Report

Potato desiccation

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Contents

1. SUMMARY

1.1. Aim of project

To find the best alternative(s) to diquat for desiccation of potato haulm within 12 months of the start date of the project, focussing on indeterminate, difficult-to-kill ware and seed crops.

1.1.1. Objectives

- Produce guidance on best desiccant or combination of desiccants or non-chemical control of haulm killing in indeterminate varieties and seed crops.
- To create synergy with other existing or previous AHDB projects (e.g. Determinacy, Cultivation and N utilization) in optimising nitrogen (N) rate for the remaining desiccants to achieve rapid haulm death and minimize time to skinset and demonstrate these at SPot Farm programmes involving N nutrition.
- To advise best practice timing on avoiding internal defects with desiccation e.g. soil moisture deficit regime prior to desiccation and weather conditions at time of desiccation.
- To identify whether certain desiccation practices lead to increased severity of blemishing diseases.

1.2. Methodology

- Using different varieties, and targeting vigorous, complete canopies at close to commercial defoliation timings, the work evaluated speed of leaf and stem desiccation, skinset, and effects on yields, internal defects and disease incidence on both ware and seed crops.
- Diquat (Reglone) was removed from permitted use in 2020 and was not used in the 2020 season. The work in 2020 assessed different sequences of protoporphyrinogen oxidase (PPO) inhibitors [Gozai (pyraflufen-ethyl) and Spotlight Plus (carfentrazone-ethyl)] and Finalsan (pelargonic acid) and Saltex (brine product) and compared them with undefoliated control treatments. Actives were also combined with mechanical flailing using tractor-mounted flails. Brine products currently have no approval as desiccants and this treatment was included for research purposes. On three of the treatments, a reduced rate of

nitrogen (N) fertilizer was used alongside the recommended (RB209) rate of N to test the effect of N on improving the speed of skinset.

- This research was closely aligned with the AHDB Potatoes Knowledge Exchange programme, so three of the sites were on Strategic Potato (SPot) Farms.
- These results were all from a single year in which desiccation was relatively easy at most sites. The relative ranking of different methods should, however, be maintained in a more difficult year, although the differences might be greater than in 2020.

1.3. Key findings

- Within individual experiments, Spotlight/Gozai combinations were no different to flail or Saltex in terms of skinset at 3 weeks post-T1, but when averaged over all experiments and demonstrations, there was a small (1-2 day) advantage in reaching skinset for flail and Saltex methods compared with Spotlight, Gozai and Finalsan chemical methods.
- Two crops were skinset 2 weeks after T1. Two crops (a Daisy seed crop in Scotland and a Royal ware crop) were still not skinset after 4 weeks.
- There was some ‘unsetting’ of skins in a Royal crop between 3 and 4 weeks after T1.
- Flailing ahead of chemical treatment resulted in instant canopy death in all the ware crops and there was no regrowth within 4 weeks of T1. However, as observed in 2019, the seed crop in Scotland had some regrowth from basal nodes on flailed stems. A part of future work should focus on pre-flail chemical treatments, at reduced rate, to determine if this prevents regrowth following flailing.
- Saltex was the most effective chemical in removing leaves in 2020. This result differed from that in 2019 where Saltex efficacy varied between sites, depending on atmospheric conditions immediately following spraying.
- Spotlight/Gozai treatments used in 2019 were all similar in terms of leaf death, but were only 2-4 days slower in killing leaves than Reglone. Spotlight only, Gozai only or Spotlight/Gozai combinations all worked similarly in terms of leaf death and skinset.
- Finalsan was generally slower in killing leaves than other chemical treatments.

- Stems were much harder to kill chemically than leaves. There were variable rates of desiccation across experiments, but a similar ranking in rate of desiccation between treatments was found in both stem and leaf desiccation.
- Differences in the rate of foliage desiccation between treatments did not correlate well with skinset, the key criterion for the ability to harvest without damage.
- Finalsan was the slowest acting of the tested actives on foliage, but was equal to Spotlight/Gozai combinations in time to skinset.
- Reducing nitrogen (N) fertilizer rate by 15 % from the recommended RB209 rate had little effect on skinset, advancing it, on average, by < 1 day.
- Plots that were left to grow on without defoliation and maintained close to complete cover increased in yield by *c*. 7 t/ha in 3 weeks compared with plots which were desiccated or flailed. There was no evidence to support differences in 'passive bulking' (yield increase after T1 applications) between chemical or mechanical treatments.
- The East and North sites received two or three applications and did not require a T4 spray, whereas the West and Scotland sites received a final T4 spray of Gozai as skinset was still some way from completion. By contrast, in 2019 there were no benefits from a third chemical application of Spotlight 2 weeks after T1.
- Not defoliating slowed skinset in most experiments.
- There was no effect of defoliation method, chemical or timing on vascular browning or stem-end necrosis.
- There were no problems with stolon detachment in most crops. Some stolon plug removal occurred in Daisy and Royal, but unrelated to chemical or mechanical method of defoliation.
- There were no effects of chemical or mechanical method of haulm destruction on rotting or black dot diseases at harvest.

1.4. Practical recommendations

- Differences in the rate of foliage desiccation between treatments did not correlate well with skinset. Finalsan was generally slower to kill canopies than PPO's and flailing was instant, but skinset did not follow the same time process.
- A guide to skinsket would be an assessment made at 3 weeks post-T1 application, but a more quantitative and rapid measure of skinset in the field would be useful. However, the torquemeter used in 2020 proved unsuccessful in monitoring the change in skinset over time and between defoliation treatments.

- The aim should be for early- to mid-morning application of PPO desiccants to give the chemical maximum time to kill cells. Time of application for Spotlight/Gozai can be more crucial later in the season when it is cooler.
- In dry soils, skinset is faster. Most sites were desiccated in 2020 with drier soils than in 2019 and would be expected that this would result in faster skin-set than in wet soils. The timing of the last irrigation prior to desiccation (particularly of salad crops), would influence skinset. Aim to stop irrigation for 7 days prior to desiccation, but no earlier owing to the risk of tuber dehydration increasing the risk of bruising.
- There was, on average, only a small (1-2 day) delay in skinset for Spotlight/Gozai compared to flail or Saltex, but this should be factored into any harvesting schedule.
- Crops which were indicating signs of active senescence (ground cover < 98 %, lodging, brittle leaf texture and paler green colouration) responded rapidly in terms of leaf death when chemical desiccation took place. Where crops did not demonstrate these symptoms and were actively growing at T1 timing, leaf death was more prolonged.
- In crops or at sites which have difficulty in achieving skinset owing to active green canopies at desiccation, 10-20 % less nitrogen than the RB209 amount should be tested to try and advance canopy senescence, despite the lack of evidence that this had an effect in 2020. Growers or agronomists should re-visit RB209 to calculate nitrogen rates and compare with commercial practice.
- Skinset depends on a combination of factors, not just leaf death. Lack of stem desiccation in Royal and Daisy delayed skinset despite the fairly rapid loss of leaf cover after desiccation or flailing.
- Mechanical methods stop carbohydrate assimilation immediately, but there is an opportunity with flailing for crops with active root systems in wet soil to take up water, reduce tuber dry matter concentration and increase fresh weight yield. This can result in a yield increase of 3-5 t/ha and a larger proportion of the crop becoming oversize, which can be crucial to crop value in seed or salad crops. There was no evidence that ‘passive bulking’ differed across chemical treatments, however.
- It is important to kill all leaves and prevent regrowth for control of tuber blight or virus infection in seed.

- Defoliation method, chemical or timing had little effect on vascular browning, stem-end necrosis or stolon adhesion or on rotting or skin blemishing diseases.

2. Introduction

Since the 1960s, diquat has played an important role in growers' rapid desiccation of potato haulm, to enable cost-effective harvesting of disease- and damage-free tubers. In October 2018, the EU Commission confirmed its decision to withdraw the approval of diquat, based on concerns related to the precautionary principle of exposure of bystanders and residents, as well as birds. In the UK, the Chemicals Regulation Division of the Health and Safety Executive gave a date for diquat products to be withdrawn from the market by 31 July 2019, with a use-up period for growers up to 4 February 2020. The 2019 growing crop would, therefore, provide the final opportunity to trial alternative desiccation options on farm, before the 2020 season when diquat could no longer be applied to crops.

In April 2019, the AHDB commissioned research work to help inform guidance to potato growers on the best methods to desiccate crops in the absence of diquat. The emphasis was on the ‘hard to stop’ situations, with long-season, indeterminate varieties and actively growing seed crops. This research was closely aligned with the AHDB potatoes Knowledge Exchange programme, so most of the sites were on existing or former Strategic Potato (SPot) Farms or demonstration sites. NIAB CUF managed the contract for both a) experimental work on selected sites and b) coordinating, analysing and reporting the overall programme. The results from these trials were reported in early 2020. A further programme of work was commissioned by AHDB in 2020, again coordinated and managed by NIAB CUF.

The objectives of the project were to:

- Produce guidance on best desiccant or combination of desiccants or non-chemical control of haulm killing in indeterminate varieties and seed crops.
- To create synergy with other existing or previous AHDB projects (e.g. Determinacy, Cultivation and N utilization) in optimising nitrogen (N) rate for the remaining desiccants to achieve rapid haulm death and minimize time to skinset and demonstrate these at SPot Farm programmes involving N nutrition.
- To advise best practice timing on avoiding internal defects with desiccation e.g. soil moisture deficit regime leading up to and actual weather conditions at time of desiccation.

- To identify whether certain desiccation practices lead to increased severity of blemishing diseases.

3. Materials and methods

3.1. Sites and Experiments

The protocol was defined by the tender conditions. The crop uses, varieties and sites chosen were pre-selected, but all varieties were RB209 Group 3 or 4 determinacy and desiccation was targeted at close to maximum canopy biomass. There were four replicated-plot experiments with eight identical treatments, replicated four times in a randomised block design. All experiments were located within commercial fields.

