisping varieties.

Alternative suppressants

Assess alternatives (small-scale)

- efficacy of sprout control
- disease & processing

Selected treatments scale-up to 16t box stores

- Storage at 6 and 9C
- 120 l capacity chambers
- 2 air exchanges per day
- assess at 3-4 & 6-8 months

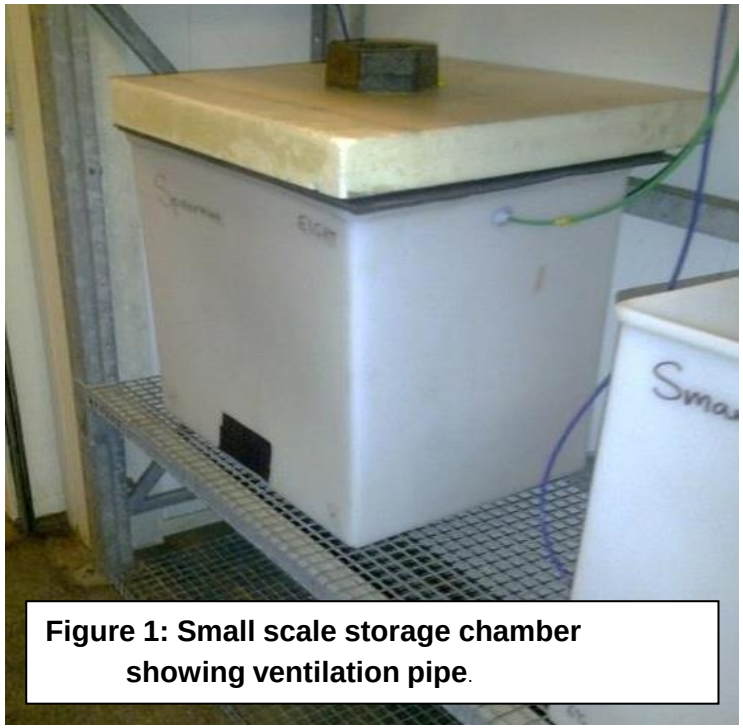


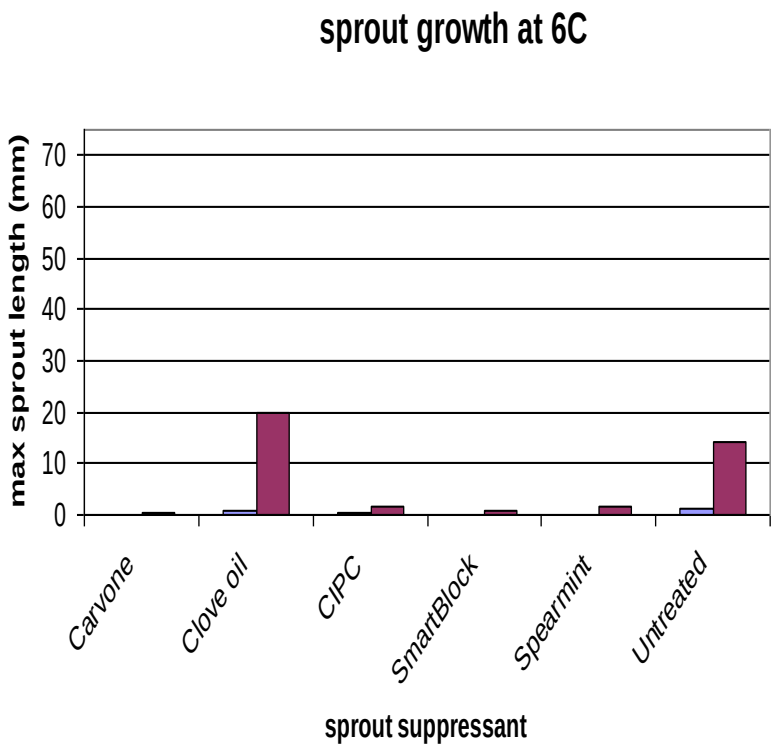
Figure 1: Small scale storage chamber showing ventilation pipe.

