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.

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 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 and actual weather conditions at time of desiccation.
- To identify whether certain desiccation practices lead to increased severity of blemishing diseases post-storage.

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.
- The work 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 Reglone and undefoliated control treatments. Actives were also combined with mechanical flailing using tractor-mounted flails. A hand-simulated haulm puller was applied to the seed experiments. No pelargonic acid or brine products currently have approval as desiccants and were included for research purposes.

- This research was closely aligned with the AHDB Potatoes Knowledge Exchange programme, so most of the sites were on Strategic Potato (SPot) Farms.
- N.B. 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 2019.

1.3. Key findings

- Within individual experiments, Spotlight/Gozai combinations were no different to Reglone, flail, haulm-pulling or Saltex in terms of skinset at 3 weeks post-T1, but when averaged over all experiments and demonstrations, there was a small (2 - 4 day) advantage in reaching skinset for Reglone, mechanical and Saltex methods compared with Spotlight, Gozai and Finalsan chemical methods.
- Some crops were skinset 2 weeks after T1. Two crops (Jelly seed and Maris Piper ware) were fully skinset after 3-4 weeks. A late-season, indeterminate ware crop of Royal was not set sufficiently even after 4 weeks.
- Flail and haulm-pulling resulted in instant canopy death.
- There was no regrowth within 4 weeks of initial treatment application (T1) in any treatment including flail, except in the experiments in Scotland where there was some regrowth in flailed plots, particularly in the seed experiment.
- Reglone and Saltex were the most effective in removing leaves. Saltex efficacy depended more on atmospheric conditions immediately following spraying than Reglone. Temperatures at T1/T2 sprays were mostly moderate (16-18 °C) and done mid- to late-morning.
- Spotlight and/or Gozai straights or combinations were all similar in terms of leaf death, but were only 2-4 days slower in killing leaves than Reglone.
- Finalsan was significantly slower in killing leaves than Reglone and slower than Spotlight/Gozai combinations.
- Using the fungicide Ranman (which contains a wetter) did not alter the speed of kill of canopy compared with a non-wetter containing fungicide (Shinkon).
- 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 skin set, 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 some other treatments in time to skin set.
- Plots that were left to grow on without defoliation increased in yield by 8-10 t/ha in 3 weeks compared with plots which were desiccated or flailed. There was no evidence to support large differences in 'passive bulking' (yield increase after T1 applications) between chemical treatments, but flail and haulm-pulling caused an immediate cessation in bulking.
- Most chemical treatments received two applications and no benefits were noted from a third application 2 weeks after the initial one.
- Not defoliating slowed skinset, but not always immediately despite the differences observed in canopy death.
- 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 Jelly, Maris Piper and Georgina, but some adhesion in Royal, with undefoliated crops demonstrating less attachment than desiccated or flailed. There was virtually no stolon plug removal in any crop (which would be a risk for post-harvest rotting).
- There were no effects of chemical or mechanical method of haulm destruction on rotting or surface blemishing diseases, either at harvest or after storage.
- There were no effects of chemical or mechanical method of haulm destruction on germination, including final proportion of tubers producing viable sprouts or the rate of eyes producing sprouts.

1.4. Practical recommendations

- Differences in the rate of foliage desiccation between treatments did not correlate well with skin set. Finalsan was much slower to kill canopies (and PPO's slightly slower) than Reglone, but skinset did not follow the same time process.
- A guide to skinsket would be 3 weeks post-T1 application, but a more quantitative and rapid measure of skinset in the field would be useful.
- Aim 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 with wet soil in 2019 and would be expected that this would result in slower skin-set than in dry soils. The timing of the last irrigation prior to desiccation (particularly salad crops), would influence skinset. Aim to stop irrigation for 7 days prior to desiccation.
- There is a 2-4 day delay in skinset for Spotlight/Gozai compared to Reglone, flail, haulm-pulling or Saltex, and 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, leaf death was more prolonged.
- In crops or at sites which have difficulty in achieving skinset owing to active green canopies at desiccation, 10 % less nitrogen than the RB209 amount should be tested to try and advance canopy senescence.
- Skinset depends on a combination of factors, not just leaf death. Stem desiccation in Royal delayed skin set despite the fairly rapid loss of leaf cover after desiccation or flailing.
- Mechanical methods stop bulking immediately, but there is little evidence that 'passive bulking' differs across chemical treatments.
- 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 has little effect on vascular browning, stem-end necrosis or stolon adhesion or on rotting or skin blemishing diseases, either pre- or post-storage.