The AHDB RB209 Nutrient Management Guide (Potatoes) was used to calculate the optimal N for the crop based on variety, expected length of growing season from emergence to desiccation, soil texture, winter rainfall and organic matter amendments.

Experiment 1 was managed by NIAB CUF and located in Sutton 922A field, Sutton, Woodbridge, Suffolk (52.061 °N, 1.352 °E) on a loamy sand soil. The variety was Lanorma grown for table production by James Foskett Farms, planted on 4 April at a within-row spacing of 34 cm in 91.44 cm rows. The RB209 recommended N fertilizer rate was 185 kg/ha and the reduced (RB209-15 %) rate was 157 kg/ha. The basal N supplied to seedbed was 137 kg/ha and the experimental area was topped up by 20 kg N/ha to supply the RB209-15 % to all plots. Following marking out of plots, the RB209 treatments then had an additional 28 kg N/ha applied by hand using ammonium nitrate prills at the time of emergence. Initial crop emergence was on 1 May. The experiment was irrigated according to standard farm practice.

Experiment 2 was managed by Richard Austin Associates and located in 50 Acre field, Somerby Top Farm, Somerby, Lincolnshire (53.548 °N, 0.385 °W) on a sandy clay loam soil. The variety was Maris Piper grown for table production by RJ & AE Godfrey, planted on 11 April at a within-row spacing of 38 cm in 91.44 cm rows. The RB209 recommended N fertilizer rate was 135 kg/ha and the reduced (RB209-15 %) rate was 115 kg/ha. The basal N supplied to seedbed was 100 kg/ha and the experimental area was topped up by 15 kg N/ha to supply the RB209-15 % to all plots. Following marking out of plots, the RB209 treatments then had an additional 20 kg N/ha applied by hand using ammonium nitrate prills at the time of emergence. Initial crop emergence was on 24 May. The experiment was irrigated according to standard farm practice.

Experiment 3 was managed by staff at the Crop and Environment Research Centre at Harper Adams University and located in Sandwells field, Edgmond, Shropshire (52.7691 °N, 2.426 °W) on a sandy loam soil. The variety was Royal grown for French-fry production, grown by PM & RE Belcher, planted on 6 April at a within-row spacing of 34 cm in 91.44 cm rows. The RB209 recommended N fertilizer rate was 160 kg/ha and the reduced (RB209-15 %) rate was 136 kg/ha. The basal N supplied to seedbed was 125 kg/ha and the experimental area was topped up by 11 kg N/ha to supply the RB209-15 % to all plots. Following marking out of plots, the RB209 treatments then had an additional 24 kg N/ha applied by hand using ammonium nitrate prills around the time of emergence. Initial crop emergence was on 24 April. The experiment was irrigated according to standard farm practice.

Experiment 4 was managed by Scottish Agronomy and located at Morphie, St Cyrus, Montrose (56.767 °N, 2.463 °W) on a sandy clay loam soil. The variety was Daisy grown for seed production, planted on 11 May at a within-row spacing of 23 cm in 91.44 cm rows. The recommended N fertiliser rate was 85 kg/ha and the reduced (-15 %) rate was 72 kg/ha. The basal N supplied to seedbed was 72 kg/ha and following marking out of plots, the recommended nitrogen rate treatments then had an additional 13 kg N/ha applied by hand using ammonium nitrate prills at the time of emergence. Initial crop emergence was on 3 June. The experiment was unirrigated.

3.2. Treatments and products

The treatments were the same for both ware and seed experiments. The initial spray or mechanical treatment application was designated timing T1, with the second T2b, the third T3b (and fourth T4, if applied) being timed 7, 14 and 21 days, respectively after T1. Intermediate treatments following T1 flail were applied 3 and 10 days after T1 and designated T2a and T3a, respectively. Occasionally, owing to weather or other logistics, the planned intervals between T1 and T2 (and T2 and T3) sprays could not be adhered to, but there was never more than 1 day difference between the intended and actual interval. Table 2 lists the treatments, products and the application dates and weather for T1, T2a, T2b, T3a, T3b and T4 timings at each of the experiments and demonstrations. T4 applications were only made if the in-field measurements of skinset with the torquemeter screwdriver indicated skinset had not been achieved. Expt 1 was the only experiment where T4 was not applied .

An application record form was sent to all trials managers. This requested information on weather conditions at spray application, including start and finish time, wind speed, wind direction, air temperature, relative humidity, cloud cover, rainfall within 1 hour after completion and soil moisture. A summary of the important weather data at each application timing is shown in Table 2.

Plots were marked out in the commercial crops between spray tramlines, with an 8 m guard area at the end of each pair of plots and at either end of the experiment to allow access for the flail into plots. Plots were four rows (3.6 m) wide x 8 m long and all four rows were sprayed or flailed. Assessments and harvests were only made on the middle two rows of each plot, leaving guard areas between harvests and at the end of each plot.

Flailing treatments were made using tractor-mounted flails, with the target being to leave 15-20 cm of exposed stem as a target for the succeeding chemical application. Unlike 2019, where all chemical applications were made withing 2 hours of flailing, in 2020, the first chemical spray application following flailing (T2b) was applied after 3 days to mimic typical commercial practice and allow drying of leaf material. The shredded foliage was as left by the flail and not removed before spraying.

Each site was sprayed with plot-sprayers operating at 3 bar and with a water volume of 400 l/ha (except Saltex, 562 /l/ha). All four rows were sprayed and there was a 0.5 m over-spray area at the end of each plot which was not sampled. The sprayer was off-set to avoid trampling the harvest area and spraying was always done in the same direction for every plot. Some spray days had to be delayed by 1 day owing to wind or rain. Treatment applications were done in the order listed in Table 1 and not by replicate.

The products were all used at the commercial or protocol-determined rate. Where two sequential applications of Spotlight Plus (carfentrazone-ethyl, FMC) were used, the second application was made at a rate of 0.6 l/ha rather than 1.0 l/ha. Gozai (pyraflufen-ethyl, Belchim) at 0.8 l/ha was always used with a Toil (methylated rapeseed oil, Interagro) adjuvant at 1.5 l/ha. Finalsan (pelargonic acid, Certis) was applied at a concentration of 16.8 % (67.2 l/ha). Saltex (concentrated brine solution, Omex) was applied at a rate of 562 l/ha, providing 156 kg/ha of common salt, NaCl.

Tap water was used to make up spray volumes. All products for any treatment/timing application were tank-mixed together, despite no commercial approval for some combinations. Blight fungicides were applied to the whole experiment according to the products and timings for the surrounding crop.

Table 1. List of treatments, products and target timings of applications

No.	Description	T1	T2a (T1+ 3 days)	T2b (T1+ 7 days)	T3a (T2a+ 7 days)	T3b (T2b+ 7 days	T4† (T3+ 7 days)
1	Control RB209						
2	Control RB209–15 %						
3	Spotlight/Gozai RB209	Spotlight (1.0)‡		Gozai (0.8) + Toil (1.5)		Spotlight (0.6)	Gozai (0.8) + Toil (1.5)
4	Spotlight/Gozai RB209–15 %	Spotlight (1.0)		Gozai 0.8 + Toil (1.5)		Spotlight (0.6)	Gozai (0.8) + Toil (1.5)
5	Flail RB209	Flail	Gozai (0.8) + Toil (1.5)		Spotlight (1.0)		Gozai (0.8) + Toil (1.5)
6	Finalsan RB209	Finalsan		Gozai (0.8) + Toil (1.5)		Spotlight (1.0)	Gozai (0.8) + Toil (1.5)
7	Saltex 50 % + Spotlight RB209	Saltex (562) + Spotlight (1.0)		Gozai (0.8) + Toil (1.5)			Gozai (0.8) + Toil (1.5)
8	Saltex 50 % + Spotlight RB209–15 %	Saltex (562) + Spotlight (1.0)		Gozai (0.8) + Toil (1.5)			Gozai (0.8) + Toil (1.5)

†If required. ‡Rates in parentheses (l/ha)

Table 2. Date, time and weather at T1-T4 for each experiment

Expt #	Timing	Date	Time	Air temp. (°C)	Relative humidity†	Cloud cover (%)	Soil water content‡
1	T1	30 July	11:00	22	Average	10	Wet
	T2a	3 August	11:30	20	Average	80	Moist
	T2b	6 August	11:15	23	Average	50	Moist
	T3a	10 August	10:45	27	Average	0	Moist
	T3b	14 August	14:30	22	High	30	Moist
	T4	Not applied					
2	T1	12 August	14:15	30	Dry	15	Moist
	T2a	15 August	12:15	18	Humid	95	Moist
	T2b	20 August	15:15	22	Dry	65	Dry
	T3a	23 August	15:45	18	Average	80	Dry
	T3b	27 August	14:45	21	Average	90	Moist
	T4	1 September	17:00	16	Average	75	Dry
3	T1	20 August	12:30	23	Average	50	Moist
	T2a	24 August	10:15	23	Humid	50	Moist
	T2b	26 August	11:30	22	Average	40	Moist
	T3a	1 September	10:45	18	Average	30	Moist
	T3b	3 September	11:30	18	Average	40	Moist
	T4	9 September	11:30	18	Average	40	Moist
4	T1	31 July	14:00	18	Average	50	Moist
	T2a	3 August	11:15	15	Average	50	Dry
	T2b	6 August	10:15	19	Average	50	Moist
	T3a	10 August	10:15	14	Average	100	Dry
	T3b	14 August	10:15	13	Average	100	Wet
	T4	19 August	10:45	16	Average	100	Dry

†Average, 50-70 % RH; Humid, > 70 % RH

‡Dry, >40 mm soil moisture deficit; Moist, 10-40 mm soil moisture deficit; Wet, < 10 mm soil moisture deficit

3.3. Ground cover

Ground cover was measured weekly (or at T1, T2 and T3 spray timings) from T1 until final harvest using a grid with 100 rectangles. Squares were counted as 1 % if they were half-full or more with green leaf tissue and 0 % if less than half-full. One measurement was taken in each plot on each assessment date. In one replicate of all treatments, a photograph was taken of the grid and underlying crop, ensuring the grid was level with the top of the canopy and horizontal.

