Interim report

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Maleic hydrazide optimisation as a sprout suppressant

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1. Introduction

Maleic hydrazide (MH) has been registered as a growth regulator in the UK since the 1980's. It has a range of crop and non-crop uses and there are currently around 20 UK authorisations for pesticide products containing the active substance[1]. Authorisations for crop use are for sprout suppression of onion and potato and for volunteer control of potato. In addition, there are Extensions of Authorisations for Minor Use (EAMU) for garlic, shallot, carrot and parsnip as well as a range of fruits.

Initially, usage of MH on potato was primarily for volunteer control (Buckley *et al*, 2006) More recently its value as a sprout suppressant has become apparent. In work investigating alternative sprout suppressants during storage of potatoes for the processing (Briddon & Stroud, 2021) and pre-packing (Saunders & Harper, 2021) sectors in the UK, replicated plots were sheeted over at the time of applications, giving MH-treated and MH-untreated samples of the same commercial crops. MH was effective as a sprout suppressant, but was also effective at improving control from other (post-harvest) sprout suppressants. Results were especially evident at higher MH residue values. In stored pre-pack crops, MH was important in maintaining sprout control during shelf-life, after removal from store (Saunders & Harper,

[1] https://secure.pesticides.gov.uk/pestreg

2021). Maleic hydrazide has also been reported to control second growth and internal sprouting during storage (Briddon & Stroud, 2021).

Maleic hydrazide is generally applied as a foliar spray. Early applications have been associated with a yield penalty (Weis, 1980) but other studies have shown no significant effect on yield (Caldiz, 2001). Maleic hydrazide is non-volatile and residue concentrations remain relatively stable during storage (Briddon & Stroud, 2021), although there are reports of MH residues reducing as it became bound, perhaps to cell wall components (Buckley *et al*, 2006).

The following work was carried out to assess the residue concentration required for control of sprout growth, and the variability in residue concentration that occurs as a result of plant-to-plant variation.

2. Materials and methods

Maleic hydrazide treatments were made to single c.10m by 3m plots at 10%, 25%, 50% and 100% rates of 5 kg Fazor in 400 l/ha, at SPot West using cv. Titan and at SPot North using cv. Maris Piper, on 5 August 2019. Photographs showing canopy condition at the time of applications are shown in Fig. 1 (SPot West) and Fig. 2 (SPot North). Further details are shown in Appendix 1.

On 17 September 2019 (cv. Titan, SPot West) and 17 October 2019 (cv. Maris Piper, SPot North), all tubers from 10 plants from each treatment were separately harvested by hand and transported to Sutton Bridge CSR.

Tubers from individual plants were divided, based on tuber size, into two sub-samples as shown in Fig. 3. One sample was analysed immediately for maleic hydrazide residue concentration. The second sample was analysed for weight of sprouts after storage at 9°C, without further treatment. Efficacy assessments were carried out after storage for 25 and 18 weeks for Titan and Maris Piper respectively. Residue concentration was quantified by liquid chromatography (LC MS-MS) following extraction using acidified methanol (ALS Food and Pharmaceutical, Chatteris, Cambs., PE16 6QZ, UK)

Data was analysed using statistical tools within Microsoft Excel 2016 (Analysis Toolpak). The analyses included ANOVA and t-tests where appropriate.