2. INTRODUCTION

Since the 1960's, 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 tendered for, and won, the contract for both a) experimental work on selected sites and b) coordinating, analysing and reporting the overall programme.

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 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 and actual weather conditions at time of desiccation.
- To identify whether certain desiccation practices lead to increased severity of blemishing diseases post-storage.

3. MATERIALS AND METHODS

3.1. Sites and Experiments

The protocol was largely defined by the tender conditions, but modifications were made between May and July prior to application of the first treatments to seed crops. 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 mass. There were five experiments with replicated plots and two demonstrations where there was no replication of the treatments. All sites were commercial fields.

Experiment 1 was located at RJ & AE Godfrey, Eastoft, Lincolnshire (54° 5' 2.40" N, 0° 48' 22.32" E), on a silty clay loam soil. The variety was Jelly grown for seed production, planted on 11 April at a within-row spacing of 20 cm in 91.4 cm rows. The N fertilizer rate was 70 kg/ha. The crop emerged on 16 May.

Experiment 2 was located at RJ & AE Godfrey, Eastoft, Lincolnshire (54° 5' 2.40" N, 0° 48' 22.32" E), on a silty clay loam soil. The variety was Maris Piper grown for ware production, planted on 11 April at a within-row spacing of 34 cm in 91.4 cm rows. The N fertilizer rate was 125 kg/ha. The crop emerged on 16 May.

Experiment 3 was located at Elveden Farms, Icklingham, Suffolk (52° 20' 51.63" N, 0° 35' 6.73" E) on a loamy sand soil. The variety was Royal grown for French-fry production, planted on 27 March at a within-row spacing of 41 cm in 3-row beds (1.83 m wide). The N fertilizer rate was 180 kg/ha. The crop emerged on 2 May.

Experiment 4 was located at the James Hutton Institute experimental farm at East Pilmore (56° 27' 32.92" N, 3° 5' 55.36" W) on a sandy loam/sandy silt loam soil. The variety was Maris Piper grown for seed production, planted on 29 April at a within-row spacing of 30 cm in 91.4 cm rows. The N fertilizer rate was 70 kg/ha. The crop emerged on 20 May.

Experiment 5 was located at the James Hutton Institute experimental farm at East Pilmore (56° 27' 32.92" N, 3° 5' 55.36" W) on a sandy loam/sandy silt loam soil. The variety was Maris Piper grown for ware production, planted on 29 April at a within-row spacing of 40 cm in 91.4 cm rows. The N fertilizer rate was 150 kg/ha. The crop emerged on 20 May.

Demonstration 1 was located at Dillington Estate, Ilminster, Somerset (50° 56' 17.61" N, 2° 53' 58.28" W) on a silty clay loam soil. The variety was Georgina grown for ware

production, planted on 28 April at a within-row spacing of 33 cm in 91.4 cm rows. The N fertilizer rate was 200 kg/ha. The crop emerged on 18 May.

Demonstration 2 was located at Heal Farms, Market Drayton, Shropshire (52° 48' 29.42" N, 2°5' 51.84" W) on a sandy loam soil. The variety was Titan grown for crisp production, planted on 18 April at a within-row spacing of 25 cm in 91.4 cm rows. The N fertilizer rate was 250 kg/ha. The crop emerged on 15 May.

Experiments 1-3 and Demonstration 1 were managed by NIAB CUF, Expts 4 and 5 were managed by staff at the James Hutton Institute and Demo 2 was managed by staff at the Crop and Environment Research Centre at Harper Adams University.

3.2. Treatments and products

Whilst the majority of the treatments were the same for both ware and seed experiments, there were slight differences. The initial spray or mechanical treatment application was designated timing T1, with the second T2 (and third T3, if applied) being timed 7 and 14 days, respectively after T1. Occasionally, owing to weather or other logistics, the 7-day interval between T1 and T2 (and T2 and T3) could not be adhered to, but there was never more than 1 day difference between intended and actual interval. Table 1, Table 2 and Table 3 list the treatments, products and the application dates and weather for T1, T2 and T3 timings at each of the experiments and demonstrations.

An application record form was sent to all operators. 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 is shown in Table 3.

Plots were marked out in the commercial crops, with a 3 m guard area at the end of each plot to allow access for the flail into plots. Plots were 4 rows (3.6 m) wide x 8 m (ware) or 6 m (seed) long and all four rows were sprayed or flailed. To permit tractor access for the flailed treatments, flail plots were double length (16 or 12 m). They were flailed along the full length of the plot, but the sprayed area was the same size as chemical only plots. Assessments and harvests were only made on the middle two rows of each plot, leaving guard areas between harvests.