3.4. Stem desiccation

Scoring stem desiccation was performed either in the field or using photographs taken of the grid using to estimate ground cover. Each stem within the grid was scored on a scale of 1-3, with 1 not differing from the Control (undefoliated), 2 for bleached stems and 3 for brittle stems.

3.5. Skinset

3.5.1. Within-field

Following initial trial work in 2019 by Bill Watts of AHDB and Scottish Agronomy, an attempt at measuring skinset in the field was made using a Sealey Premier Hex Drive Digital Torque Screwdriver (0.05-5 Nm). A piece of 10 mm wooden dowel was attached to a hex shaft, slotted into the torque screwdriver and the end of the dowel placed on the surface of the tuber at its largest diameter (Figure 1). The torque force (Nm) to require shear the skin was recorded on 25 tubers in each plot. Sandpaper was used periodically to keep the contact face of the wooden dowel clean of skin and soil.

Figure 1. Operator using the digital torque screwdriver in Expt 1

3.5.2. Cement mixer

From the harvest rows, 50 tubers were harvested from a minimum of 10 adjacent plants in each plot and placed in paper sacks. They were transported to a laboratory at the collaborating institution and assessed the following day. An electric cement mixer of 100-150 l capacity was used at each site. The mixer drum was lined with anti-slip tape to ensure 50 % of drum interior was covered in tape (Figure 2). The 50 tubers from each sack were placed in the mixer, 4 l of water added and the drum rotated for 2 minutes (48 revolutions). The tubers were removed and assessed for the proportion of skin removed using categories, 0, 1, 5 and 5 % increments thereafter. The drum of the mixer was rinsed out with water using a hose between each plot. The anti-slip tape was replaced every 200 batches of tubers.

Figure 2. Cement mixer used for assessing skinset

3.6. Regrowth

The entire length of the guarded rows in each plot was assessed for regrowth at 7-day intervals after T1.

3.7. Yield

A harvest of 1.5 m x two rows (2.74 m^2) was hand-dug, either 3 or 4 weeks after T1. In Expt 2 at SPot North, only 1 m of each harvest row was dug owing to lack of remaining plants. Tubers were transported back to the collaborating institution and graded into 10 mm (ware) or 5 mm (seed) increments and the number and weight of tubers in each grade recorded. No measurement of tuber dry matter concentration was made.

3.8. Disease

One assessment was made of the disease incidence and severity soon after final harvest (T1 +3-4 weeks). At harvest, 50 random tubers were selected from each plot after grading and assessed for incidence of blight and other rotting disease. After washing this sample, the incidence and severity of black dot (*Colletotrichum coccodes*) was recorded, using categories with lower limits of 0, 1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80 and 90 % surface area infected.

3.9. Internal defects and stolon adhesion

The 50-tuber sample dug for skinset at T1 +3 weeks was assessed for stolon adhesion prior to being placed in the cement mixer. The three categories were stolon detached; stolon attached, but detaches with clean scar on tuber; stolon attached, but stolon detachment removes a plug of tissue from tuber. The number of tubers in each category was recorded. For internal defect assessment, the 50-tuber sample assessed for disease was assessed for two defects: vascular browning and stem end necrosis. Tubers were cut lengthwise through the stolon attachment point and scored in four categories for vascular browning: none, staining < 25 % up the vascular ring, 25-75 % of the vascular ring or > 75 % of the vascular ring. Stem end necrosis was scored in three categories: none, < 5mm from the stolon or > 5 mm from the stolon. The number of tubers in each category for each defect was recorded.

3.10. Statistical analysis

Data were analysed using analysis of variance and treatment differences are only stated as significantly different if the probability of the differences occurring by chance were < 5 % ($P < 0.05$). Error bars in figures are one standard error (S.E.).

4. RESULTS

4.1. Spraying conditions

Soils were mostly at ‘moist’ status or slightly drier during the T1-T4 desiccation period (Table 2). Higher soil water content delays skinset, so it might be expected that skinset would be slower than typical seasons where soils would be, on average, drier. Most spraying was done in late morning to early afternoon (Table 2) and most spraying events in England were under average humidity and bright to very bright (< 50 % cloud cover) conditions and the initial two (T1 and T2b) applications at high (22-30 °C) temperatures. In Expt 4 in Scotland, it was only 18-19 °C at T1 and T2b (Table 2), but this was 10 °C warmer than at the same time at the Scottish site in 2019. Temperatures dropped in September at the English sites, and it was cool and dull (13-16 °C and 100 % cloud cover) at the Scottish site for the latest applications (Table 2). Most applications had 24 hours of dry weather following spraying and there was only one spray event when rain fell withing 6 hours of application.

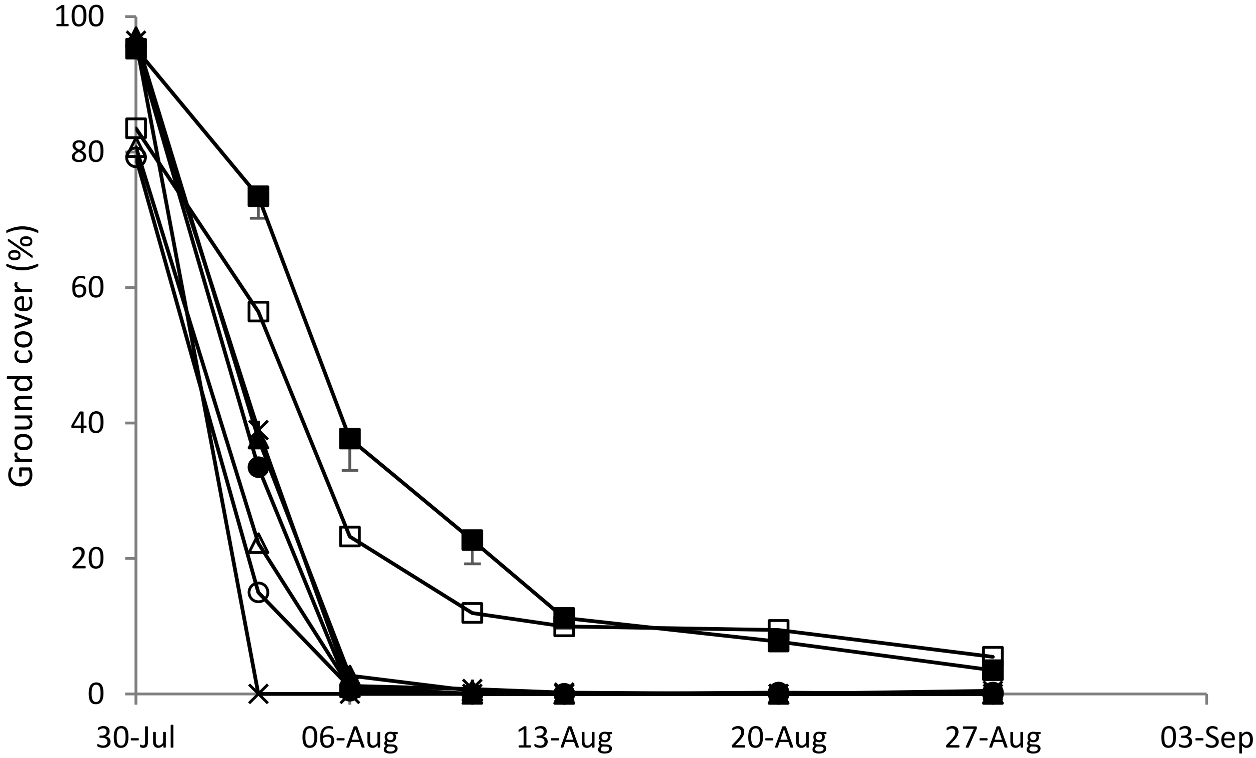
4.2. Canopy death

Photographic images of the representative plots for each treatment at each sample date are shown in Appendix 1.

Flailing gave instant canopy removal, although there was variable stem length left following flailing. Most sites achieved a cut length of 15-20 cm stem length post-flailing, which was an ideal target for the desiccant (Gozai) applied 3-4 days after flailing. With the Royal in Expt 3, there were some stems > 1 m in length and these were difficult to cut to the correct length, particularly when they lay in the furrow. There was no regrowth within 4 weeks of T1 in any treatment, including flail, at any of the sites in England. There was some regrowth in flailed and haulm-pulled treatments in the Daisy seed experiment in Scotland (Expt 4).