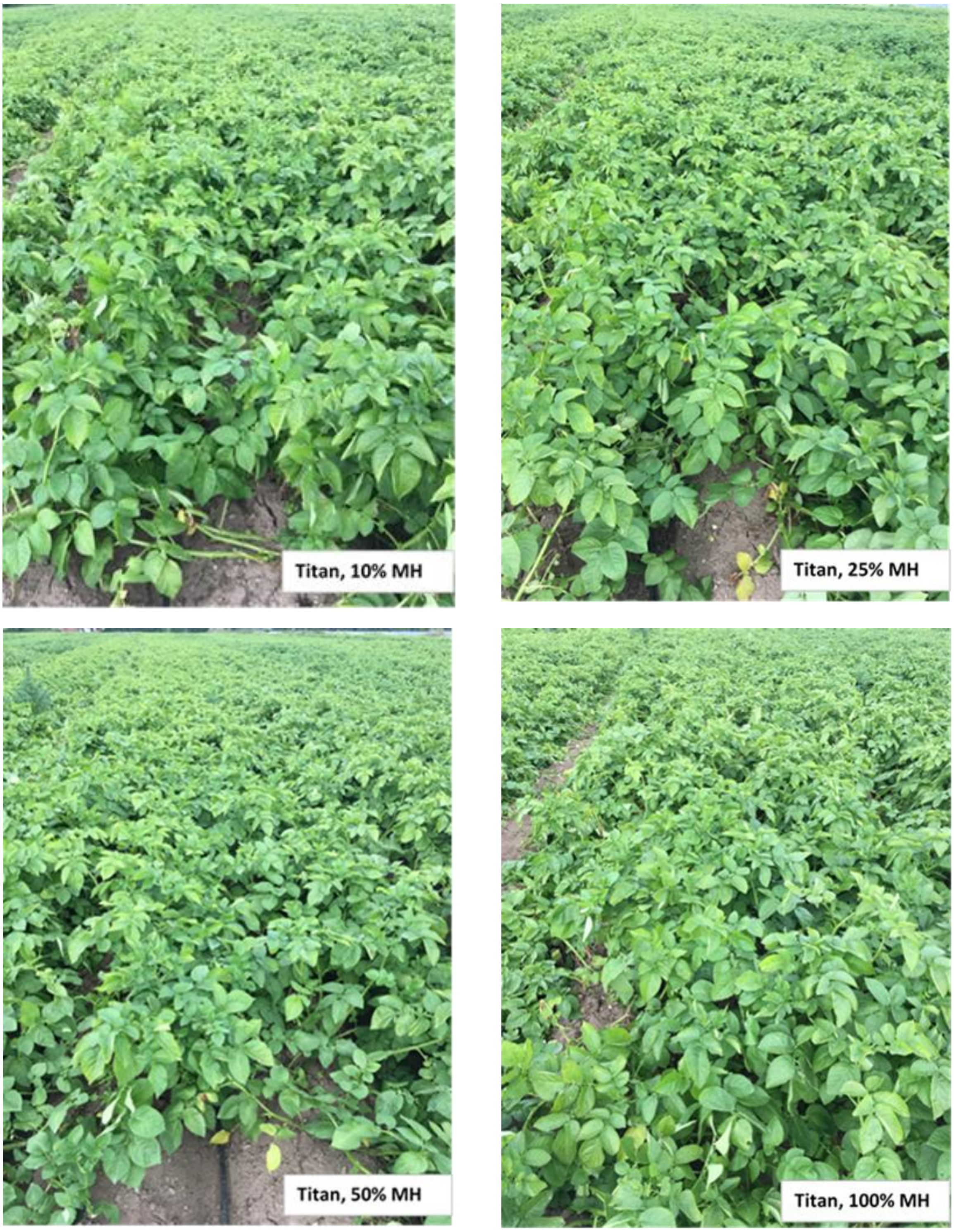


Fig.1 Photographs showing canopy conditions at the time of maleic hydrazide applications to cv. Titan at SPot West.

Fig. 2. Photographs showing canopy conditions at the time of maleic hydrazide applications to cv. Maris Piper at SPot North.