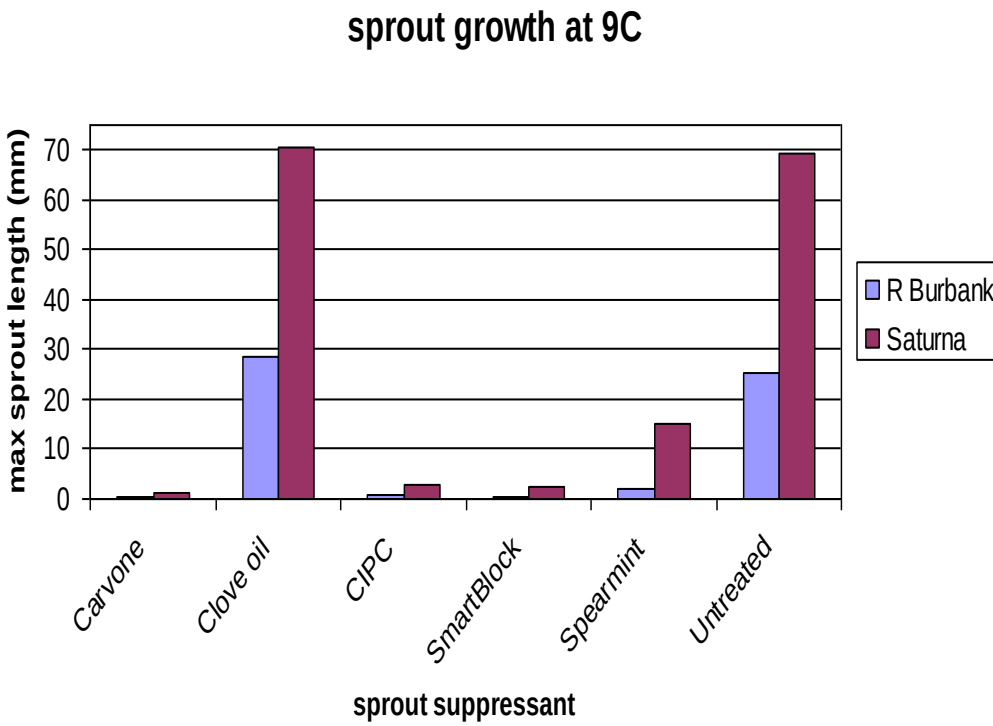
Formulations/actives

- GroStop Ready (CIPC)
  - single application at loading (at 18 g tonne $^{-1}$)
- Biox-M (spearmint oil)
  - 90ml and 30ml tonne^{-1} at 21 day intervals
- Biox-C (clove oil)
  - as required (48ml tonne^{-1})
- Talent (carvone)
  - 30 -15ml tonne^{-1} at weekly interval
- SmartBlock (3-decen-2-one)
  - 115ml tonne^{-1} as required
- Untreated – control

Sutton Bridge CSR (483) 2010/11

Alternative sprout suppressants

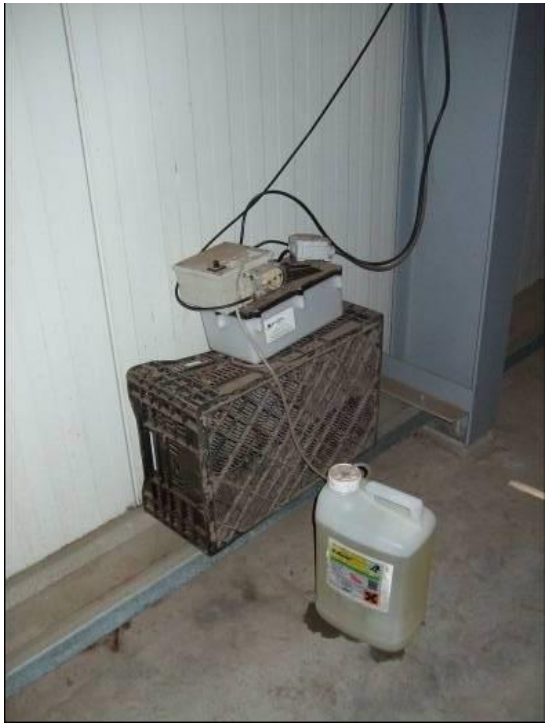




Clove oil dropped in year 2 due to lack of efficacy

Sutton Bridge CSR

Larger scale assessments



Auto-dosing system attached to store controller for daily or weekly application of carvone to a stored seed crop in the Netherlands.