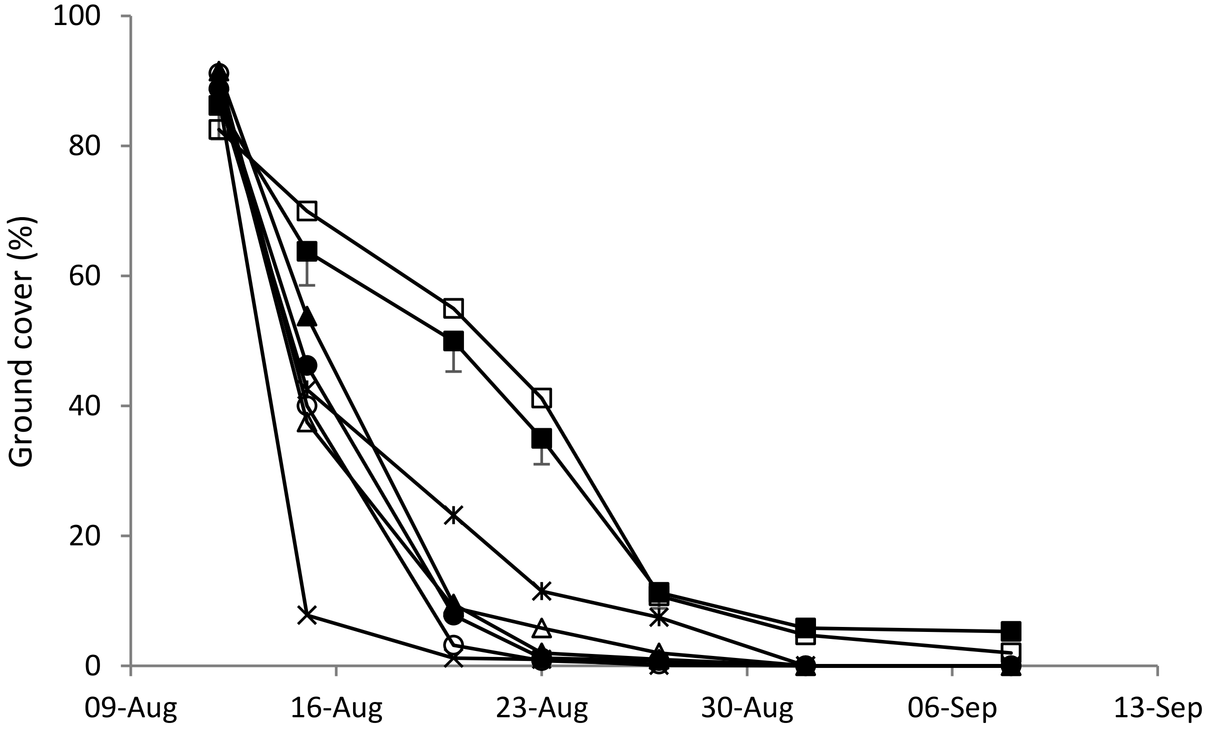
In Expt 1, leaf death following treatment was rapid (< 7 days to zero) in the chemical treatments and although there appear to be differences in the ground cover between chemical desiccant treatments 4 days after T1, this was a consequence of different treatments having slightly different ground covers at T1 rather than the rate of decline (Figure 3). The undefoliated controls senesced rapidly, maintained 10 % ground cover for the last 2 weeks before harvest and were never completely dead. Although reduced N treatments had lower ground covers in all treatments than RB209 treatments, N had little effect on the time to complete leaf death in the chemical treatments (Figure 3).

Figure 3. **Expt 1 (East): time course of ground cover. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ✕; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.**



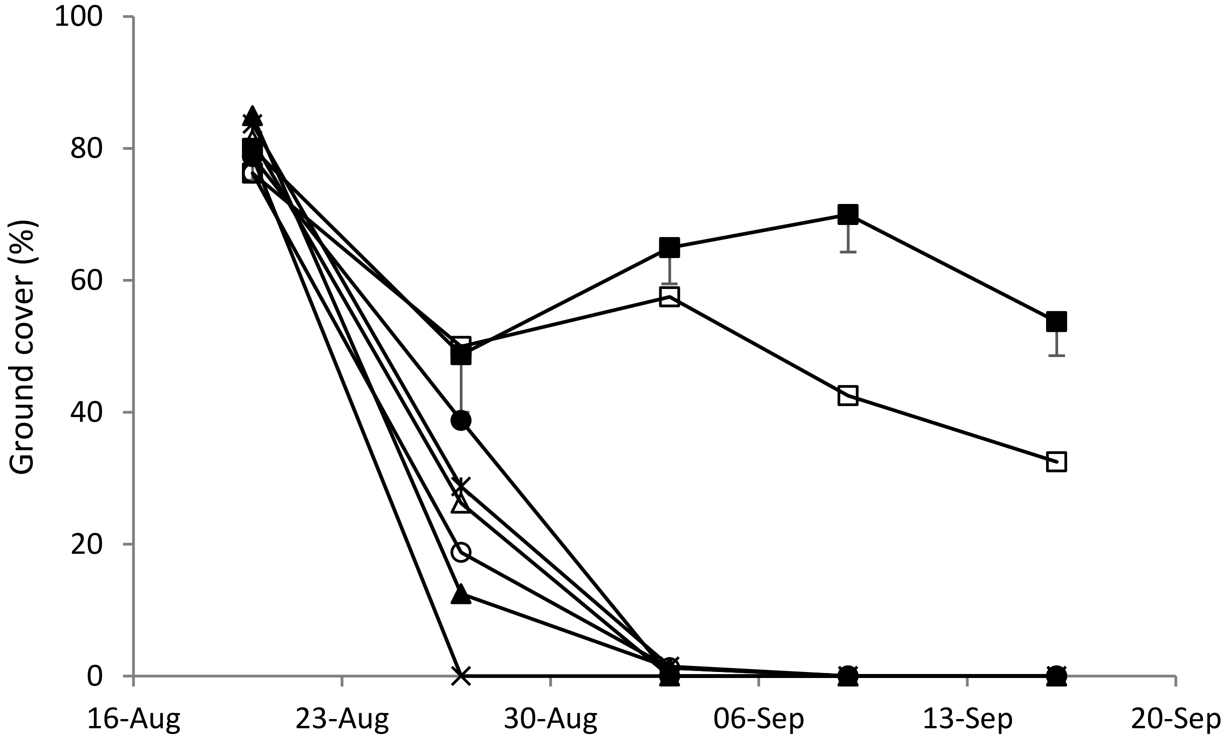
In Expt 2, canopy death was rapid following mechanical and chemical desiccation and crops were completely devoid of leaf cover 20 days after T1 (Figure 4). Finalsan was slower in killing leaves completely than the other chemical treatments, which were all similar in terms of rate of kill (Figure 4). Control treatments still had *c*. 2-5 % ground cover at final harvest. There was no effect of N on canopy death in control plots, but reduced N resulted in more rapid initial leaf death with Saltex and Spotlight/Gozai treatments than the RB209 rate (Figure 4).

Figure 4. Expt 2 (North): time course of ground cover. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.



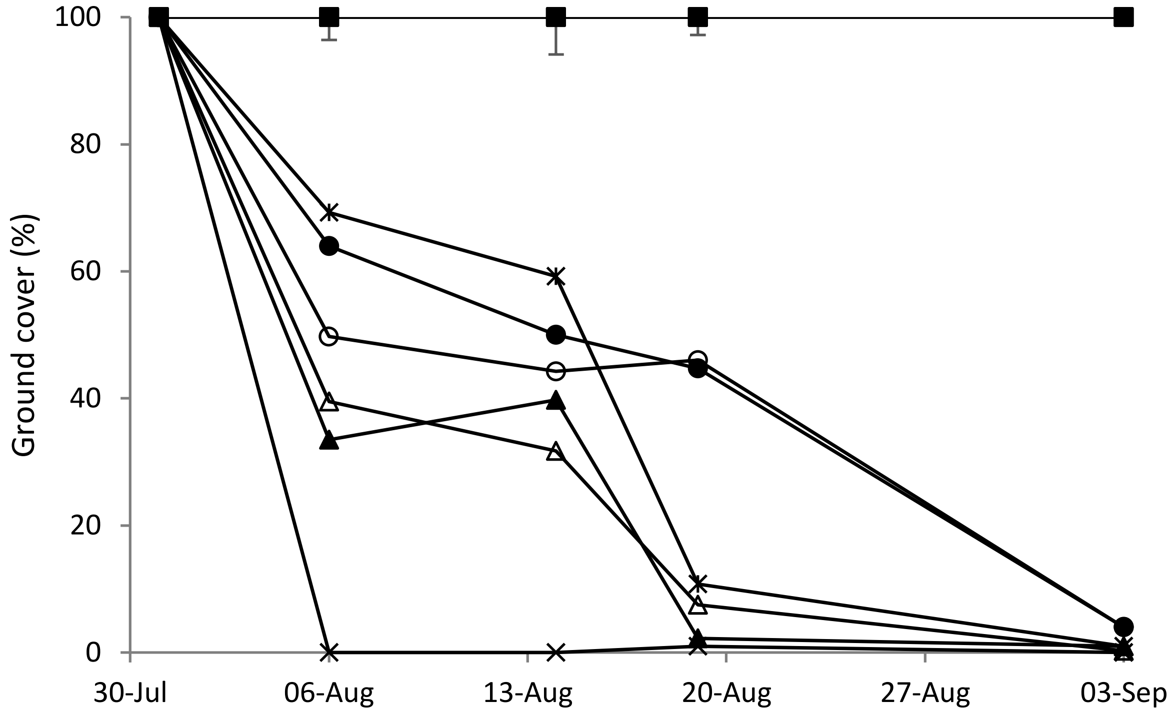
In Expt 3, the control plots maintained ground cover above 40 % for most of the 4 weeks following T1 and reduced N senesced faster (Figure 5). There was no consistent effect of N on rate of leaf loss when comparing the chemical desiccants, which were all similar in terms of their effect on leaf death, but there was considerable variation between replicates. By 2 weeks after T1, all treatments apart from the control had < 1 % ground cover (Figure 5).

Figure 5. Expt 3 (West): time course of ground cover. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.



In Expt 4, leaf death was slow following chemical treatment and control treatments maintained complete cover from T1 until T4 (Figure 6). The most rapid initial kill of leaves was with Spotlight/Gozai, with Saltex being slower and Finalsan even slower (Figure 6). However, canopies sprayed with Saltex died more slowly from 2-4 weeks after T1 than other chemical treatments and there was still 45 % ground cover in the two Saltex treatments 3 week after T1 application (Figure 6). There was some regrowth in the flailed treatment 3 weeks after topping, despite the application of both Gozai and Spotlight by that stage.

Figure 6. **Expt 4 (Scotland): time course of ground cover. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ✕; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.**



4.3. Stem desiccation

Stems were much harder to kill chemically than leaves in both the Scottish and West sites. There were variable rates of desiccation across experiments, but a similar ranking in rate of desiccation between treatments was found in both stem and leaf desiccation.