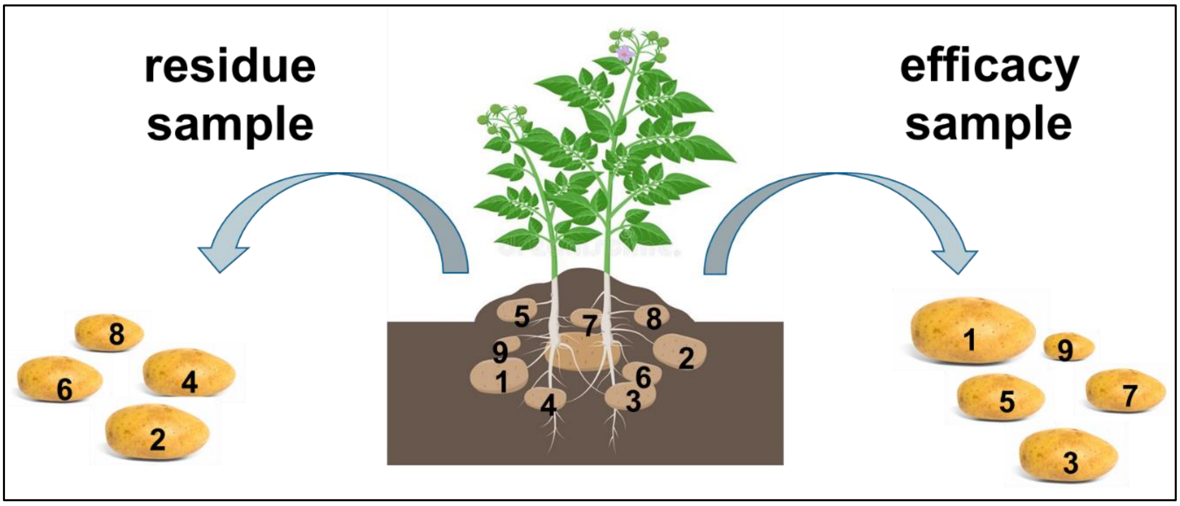


Fig. 3. Schematic representation showing division of tubers, on the basis of tuber size, into separate sub-samples for maleic hydrazide residue and efficacy assessment.

3. Results

3.1 Maleic hydrazide residue concentration

The residue concentration of samples is shown in Table 1. All untreated samples of cv. Maris Piper had residue concentrations of less than the limit of quantification (0.5 mg kg^{-1}). In cv. Titan, seven replicate untreated samples had a residue value of <0.5 mg kg^{-1} and three had concentrations of 0.6 mg kg^{-1}, suggesting some spray drift had occurred.

Table 1. Summary statistics (n=10) for maleic hydrazide residue concentration (mg kg^{-1}) of samples of cvs Titan and Maris Piper.

cultivar	treatment	**mean**	standard deviation	minimum	maximum
Titan	untreated	**<0.5**[a]	-	<0.5	0.6
	10%	**2.6**	0.86	1.6	4.2
	25%	**5.9**	1.03	4.3	7.2
	50%	**10.0**	2.50	7.5	14.0
	100%	**19.4**	4.84	14.0	30.0
Maris Piper	untreated	**<0.5**	-	-	-
	10%	**0.7**	0.47	<0.5	1.3
	25%	**2.5**	0.76	1.1	3.4
	50%	**5.3**	2.86	2.6	13
	100%	**12.1**	3.60	6.9	18.0

[a]Titan: of 10 untreated samples, seven had <0.5 ppm and three 0.6 ppm maleic hydrazide residue

In both cultivars maleic hydrazide residue levels were approximately proportional to application rates (Fig. 4). However, values were higher, by about 100% in cv. Titan, compared with Maris Piper. At the 100% application rate the difference in residue concentration of the two cultivars was highly significant (p=0.0026). The residue distribution of samples at 100% treatment rate is shown in the appendix.