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.

All chemical applications were made withing 2 hours of flailing. The haulm puller was simulated by pulling all plants out of the ground by hand, placing one hand on the ridge to ensure that tubers remained underground. The foliage was placed outside the plot.

Each site was sprayed with plot-sprayers operating at 3 bar and with a water volume of 400 l/ha (except Saltex, 1123 /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. Treatments were done in the order listed in Table 1 and Table 2.

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 %. Saltex (concentrated brine solution, Omex) was applied at a rate of 1123 l/ha, providing 301kg/ha of common salt, NaCl.

A late blight fungicide addition to the desiccation programme was recommended as this would be commercial practice. After long negotiation, Ranman Plus (cyazofamid, Belchim) was chosen. It was applied with most treatments at a rate of 0.5 l/ha, but where it was tank-mixed with an adjuvant (Toil), its rate was reduced to 0.25 l/ha to comply with label requirements. To compare the effect of adding a blight fungicide with no wetter, Shinkon (amisulbrom, Gowan) was used as a comparison in the ware trials. Again, its rates were adjusted depending on whether it was used without an adjuvant (0.5 l/ha) or with the addition of Toil (0.25 l/ha). A mistake was made in Experiment 4 in that an earlier variant of the protocol was used. Ranman Plus was replaced by Infinito (fluopicolide + propamocarb, Bayer CropScience) at a rate of 0.5 l/ha.

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.

Table 1. List of treatments, products and timings of applications in the seed experiments (Expt 1, Expt 4)

Treat	Product 1	Rate (l/ha)	Product 2	Rate (/ha)	Product 3	Rate (l/ha)	Product 4	Rate (l/ha)
T1								
1	Reglone†	1.5						
2	Flail	1.0	Spotlight Plus†	1.0				
3	Flail	1.0	Spotlight Plus‡		Gozai	0.8	Toil	1.5
4	Gozai‡	0.8	Toil	1.5				
5	Spotlight Plus†	1.0						
6	Spotlight Plus‡	1.0	Gozai	0.8	Toil	1.5		
7	Finalsan†	67						
8	No desiccant†							
9	Spotlight Plus†	1.0						
10	Haulm puller							
T2								
1	Reglone†	2.5						
2	†							
3	†							
4	Spotlight Plus†	1.0						
5	Gozai‡	0.8	Toil	1.5				
6	Spotlight Plus‡	1.0	Gozai	0.8	Toil	1.5		
7	Spotlight Plus†	1.0						
8	No desiccant†							
9	Gozai‡	0.8	Toil	1.5				
10								
T3								
1								
2								
3								
4								
5								
6								
7								
8								
9	Spotlight Plus†	0.6						
10								

†Ranman Top fungicide applied at 0.5 l/ha
‡Ranman Top fungicide applied at 0.25 l/ha

Table 2. List of treatments, products and timings of applications in the ware experiments (Expt 2, Expt 3, Expt 5, Demo 1, Demo 2)

Treat	Product 1	Rate (l/ha)	Product 2	Rate (/ha)	Product 3	Rate (l/ha)	Product 4	Rate (l/ha)
T1								
1	Reglone†	1.5						
2	Flail	1.0	Spotlight Plus†	1.0				
3	Flail	1.0	Spotlight Plus‡		Gozai	0.8	Toil	1.5
4	Gozai‡	0.8	Toil	1.5				
5	Spotlight Plus‡	1.0						
6	Spotlight Plus*	1.0						
7	Spotlight Plus‡	1.0	Gozai	0.8	Toil	1.5		
8	No desiccant†							
9	Finalsan†	67						
10	Spotlight Plus†	1.0						
11	Saltex†	1123						
T2								
1	Reglone†	2.5						
2	†							
3	†							
4	Spotlight Plus†	1.0						
5	Gozai‡	0.8	Toil	1.5				
6	Gozai⁂	0.8	Toil	1.5				
7	Spotlight Plus‡		Gozai	0.8	Toil	1.5		
8	No desiccant†							
9	Spotlight Plus†	1.0						
10	Gozai‡	0.8	Toil	1.5				
11	Spotlight Plus†	1.0						
T3								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10	Spotlight Plus†	0.6						
11								