In Expt 1, nearly all stems were green at T1 (30 July). Following chemical application at T1, more than 84 % of stems had reached the brittle stage by 3 weeks after T1 (Table 3). By 4 weeks after T1, all defoliation treatments except Finalsan had > 93 % bleached stems, but there was no difference across defoliated treatments at either 3 or 4 weeks after T1 (Table 3).

Table 3. Expt 1 (East): desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

		Date			
		20 August		27 August	
Treat	Description	BL	BR	BL	BR
1	Control RB209	22	38	15	62
2	Control RB209–15 %	17	55	20	57
3	Spotlight/Gozai RB209	4	96	0	100
4	Spotlight/Gozai RB209–15 %	13	87	0	100
5	Flail RB209	0	100	0	96
6	Finalsan RB209	14	84	7	89
7	Saltex 50 % + Spotlight RB209	15	85	7	93
8	Saltex 50 % + Spotlight RB209–15 %	14	86	5	95
S.E.	(21 D.F.)	2.9	5.9	3.5	4.6

In Expt 2, flailed plots had more brittle stems than some of the chemical desiccants at 3 weeks after T1 applications, but by 1 week later there were no differences in stem desiccation across all defoliation treatments (Table 4).

Table 4. Expt 2 (North): desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

		Date			
		1 September		8 September	
Treat	Description	BL	BR	BL	BR
1	Control RB209	30.5	0.0	46.2	44.8
2	Control RB209–15 %	10.0	0.0	37.2	41.8
3	Spotlight/Gozai RB209	55.0	45.0	32.8	67.2
4	Spotlight/Gozai RB209–15 %	63.0	37.0	43.8	56.2
5	Flail RB209	50.0	50.0	39.2	60.8
6	Finalsan RB209	63.0	37.0	29.5	70.5
7	Saltex 50 % + Spotlight RB209	61.2	38.8	33.0	67.0
8	Saltex 50 % + Spotlight RB209–15 %	54.2	45.8	32.2	67.8
S.E.	(21 D.F.)	4.82	3.11	8.02	9.23

In Expt 3, stem desiccation was rapid following T1, but there were no effects of defoliation method on the proportion of bleached or brittle stems on either 9 or 16 September (Table 5). The control treatments remained green over the same period, with less than half of the stems being brittle by 4 weeks after T1. There was no effect of reduced N on stem desiccation (Table 5).

Table 5. Expt 3 (West): desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

		Date			
		9 September		16 September	
Treat	Description	BL	BR	BL	BR
1	Control RB209	19.8	13.8	39.2	28.5
2	Control RB209–15 %	27.2	12.2	20.5	41.2
3	Spotlight/Gozai RB209	7.5	92.5	1.5	98.5
4	Spotlight/Gozai RB209–15 %	17.0	83.2	1.0	99.0
5	Flail RB209	3.2	96.8	0.0	100.0
6	Finalsan RB209	17.0	83.0	2.8	97.2
7	Saltex 50 % + Spotlight RB209	6.0	94.0	0.5	99.5
8	Saltex 50 % + Spotlight RB209–15 %	15.8	84.2	0.5	99.5
S.E.	(21 D.F.)	7.16	6.37	4.82	6.20

In Expt 4, most stems were bleached 3 weeks after T1 following chemical treatment, but Finalsan and reduced-N Saltex treatments had numerically a lower proportion of bleaching (Table 6). There were no brittle stems after 5 weeks in any treatment except flail (Table 6). There was no effect of N rate on stem desiccation.

Table 6. Expt 4 (Scotland): desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

		Date			
		19 August		3 September	
Treat	Description	BL	BR	BL	BR
1	Control RB209	0	0	0	0
2	Control RB209–15 %	0	0	25	0
3	Spotlight/Gozai RB209	100	0	100	0
4	Spotlight/Gozai RB209–15 %	100	0	100	0
5	Flail RB209	100	0	0	100
6	Finalsan RB209	78	0	100	0
7	Saltex 50 % + Spotlight RB209	100	0	100	0
8	Saltex 50 % + Spotlight RB209–15 %	75	0	100	0
S.E.	(21 D.F.)	11.0	0.0	8.8	0.0

4.4. Regrowth

There was no regrowth of stems in any treatment in Expts 1, 2 or 3. In Expt 4, the regrowth was not measured on a number of stems with regrowth basis, but 1-2 % groundcover from new leaf growth at the base of the cut stem was measured 3 weeks after T1 in the flailed treatment (Figure 6).

4.5. Skinset

4.5.1. In-field

The torque screwdriver did not prove successful in predicting either the rate of change in skinset or distinguishing between treatments in the field. Measurements differed between varieties and between operators and in some cases did not change over a 3-week period following T1 treatment applications.

In Expt 1, the pattern was for the torque required to remove skin to increase over a 10-day period after T1 (Figure 7). There was also a trend for control treatments to have poorer skinset over this period than the defoliated treatments.

In Expt 2, there was a progressive increase in the torque required to remove skin between T1 and 15 days later (Figure 8). The flail treatment had greater torque readings at both 8 and 15 days after T1 than all chemical desiccants except Saltex (Figure 8). The torque readings for the rest of the chemical treatments did not differ from Saltex (Figure 8).

In both Expt 3 and Expt 4, there was no effect of treatment on torque readings and the readings a) were much lower than in Expts 1 and 2 at 2 weeks after T1 and b) did not change over the measurement period (Figure 9 and Figure 10).

Figure 7. **Expt 1 (East): time course of the torque required to remove skin. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.**

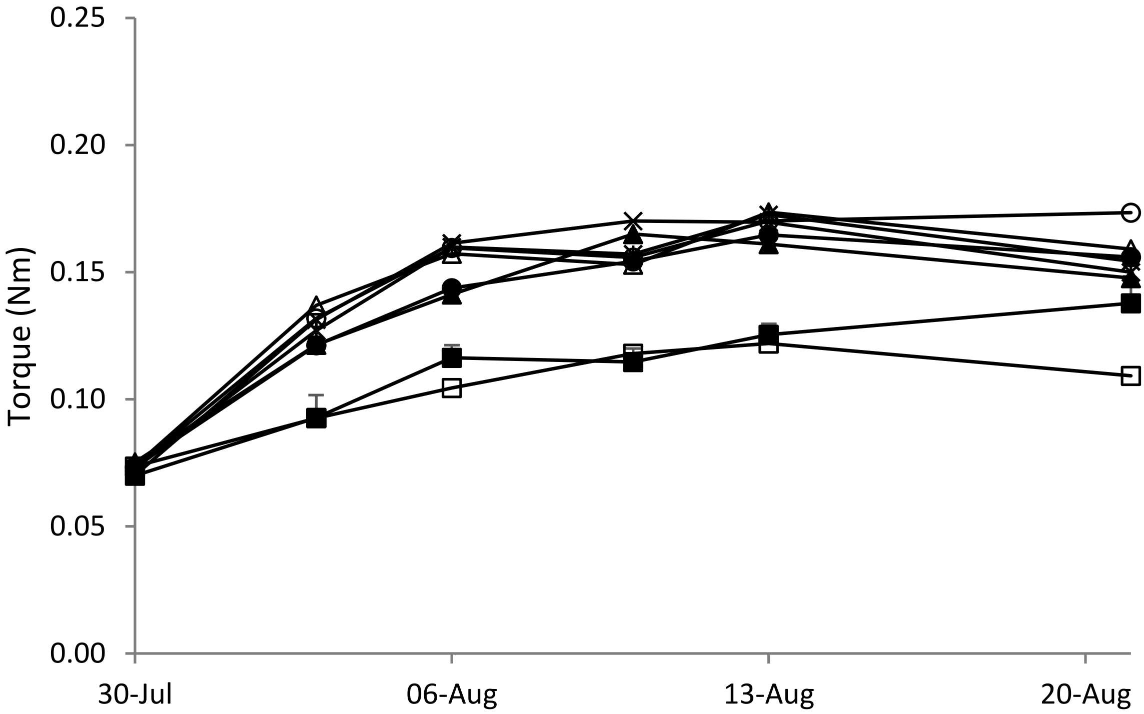


Figure 8. **Expt 2 (North): time course of the torque required to remove skin. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.**

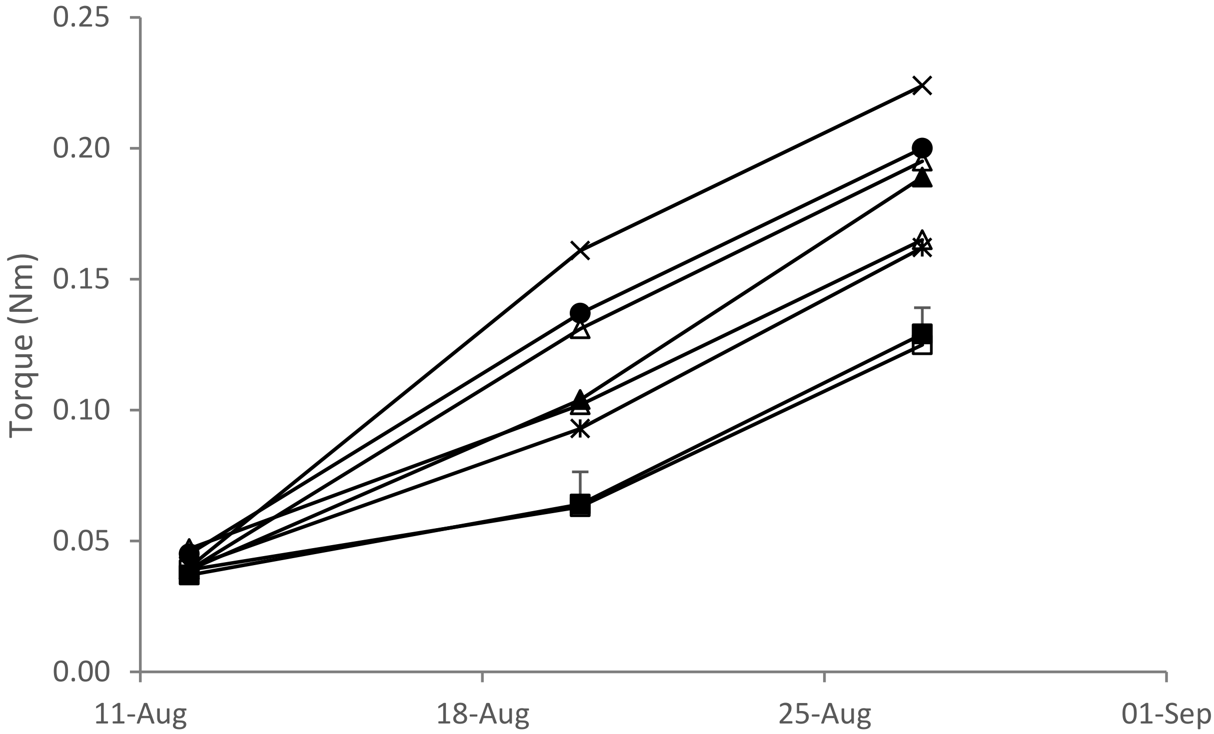


Figure 9. Expt 3 (West): time course of the torque required to remove skin. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.