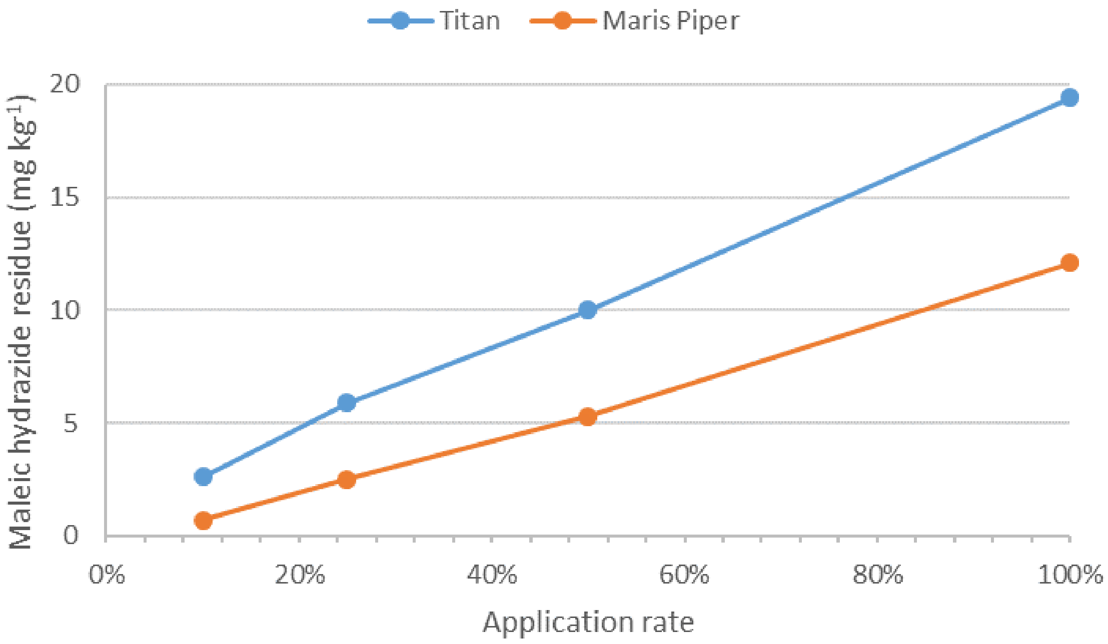


Fig. 4. Mean residue concentration (mg kg^{-1}) of samples of cvs. Titan and Maris Piper following application of maleic hydrazide at 10, 25, 50 and 100% rates.

3.2 Sprouting

Results of efficacy assessment are shown in Table 2. In untreated samples sprout weight was greatest in cv. Titan. Sprout weight reduced with increasing MH application rate, but there was no significant difference in cv. Maris Piper between untreated samples and the 10% MH application rate (p= 0.3753) and, in cv. Titan, between the 50 and 100% MH application rates (p= 0.2725).

Table 2. Summary statistics *(n=10)* for sprout weight (mg sprouts/g potato) of samples of cvs. Titan and Maris Piper after storage

cultivar	treatment	mean	standard deviation	min	max
Titan	untreated	**21.3**	3.10	17.3	25.3
	10%	**12.6**	4.49	5.7	19.7
	25%	**5.4**	1.74	2.7	8.7
	50%	**1.4**	1.18	0.2	4.1
	100%	**2.3**	2.22	0.1	6.9
Maris Piper	untreated	**13.8**	2.87	9.5	18.2
	10%	**12.7**	2.53	8.8	16.8
	25%	**6.9**	2.75	2.5	12.1
	50%	**6.0**	2.09	2.7	8.6
	100%	**3.1**	2.37	0.7	9.3

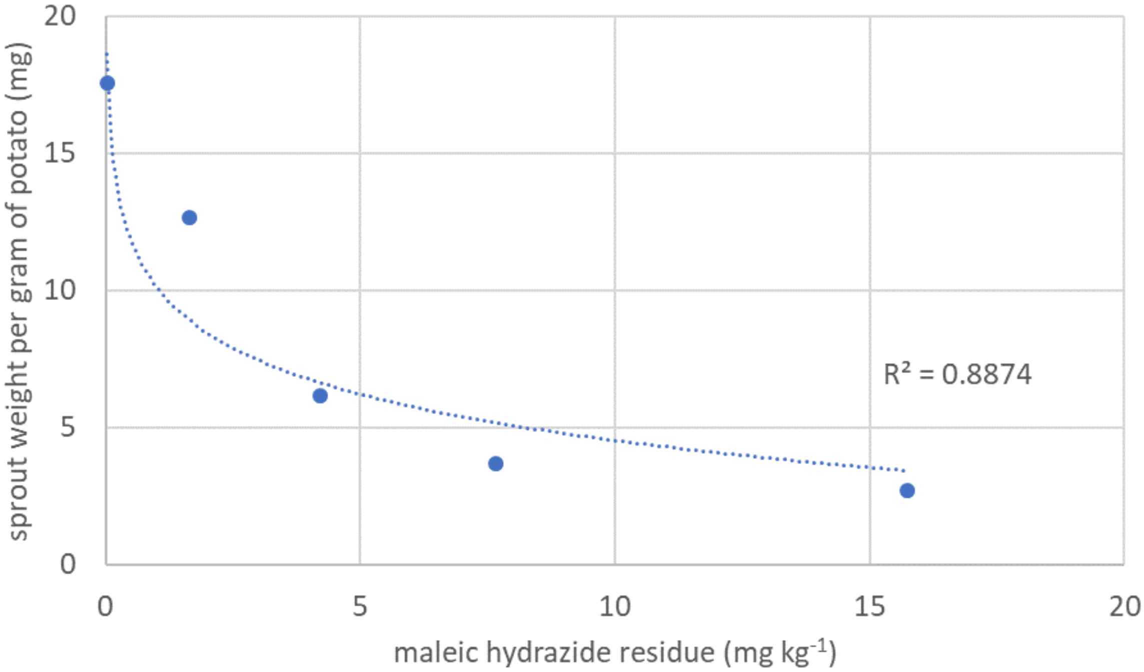
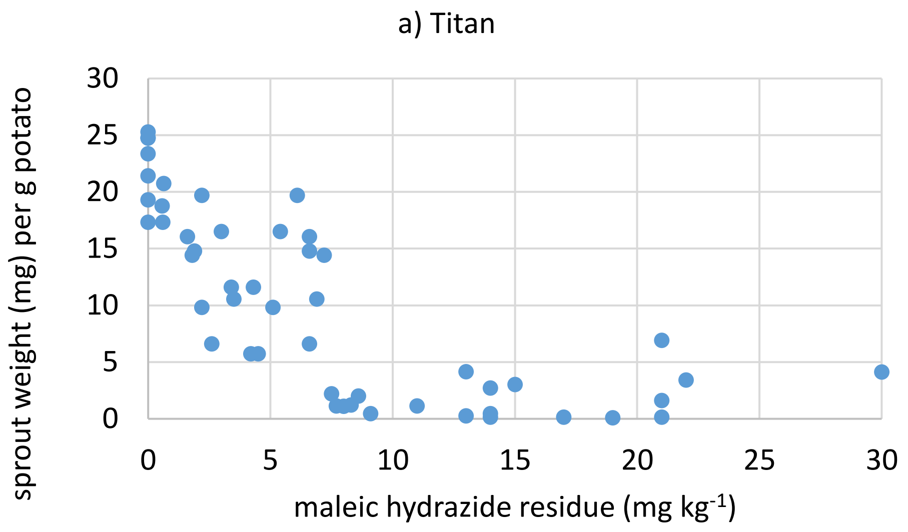