Weekly application of carvone to a 16 tonne box store with non-positive ventilation

Large scale

9°C in boxes, using caraway oil and non-positive ventilation

placement	Russet Burbank				Saturna			
	12 weeks	(sd)	24 weeks	(sd)	12 weeks	(sd)	24 weeks	(sd)
front	**1.4**	(0.7)	**28.8**	(45.8)	**11.8**	(10.1)	**89.0**	(59.0)
back	**1.5**	(1.1)	**36.9**	(54.8)	**11.0**	(9.1)	**66.7**	(45.4)
left	**1.4**	(0.8)	**29.6**	(49.7)	**10.3**	(8.7)	**86.3**	(62.5)
right	**1.5**	(1.1)	**36.1**	(51.4)	**12.5**	(10.3)	**69.4**	(41.7)
top	**1.2**	(0.5)	**5.3**	(7.1)	**4.2**	(4.7)	**45.1**	(22.2)
upper middle	**1.1**	(0.4)	**57.4**	(63.7)	**9.0**	(7.2)	**81.9**	(45.4)
lower middle	**2.1**	(1.5)	**34.9**	(48.5)	**14.7**	(9.4)	**119.3**	(73.1)
bottom	**1.3**	(0.5)	**33.8**	(50.2)	**17.6**	(10.1)	**65.0**	(27.5)
grand mean	**1.4**	(0.9)	**32.8**	(50.5)	**11.4**	(9.6)	**77.8**	(53.7)

Large scale

9°C in boxes, using spearmint oil and positive ventilation

placement	Russet Burbank				Saturna			
	14 weeks	(sd)	26 weeks	(sd)	14 weeks	(sd)	26 weeks	(sd)
front	**2.2**	(4.3)	**58.1**	(25.9)	**4.2**	(2.8)	**37.7**	(11.6)
back	**2.2**	(4.8)	**66.2**	(34.1)	**3.4**	(2.7)	**38.2**	(13.6)
left	**1.7**	(3.6)	**60.1**	(27.4)	**3.5**	(2.4)	**38.8**	(12.8)
right	**2.6**	(5.4)	**64.2**	(33.3)	**4.1**	(3.1)	**37.1**	(12.5)
top	**2.5**	(4.9)	**66.2**	(36.8)	**3.8**	(2.7)	**34.7**	(13.5)
upper middle	**2.2**	(5.0)	**61.6**	(23.7)	**3.4**	(2.2)	**35.8**	(10.5)
lower middle	**1.8**	(3.2)	**67.8**	(32.7)	**3.9**	(2.7)	**42.6**	(15.1)
bottom	**2.1**	(5.0)	**53.1**	(25.6)	**3.9**	(3.3)	**38.6**	(9.5)
grand mean	**2.2**	(4.6)	**62.2**	(30.5)	**3.8**	(2.7)	**37.9**	(12.6)

Alternative sprout suppressants

Spearmint - Biox M
1,4-Dimethylnaphthalene - 1,4SIGHT
3-decen-2-one - SmartBlock
Carvone – Talent

What influences adoption?

- Efficacy
- Cost
- MRL status
- Ease of use
- Crop quality

Delivering Best Practice - CIPC

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

SPROUT SUPPRESSION 2020

Be CIPC Compliant

A potato industry stewardship initiative

HOME | ABOUT CIPC | NEWS | R&D | Q&A | NAAC CONTRACTORS | SUPPLY CHAIN | STEWARDSHIP | CONTACT US

NEWS · followed

Sprout Suppression | Regulation | Best Practice - BOX | Best Practice - BULK

Useful resources

- CIPC Store Checklist >
- Best practice guidance >
- Literature Request >
- NAAC contractors >
- Storage Bulletin >
- Being CIPC compliant >
- Code of Practice >

Be CIPC Compliant

'Be CIPC Compliant' is a new initiative from the industry-led **CIPC Stewardship Group**.

Please read the following which explains what you need to do to be compliant:

Training

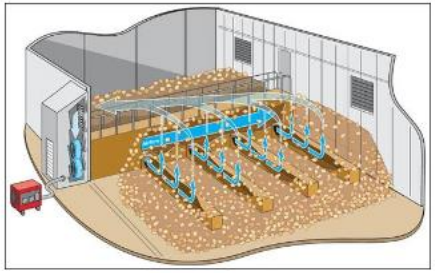
Get it on early

Be CIPC Compliant

A potato industry stewardship initiative

Best practice - Bulk

Conventional applications of CIPC to bulk stores, without fans operating, can result in uneven distribution of the treatment. Some areas in the store may receive little chemical, resulting in earlier regrowth and the need for further applications. A better procedure involves low-speed recirculation of CIPC fog through bulk piles. This can significantly reduce the total dose of CIPC required over a storage season by providing a more even distribution of sprout suppressant.



Best practice CIPC in bulk stores showing repeated recirculation of fog t

To use the technique, some changes to storage ventilation e be carried out with fans operating at lower speeds than r

The principle is for CIPC fog to be recirculated thro ventilation system. To prevent the chemical depositi operated at low speed by connecting them to a variable

Before application, the airflow into lateral ducts must be displaced can result in an uneven distribution continuously during and after CIPC application, until the

Best practice - Box

Effective treatment of potatoes stored in boxes requires a range of approaches depending on the type of storage system being used.