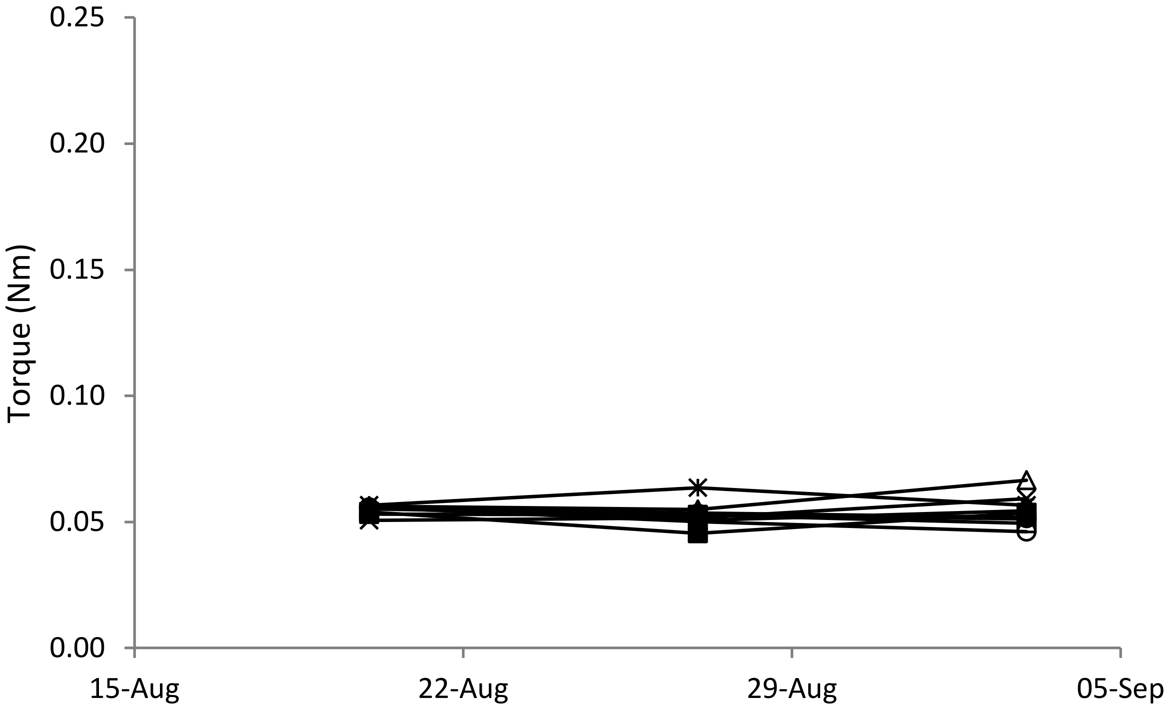
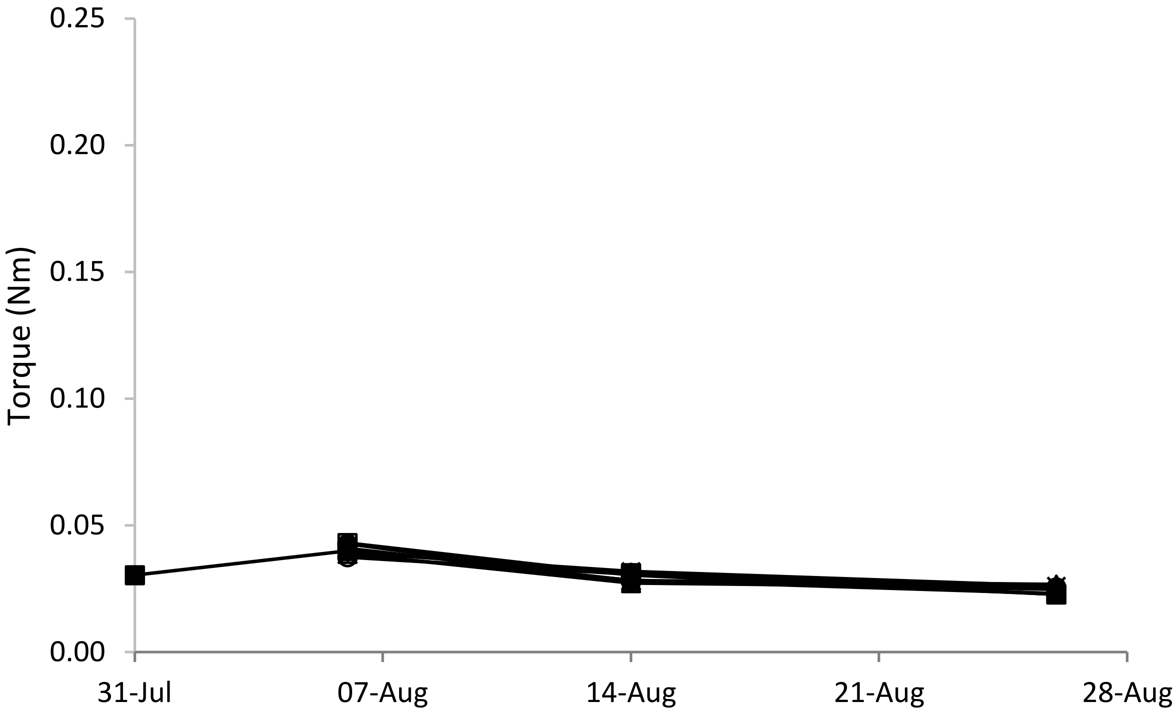


Figure 10. Expt 4 (Scotland): time course of the torque required to remove skin. Control RB209, ■; Control RB209–15 %, □; Spotlight/Gozai RB209, ▲; Spotlight/Gozai RB209–15 %, △; Flail RB209, ×; Finalsan RB209, ✳; Saltex 50 % + Spotlight RB209, ●; Saltex 50 % + Spotlight RB209–15 %, ○.



4.5.2. Cement mixer

A calibration was done in 2019 against an old skinning barrel used in 1999-2003 for desiccation work (Firman & Brinkworth, 2001). This showed that if tubers had < 15 % skinning in the cement mixer, then they should be capable of being harvested mechanically with a correctly set up harvester, a trained driver and not excessively abrasive soil. This mean value for skinning was judged to be the point when tubers were judged as having set skin.

When assessed at 3 weeks post-T1 across all sites, there were very contrasting degrees of skinset between sites, with Expts 1 and 2 (East and North, respectively) having full skinset and Expts 3 (West) and 4 (Scotland) not having skinset even at 4 weeks.

In Expt 1, skinset was very rapid and all treatments had reached < 2 % surface area skinned by 3 weeks after T1 (Table 7). There was no effect on rate of skinset across all chemical and mechanical treatments (Table 7). There was no effect of reduced N on rate of skinset (Table 7).

Table 7. Expt 1 (East): skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (30 July)

Treat	Description	Date 21 August	28 August
1	Control RB209	1.74	0.45
2	Control RB209–15 %	1.55	0.46
3	Spotlight/Gozai RB209	0.34	0.24
4	Spotlight/Gozai RB209–15 %	0.30	0.16
5	Flail RB209	0.29	0.22
6	Finalsan RB209	0.40	0.23
7	Saltex 50 % + Spotlight RB209	0.48	0.21
8	Saltex 50 % + Spotlight RB209–15 %	0.47	0.16
S.E.	(21 D.F.)	0.164	0.066

In Expt 2, skinset was again very rapid (< 7 % surface area skinned by 3 weeks after T1) and there was no effect of any treatment (including control) on skinset at 3 weeks, although by 4 weeks after T1, all chemical and mechanical defoliation methods were more set than the control undefoliated (Table 8). There was no effect of N rate on skinset (Table 8).

Table 8. **Expt 2 (North): skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (12 August)**

Treat	Description	Date	
		2 September	9 September
1	Control RB209	6.88	3.23
2	Control RB209–15 %	6.84	3.50
3	Spotlight/Gozai RB209	4.00	1.46
4	Spotlight/Gozai RB209–15 %	5.16	1.53
5	Flail RB209	4.27	0.78
6	Finalsan RB209	4.60	1.73
7	Saltex 50 % + Spotlight RB209	3.74	1.24
8	Saltex 50 % + Spotlight RB209–15 %	5.13	1.73
S.E.	(21 D.F.)	1.074	0.432

In Expt 3, an odd effect was observed, in that skinset became worse across all treatments after 4 weeks than after 3 weeks (Table 9). Many of the treatments had dropped below the 15 % threshold for harvesting by 3 weeks after T1, including the controls, but the proportion of skin removed by the cement mixer 1 week later had increased to a mean value of 38 %, with no effect of defoliation treatment or N rate (Table 9). The data were verified correct and could not be supported with data from the torque screwdriver, since no comparisons were made at this harvest. There are anecdotal reports of skins ‘unsetting’ and this may be an example.