Fig. 5 Correlation between mean sprout weight and mean MH residue concentration (cvs. Titan and Maris Piper).

The correlation for sprout weight against maleic hydrazide residue concentration is shown in Fig. 5 for the average of cvs. Titan and Maris Piper. Data is best represented by a curve, with sprout inhibition improving with increasing maleic hydrazide residue. The curve indicates that the relative reduction in sprout weight was greater as residue levels increased to *c.* 4 ppm, compared with values up to around 8 ppm. Scatter plots for the two cultivars are shown separately in Fig. 6.



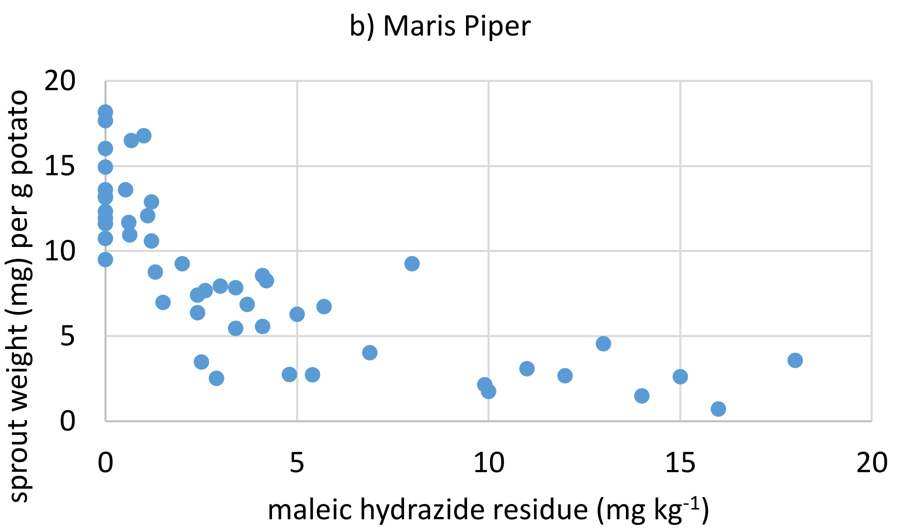


Fig. 6 Scatter plots for sprout weight per gram of potato against maleic hydrazide residue concentration of cvs. (a) Titan and (b) Maris Piper.
Note different scales used on the axes.