The major factor dictating the way CIPC is applied is whether or not the store has positive ventilation, i.e. whether the ventilating air (and fog) can be forced through the potatoes, rather than simply pass around them.

A store with non-positive 'overhead throw' air delivery system. CIPC applications in this store type are problematic and may be subject to stricter controls in the future.

It is crucial that temperature in any store is as uniform as possible prior to treatment. This requires the air to be recirculated around the store (without cooling) ideally overnight but for a minimum of 6 hours before the application is made. Do not apply CIPC immediately after cooling has been taking place as there is a high risk that deposition will be uneven.

Low temperature stores

Delivery of Best Practice

Annual tests for fogging equipment became a requirement from 1 January 2010

NSTS
NATIONAL SPRAYER TESTING SCHEME

34 machines tested & certificated

New Course for CIPC stewardship

BASIS Certificate
in Crop Protection
(Stored Potatoes)

90 advisors certificated under the new scheme

April 2015

NAAC applicators group

National Association of Agricultural Contractors

Established
November 2011

Builds on Stewardship contractors meetings

Fogging contractors (9) and owner/self applicators (2)

Adherence to CIPC Code of Best Practice

Store Checklist: Red Tractor

STORE CHECKLIST FOR USE PRIOR TO CIPC TREATMENT

CROP/STORE OWNER FORM: COMPLETE ONE CHECKLIST PER STORE PER APPLICATION

Be CIPC Compliant

www.cipccompliant.co.uk

Under Potato Industry CIPC Stewardship, crop owners must assess every store against the criteria listed before each CIPC application is made.
If a satisfactory checklist is not available, contractors cannot apply CIPC.
Use one form per store.
Address any red categories before treatment. If red categories remain, DO NOT TREAT.

Red Tractor Assurance for Farms
Fresh Produce Scheme

NAAC

Crop/Store Owner		
Store ID		No

Key issue	Guidelines	☹ R	😐 A	☺ G
STORE LOCATION	Proximity to residential property Proximity to non-target crops, seed or other goods Sheltered from prevailing wind?	Adjacent	Distant	+Sheltered
STORE INTEGRITY	Test for leakage, eg close store, turn lights off & do lightproof test Check louvre and door seals Evidence of leakage, eg at eaves or base of walls?	Many leaks	Some	Few/None
EMPTY AIR SPACE IN STORE	Is the store full enough? Divide the building volume occupied (length x width x average height) by the approximate volume occupied by the crop	Over 2.5	1.8-2.5	Below 1.8
CIPC APPLICATION POINT	Dedicated ports/ducts installed? Fog not directed straight on to boxes Centrally positioned or positive plenum for boxes	Poor	Fair	Good
UNIFORM STORE ENVIRONMENT	Capability to recirculate 24h before application without cooling to eliminate condensation and create an even temperature throughout stack?	Poor	Fair	Good
BULK STORE SUITABILITY	Clear ductwork, adequate laterals Balanced airflow Inverters for slow speed recirculation of fog	Poor	Good	+Inverters
BOX STORE SUITABILITY	Unimpeded air circulation throughout store Clear pallet slots with even stack height Applying into plenum to stop fog going direct to roof space	Poor	Fair	+Plenum

I confirm that this checklist has been shown to the advisor(s) giving the BASIS recommendation for application and to the CIPC applicator(s).