Table 9. **Expt 3 (West): skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (20 August)**

Treat	Description	Date	
		10 September	17 September
1	Control RB209	9.0	40.4
2	Control RB209–15 %	13.8	33.8
3	Spotlight/Gozai RB209	31.2	35.4
4	Spotlight/Gozai RB209–15 %	16.1	38.1
5	Flail RB209	12.1	40.1
6	Finalsan RB209	20.6	41.0
7	Saltex 50 % + Spotlight RB209	10.1	45.0
8	Saltex 50 % + Spotlight RB209–15 %	14.8	33.3
S.E.	(21 D.F.)	7.42	5.79

Skinset was very slow to occur in Expt 4, and was only achieved 5 weeks after T1 in the best treatments (Table 10). All chemical and mechanical treatments were similar in time to skinset, with the exception of Finalsan, which was slower than other defoliation methods (Table 10). There was no effect of reduced N on skinset (Table 10).

Table 10. Expt 4 (Scotland): skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (31 July)

Treat	Description	Date	
		20 August	4 September†
1	Control RB209	66.6	52.1
2	Control RB209–15 %	58.1	47.7
3	Spotlight/Gozai RB209	39.8	13.5
4	Spotlight/Gozai RB209–15 %	35.5	14.3
5	Flail RB209	34.0	12.7
6	Finalsan RB209	48.4	21.8
7	Saltex 50 % + Spotlight RB209	36.6	14.4
8	Saltex 50 % + Spotlight RB209–15 %	34.9	14.1
S.E.	(21 D.F.)	3.52	2.57

†Delayed by 7 days owing to poor skinset on 20 August

An overall summary of the effect of treatments on skinset at 3 weeks after T1 is shown in Table 11. There were only very small differences in the speed of skinset between chemical and mechanical methods of defoliation and in reality, the differences amount to a variation of only 1-2 days to skinset across all defoliation treatments, supporting the data from 2019. The relative lack of apparent differences between control and the defoliation treatments is largely a consequence of the rapid skinset at the East and North sites and the odd effect of the control treatments at the West site having the same skinset at 3 weeks as the defoliated treatments. There was no overall effect of reduced N on skinset versus standard RB209 N rates and there was no interaction of N rate with chemical desiccant. The numerical advantage of using 15 % less N was to reduce time to skinset by < 1 day (Table 11).

Table 11. Summary of skinset at 3 weeks post-T1 (mean of all experiments)

Treatment	Skinning (% SA)
Control RB209	21.1
Control RB209–15 %	20.1
Spotlight/Gozai RB209	18.8
Spotlight/Gozai RB209–15 %	14.3
Flail RB209	12.7
Finalsan RB209	18.5
Saltex 50 % + Spotlight RB209	12.7
Saltex 50 % + Spotlight RB209–15 %	13.8
RB209	17.5
RB209–15 %	16.1

4.6. Yield and crop quality at final harvest

4.6.1. Yield

Anecdotal reports suggests that ‘passive bulking’ can take place following application of slower-acting foliar desiccants compared with complete removal of haulm by flailing. However, the average yield loss compared with allowing the crops to grow on was 8-10 t/ha for Spotlight and Gozai, suggesting that bulking ceased quickly and similarly across these treatments. The yield data are presented in Table 12 to Table 15.

In Expt 1, there was no effect of any defoliation treatment on total, marketable or oversize yield, including the controls (Table 12). Nitrogen rate had no effect on these variables either (Table 12).

Table 12. Expt 1 (East): total, marketable and oversize yield at final harvest

Treat	Description	Total yield (t/ha)	Yield 40-80 mm (t/ha)	Yield >80 mm (t/ha)
1	Control RB209	55.3	53.3	0.6
2	Control RB209–15 %	60.4	57.6	0.4
3	Spotlight/Gozai RB209	56.5	55.2	0.0
4	Spotlight/Gozai RB209–15 %	57.7	56.0	0.0
5	Flail RB209	54.2	51.3	0.8
6	Finalsan RB209	53.2	51.7	0.0
7	Saltex 50 % + Spotlight RB209	57.1	55.9	0.0
8	Saltex 50 % + Spotlight RB209–15 %	57.7	55.9	0.0
S.E.	(21 D.F.)	2.82	2.72	0.39

In Expt 2, there were no difference in total, marketable or oversize yield between chemical or mechanical defoliation techniques, but allowing the crop to grow on until final harvest did increase the yield of oversize tubers by 2.7 t/ha (Table 13). There was no effect of N rate on yield in any fraction.

Table 13. Expt 2 (North): total, marketable and oversize yield at final harvest

Treat	Description	Total yield (t/ha)	Yield 40-80 mm (t/ha)	Yield >80 mm (t/ha)
1	Control RB209	49.2	44.0	3.58
2	Control RB209–15 %	49.3	43.9	3.15
3	Spotlight/Gozai RB209	41.4	39.0	0.55
4	Spotlight/Gozai RB209–15 %	41.8	37.6	1.47
5	Flail RB209	41.1	38.0	0.80
6	Finalsan RB209	40.9	39.0	0.82
7	Saltex 50 % + Spotlight RB209	42.0	40.3	0.40
8	Saltex 50 % + Spotlight RB209–15 %	38.7	37.6	0.27
S.E.	(21 D.F.)	2.41	2.47	0.56

In Expt 3, there were no effects of defoliation treatment on total, marketable or oversize yield and the undefoliated control treatments had similar yields to the defoliated treatments (Table 14). There was no effect of N rate on yield in any fraction.

Table 14. Expt 3 (West): total, marketable and oversize yield at final harvest

Treat	Description	Total yield (t/ha)	Yield 40-90 mm (t/ha)	Yield >90 mm (t/ha)
1	Control RB209	65.5	57.2	7.9
2	Control RB209–15 %	67.0	58.8	8.1
3	Spotlight/Gozai RB209	52.9	43.0	9.5
4	Spotlight/Gozai RB209–15 %	59.2	54.3	4.4
5	Flail RB209	64.8	58.7	5.6
6	Finalsan RB209	55.9	49.7	5.9
7	Saltex 50 % + Spotlight RB209	65.7	55.6	9.7
8	Saltex 50 % + Spotlight RB209–15 %	60.1	51.7	8.2
S.E.	(21 D.F.)	5.32	4.18	1.66

In Expt 4, there were no effects of defoliation method on the marketable yield of seed or the yield greater than 55 mm and the flail treatment had similar seed yield and yield of oversize tubers as some of the chemical treatments (Table 15). Nitrogen rate had no effect on seed yield. There was a large yield penalty incurred in terms of seed yield if the crop was left undefoliated, since many tubers grew to exceed the upper limit (55 mm) for seed (Table 15).

Table 15. Expt 4 (Scotland): total, marketable and oversize yield at final harvest

Treat	Description	Total yield (t/ha)	Yield 25-55 mm (t/ha)	Yield >55 mm (t/ha)
1	Control RB209	45.6	12.2	33.4
2	Control RB209–15 %	49.0	16.9	32.1
3	Spotlight/Gozai RB209	41.4	27.9	13.4
4	Spotlight/Gozai RB209–15 %	40.7	25.1	15.5
5	Flail RB209	38.2	27.9	10.3
6	Finalsan RB209	40.7	22.8	17.8
7	Saltex 50 % + Spotlight RB209	37.4	22.6	14.8
8	Saltex 50 % + Spotlight RB209–15 %	42.9	30.7	12.1
S.E.	(21 D.F.)	2.63	2.52	1.63

4.6.2. Internal defects and stolon detachment

The incidence and severity of internal defects (vascular browning and stem-end necrosis) was very low and related to variety. Both Royal (Expt 3) and Daisy (Expt 4) had some slight symptoms (< 25 % of vascular ring affected) of staining and some slight stem end necrosis, but these were unrelated to defoliation method or chemical or timing (Table 18 and Table 19). In the other two experiments, there was no effect of defoliation treatment on internal defects (Table 16 to Table 19), repeating the findings of 2019.

Stolon were either mostly detached or easily detachable at harvest, but there were some cases (*c*. 6-8 %) of stolon plug removal in Royal (Expt 3) at final harvest in control treatments and numerically slightly less in chemical or mechanical defoliation treatments (Table 18). This was the opposite of what was found in Royal in 2019, where undefoliated treatment had less stolon plug removal than defoliated treatments. In Expt 2, control treatments were the only ones to have stolon plug removal (*c*. 5 % of tubers at 3 weeks after T1), but by 4 weeks after T1, there was no plug removal in any treatment (Table 17). In Expt 4, where canopy death in Daisy was slow, on average *c.* 12 % of stolons when detached removed a plug of tissue, but there were no treatment effects (Table 19). Across all experiments, at 4 weeks after T1, there was no significant effect of defoliation treatment on stolon plug removal.