4. Discussion & conclusions

Maleic hydrazide is an established growth regulator (Buckley *et al*, 2006) that has commonly been used for volunteer control. With fewer products remaining since the non-renewal of chlorpropham (CIPC), there has been renewed interest in the active substance as a sprout suppressant for use on stored potatoes (Cunnington, 2019).

Maleic hydrazide residue levels required for sprout control are not well established. In this work, samples with a range of residue levels were generated, and efficacy assessed after a period of storage at 9^{o}C. Limited efficacy of sprout control was evident at low (1-2ppm) concentrations and increased with MH residue level. The increase in efficacy with residue concentration was not linear though. Re-drawing data from Fig. 5 to show *inhibition of sprouting* (sprout weight of samples relative to untreated samples, Fig. 7), shows increasing residue concentration up to c.4ppm in this data set, resulted in close to 65% of sprout inhibition. But increasing residue value to c.8ppm (a doubling in residue concentration) only resulted in a further increase in sprout inhibition to c 80%. Further increases in residue level resulted in further improvements in sprout control, but at a diminishing rate. Sprout control was generally most effective in samples with the highest residue concentration.

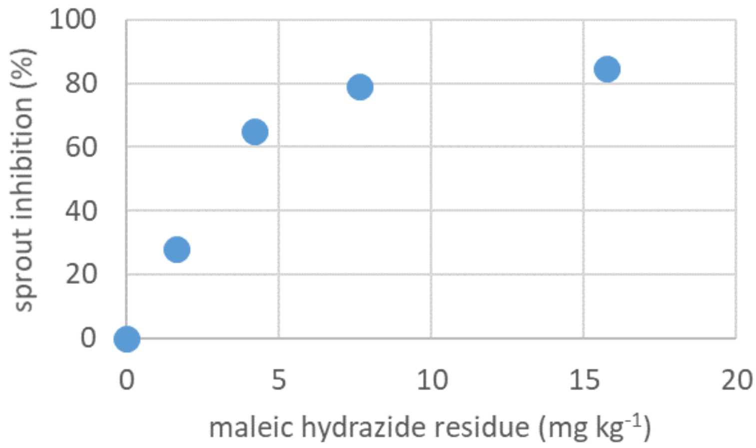


Fig. 7. Average reduction in sprout weight (%), relative to untreated samples.

Residue variability is also an important factor. Results indicate that the lowest residue level, with this sampling method, was approximately 60 to 70% of the mean value. This value is of greater importance to the store manager as it is the lesser efficacy of these samples that prompt in-store treatments. Maleic hydrazide can be an efficacious sprout suppressant and reduce the need for post-harvest treatments. Adoption of best practice procedures in the application of MH are likely to result in higher residue levels and better quality crops from store at lower cost, where post-harvest treatments are being made.

This work is continuing in 2020/21.

5. References

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Appendix

Maleic hydrazide residue distribution

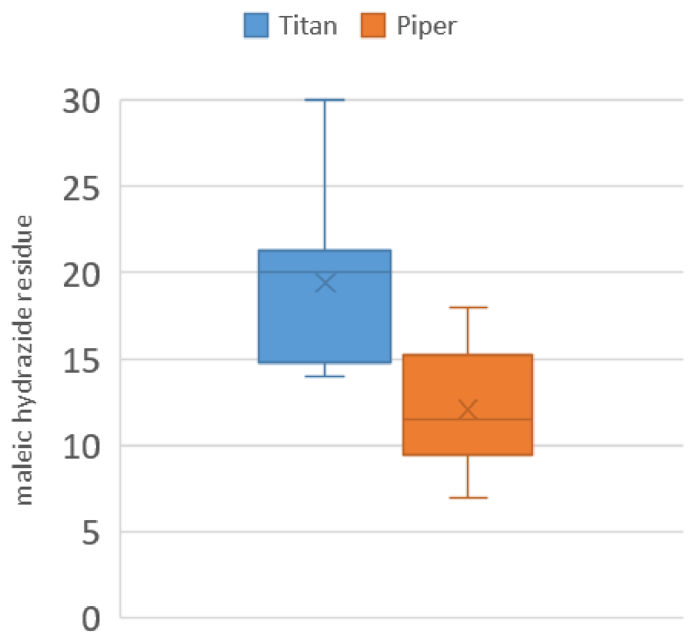

Fig. 8. Residue distribution (box plots) of samples at the 100% MH treatment rate.