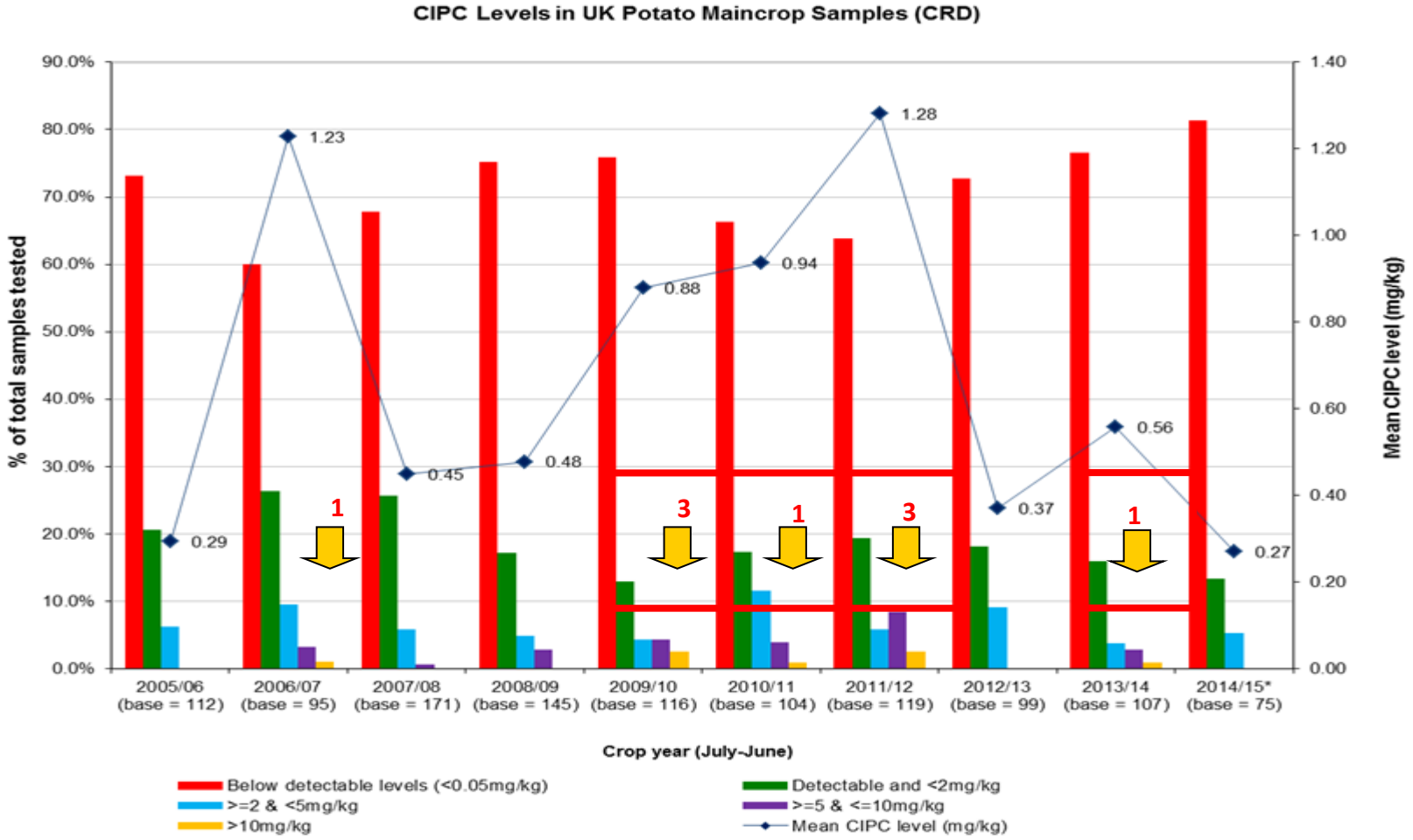
Signed ..... Date ..... PICSG/Sep 2014/CSO/v4

Permanent signage to confirm CIPC use in the building will be required in all stores subject to Red Tractor Farm Assurance audit: see redtractorassurance.org.uk

Achieved

- Particle size and distribution modelling
- Fogging conditions – temp & flow rates etc
- Liquid/ solid formulations
- Timing of CIPC application
- Dose management
- Ethylene understanding
- Use of Carvone, Spearmint, DMN, 2-decen-3-one
- Store integrity
- Bulk stores
- Box stores - principles
- Maintain quality and reduce risk of MRL exceedances

Residue monitoring



AHDB Agriculture & Horticulture DEVELOPMENT BOARD

SPROUT SUPPRESSION 2020

More effective CIPC use

PUS year	2002	2006	2010	2012
Stored total (mtonnes)	4.69	3.75	3.9	2.95
Basic treated total (mt)	2.40	1.69	2.03	1.68
CIPC %	94	94	88	89
Basic treated CIPC (mt)	2.26	1.59	1.79	1.50
Total a.i. (t)	79	55	36	31
CIPC %	91	90	85	92
CIPC a.i. (t)	71.8	49.5	30.6	28.5
t crop treated/t CIPC	31,421	32,093	58,379	52,463

PUS Pre- & Post-Stewardship

Pre (av 2002 & 2006)

- 60.65t a.i. CIPC
- 31.6g/t
- 31,700t treated/t

Post (av 2010 & 2012)

- 29.55t a.i. CIPC
- 18.0g/t
- 55,421t treated/t

↓ total CIPC used (tonnes a.i.) reduced by 51%

↓ 43% reduction in CIPC use /t treated

↑ increased the efficiency of CIPC dose by 74%