Table 16. Expt 1 (East): incidence (%) of vascular staining, stem end necrosis and stolon plug removal 4 weeks after T1

Treat	Description	Vascular staining	Stem end necrosis	Stolon plug removal
1	Control RB209	1.0	0.0	0.0
2	Control RB209–15 %	0.0	0.0	0.0
3	Spotlight/Gozai RB209	0.0	1.0	0.0
4	Spotlight/Gozai RB209–15 %	2.0	1.0	0.0
5	Flail RB209	0.0	0.0	0.0
6	Finalsan RB209	1.0	0.0	0.0
7	Saltex 50 % + Spotlight RB209	1.0	0.0	0.0
8	Saltex 50 % + Spotlight RB209–15 %	0.0	0.0	0.0
S.E.	(21 D.F.)	0.74	0.46	-

Table 17. Expt 2 (North): incidence (%) of vascular staining, stem end necrosis and stolon plug removal 4 weeks after T1

Treat	Description	Vascular staining	Stem end necrosis	Stolon plug removal
1	Control RB209	0.0	0.0	0.0
2	Control RB209–15 %	0.0	0.0	0.0
3	Spotlight/Gozai RB209	0.0	0.0	0.0
4	Spotlight/Gozai RB209–15 %	0.0	0.0	0.0
5	Flail RB209	0.0	0.0	0.0
6	Finalsan RB209	0.0	0.0	0.0
7	Saltex 50 % + Spotlight RB209	0.0	0.0	0.0
8	Saltex 50 % + Spotlight RB209–15 %	0.0	0.0	0.0
S.E.	(21 D.F.)	-	-	-

Table 18. Expt 3 (West): incidence (%) of vascular staining, stem end necrosis and stolon plug removal 4 weeks after T1

Treat	Description	Vascular staining	Stem end necrosis	Stolon plug removal
1	Control RB209	6.0	1.5	8.0
2	Control RB209–15 %	4.5	1.0	6.5
3	Spotlight/Gozai RB209	7.5	3.5	2.0
4	Spotlight/Gozai RB209–15 %	6.0	1.5	1.0
5	Flail RB209	6.5	2.5	0.5
6	Finalsan RB209	8.5	1.5	2.5
7	Saltex 50 % + Spotlight RB209	8.0	1.5	0.0
8	Saltex 50 % + Spotlight RB209–15 %	5.5	4.0	0.0
S.E.	(21 D.F.)	1.72	0.98	1.97

Table 19. Expt 4 (Scotland): incidence (%) of vascular staining, stem end necrosis and stolon plug removal 5 weeks after T1

Treat	Description	Vascular staining	Stem end necrosis	Stolon plug removal
1	Control RB209	15.0	2.0	7.0
2	Control RB209–15 %	14.0	0.5	13.8
3	Spotlight/Gozai RB209	10.0	1.0	10.0
4	Spotlight/Gozai RB209–15 %	11.5	0.0	11.5
5	Flail RB209	10.5	0.0	18.2
6	Finalsan RB209	10.5	1.0	10.5
7	Saltex 50 % + Spotlight RB209	10.5	0.0	11.5
8	Saltex 50 % + Spotlight RB209–15 %	12.5	1.0	12.0
S.E.	(21 D.F.)	2.34	0.79	4.09

4.6.3. Rotting and surface blemishing diseases

The incidence of rotting tubers at harvest was almost zero in all experiments and black dot severity very low. In Expt 1, black dot severity averaged 3.3 % surface area infected (Table 20) and in Expt 3 there was 8.1 % surface area infected with black dot (Table 22). In Expt 4, there were only two tubers in the entire experiment with black dot severity > 1 % surface area (Table 23) and there were no tubers affected with black dot in Expt 2 (Table 21). There were no defoliation treatment effects in any experiment on the proportion of rotted tubers or the severity of black dot on the surface of progeny tubers (Table 20 to Table 23)

Table 20. Expt 1 (East): incidence (%) of rotting diseases and severity (% surface area affected) of black dot at harvest

Treat	Description	Rotting incidence	Black dot severity
1	Control RB209	0.0	3.5
2	Control RB209–15 %	0.0	3.3
3	Spotlight/Gozai RB209	0.0	3.0
4	Spotlight/Gozai RB209–15 %	0.0	4.3
5	Flail RB209	0.0	3.8
6	Finalsan RB209	0.0	3.0
7	Saltex 50 % + Spotlight RB209	0.0	2.8
8	Saltex 50 % + Spotlight RB209–15 %	0.0	3.0
S.E.	(21 D.F.)	-	1.05

Table 21. Expt 2 (North): incidence (%) of rotting diseases and severity (% surface area affected) of black dot at harvest

Treat	Description	Rotting incidence	Black dot severity
1	Control RB209	0.0	0.0
2	Control RB209–15 %	0.0	0.0
3	Spotlight/Gozai RB209	0.0	0.0
4	Spotlight/Gozai RB209–15 %	0.0	0.0
5	Flail RB209	0.0	0.0
6	Finalsan RB209	0.0	0.0
7	Saltex 50 % + Spotlight RB209	0.0	0.0
8	Saltex 50 % + Spotlight RB209–15 %	0.0	0.0
S.E.	(21 D.F.)	-	-

Table 22. Expt 3 (West): incidence (%) of rotting diseases and severity (% surface area affected) of black dot at harvest

Treat	Description	Rotting incidence	Black dot severity
1	Control RB209	0.0	8.9
2	Control RB209–15 %	0.0	4.9
3	Spotlight/Gozai RB209	0.0	6.9
4	Spotlight/Gozai RB209–15 %	0.0	6.0
5	Flail RB209	0.0	10.9
6	Finalsan RB209	0.0	7.0
7	Saltex 50 % + Spotlight RB209	0.0	8.3
8	Saltex 50 % + Spotlight RB209–15 %	0.0	11.7
S.E.	(21 D.F.)	-	1.61

Table 23. Expt 4 (Scotland): incidence (%) of rotting diseases and severity (% surface area affected) of black dot at harvest

Treat	Description	Rotting incidence	Black dot severity
1	Control RB209	0.0	0.0
2	Control RB209–15 %	0.0	0.0
3	Spotlight/Gozai RB209	0.0	0.03
4	Spotlight/Gozai RB209–15 %	0.0	0.03
5	Flail RB209	0.0	0.0
6	Finalsan RB209	0.0	0.0
7	Saltex 50 % + Spotlight RB209	0.0	0.0
8	Saltex 50 % + Spotlight RB209–15 %	0.0	0.0
S.E.	(21 D.F.)	-	0.013

5. Conclusions

Many crops achieved rapid skinset in the 2 years of the AHDB Desiccation Projects, with the exceptions being crops in Scotland in both 2019 and 2020 and the West site in 2020. Crops showing signs of senescence (i.e. loss of ground cover) responded rapidly to chemical desiccation, with skinset achieved in 2 weeks and the target should be to have canopies at this stage at defoliation if possible. Stems were much harder to kill chemically than leaves at both the Scottish and West sites. There were variable rates of desiccation across experiments, but a similar ranking in rate of desiccation between treatments was found in both stem and leaf desiccation. Summarising both 2019 and 2020, Spotlight, Gozai, Finalsan and Saltex chemical treatments were only 1-2 days slower to skinset than Reglone, flail or haulm-pulling. Skinset with Saltex could be rapid as flail, even at 50 % rate of the rate used in 2019, but application conditions appeared to be important. Similarly, there should be an aim for early- to mid-morning application of PPO (e.g. Spotlight and Gozai) desiccants and there may be some opportunity to vary both chemical and water rates at different application timings, although this was not tested. Whilst Finalsan was slowest to kill leaves, skinset was achieved at a similar time to Spotlight/Gozai. There was minimal effect on either skinset or yield of 15 % lower N than the RB209 recommended rate, but canopies generally had lower ground cover at T1 applications with reduced N. Skinset is faster in dry soils, so the aim should be to stop irrigating 7 days prior to desiccation, irrespective of the defoliation method, but ensuring that soil moisture deficits do not increase beyond limiting for more than 1-2 days.

It was a shame that the torque screwdriver technique proved unsuitable for detecting changes in skinset in the field as it would have been a useful tool for growers. There was no evidence that ‘passive bulking’ differed across chemical treatments, but flailing and haulm pulling (in 2019) had numerically higher yields in seed fractions than some chemical treatments. Defoliation method had no effect on internal defects in tubers, stolon detachment or skin blemishing diseases at any site. The regrowth observed in Scotland from flail treatments demonstrated the importance of killing all leaves with subsequent chemical treatments to avoid late blight or virus infection.

6. REFERENCES

AHDB (2020). *Nutrient Management Guide (RB209)*. Section 5 Potatoes.

Firman, D.M. & Brinkworth, S.J. (2001). Defoliation using Reglone. *Cambridge University Potato Growers Research Association Annual Report 2000*, p. 33-237.

7. KNOWLEDGE TRANSFER ACTIVITIES

Presentations

- AHDB Agronomy Week 2nd December 2020
- AHDB SPot Farm Results Week, 19th January 2021

Press

- Theory to Field, Lucy de la Pasture, CPM, June 2020

AHDB Potatoes Website

- Desiccation - what to consider before you plant, 31st January 2020
- The cost of desiccation without diquat, 31st January 2020

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9. Appendix 1

Photographic images of the representative plots for each treatment (RB209 N rate) at T1 and T3b (T1 + 2 weeks) are shown in Figure 11 to Figure 14.

Figure 11. Expt 1 (East): photographs of ground cover

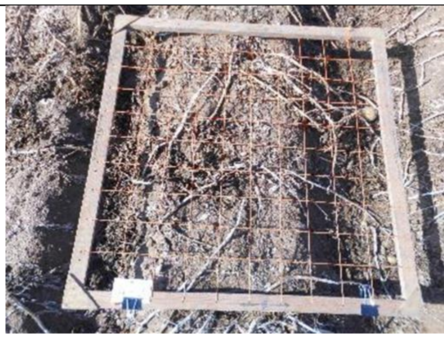
30 Jul Pre-T1		30 Jul Post-flail	
14 Aug Control		14 Aug Spotlight /Gozai	
14 Aug Finalsan		14 Aug Saltex	

Figure 12. Expt 2 (North): photographs of ground cover

12 Aug Pre-T1		12 Aug Post-flail	
27 Aug Control		27 Aug Spotlight /Gozai	
27 Aug Finalsan		27 Aug Saltex	

Figure 13. Expt 3 (West): photographs of ground cover

20 Aug Pre-T1			
3 Sep Control		3 Sep Spotlight /Gozai	
3 Sep Finalsan		3 Sep Saltex	

Figure 14. Expt 4 (Scotland): photographs of ground cover

31 Jul Pre-T1		31 Jul Post-flail	
14 Aug Control		14 Aug Spotlight /Gozai	
14 Aug Finalsan		14 Aug Saltex