†Ranman Top fungicide applied at 0.5 l/ha
‡Ranman Top fungicide applied at 0.25 l/ha
*Shinkon fungicide applied at 0.5 l/ha
⁂Shinkon fungicide applied at 0.25 l/ha

Table 3. Date, time and weather at T1-T3 for each experiment/demonstration

Expt/ Demo	Timing	Date	Time	Air temp. (°C)	Relative humidity†	Wind force‡	Soil water content⁑
Expt 1	T1	1 August	11:27-13:38	20	Humid	4	Wet
	T2	7 August	10:48-12:08	18	Humid	4	Wet
	T3	14 August	9:00-9:10	16	Humid	1	Wet
Expt 2	T1	5 September	10:00-12:30	18	Humid	4	Moist
	T2	12 September	11:30-12:45	18	Humid	3	Moist
	T3	19 September	12:40-12:50	20	Average	1	Moist
Expt 3	T1	4 September	9:45-12:55	18	Average	4	Moist
	T2	11 September	10:00-11:45	18	Humid	4	Moist
	T3	18 September	9:11-9:25	12	Humid	1	Moist
Expt 4	T1	30 July	Morning	17	Humid	1	Wet
	T2	6 August	12:00-16:00	15	Humid	1	Wet
	T3	13 August	11:00-11:30	11	Humid	1	Moist
Expt 5	T1	12 September	13:00-17:00	8	Humid	2	Wet
	T2	19 September	13:00-17:00	11	Humid	2	Wet
	T3	26 September	11:00-11:30	12	Humid	1	Wet
Demo 1	T1	12 August	11:02-12:42	19	Humid	0	Wet
	T2	19 August	20:30-21:00	15	Average	1	Wet
	T3	26 August	9:30-10:00	15	Humid	1	Wet
Demo 2	T1	7 August	11:10-11:55	20	Average	4	Moist
	T2	13 August	15:30-15:55	14	Average	2	Moist
	T3	21 August	10:15-10:20	14	Average	2	Moist

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

‡Beaufort Scale. 0, calm; 1, light air; 2, light breeze; 3, gentle breeze; 4, moderate breeze

⁑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. 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

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 1). 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 1. 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 3 m x 1 row (2.74 m^2) was hand-dug, either 3 or 4 weeks after T1. 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

Two assessments were made of the disease incidence and severity. One at final harvest (T1 +3-4 weeks) and another one following storage at 3 °C until February. No samples were treated with sprout suppressants in store. At harvest, 50 random tubers were selected from each plot after grading and assessed for incidence of blight, black dot, black scurf and other rotting diseases. Following storage, 50 tubers from each plot were assessed for incidence of blight, other rotting diseases and incidence and severity of black dot and black scurf. The categories for the surface area affected by blemishing diseases were 0, 1, 5, 10, 15, 20 and 10 % increments thereafter.

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. Germination

Following storage until February, 50 tubers per plot were selected from the two seed experiments only and assessed for dormancy. They were placed into cardboard egg trays in a well-lit store set at 16 °C and at weekly intervals the number of sprouts

> 3 mm length was recorded. The final percentage of tubers that germinated and the number of days to 100 % germination from entry to store at 16 °C were calculated.

3.11. 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 % ($P < 0.05$).

4. RESULTS

4.1. Spraying conditions

Owing to rainfall during August and September at all sites, soils were mostly at field capacity or slightly drier during the T1-T3 desiccation period (Table 3). Soil water content plays a significant role in speed of 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 mid-morning, with one event at Demonstration 1 done just before dark. Most spraying events were under humid conditions and the initial (T1) application at warm (17-20 °C) temperatures. The exception was the T1 in Expt 5, the Maris Piper ware trial in Scotland, where it was only 8 °C (Table 3). Expt 5 was the coldest site during the desiccation period. The second timing (T2) was, on average, 2 °C cooler than T1. By late September (T3 in Expts 4 and 5), temperatures had dropped to 11-12 °C.

4.2. Canopy death

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

Flail and haulm-pulling gave instant canopy removal, although there was variable stem length left following flailing. Most sites achieved the 15-20 cm stem length post-flailing, which was an ideal target for the Spotlight or Gozai desiccant applied after flailing. With the Royal in Expt 3, there were some stems up to 180 cm 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 Maris Piper seed experiment in Scotland (Expt 4).

As a summary, Reglone was the most effective chemical in removing leaves. Saltex was as effective as Reglone under some conditions. Spotlight or Gozai alone, or combinations of Spotlight followed by Gozai, Gozai followed by Spotlight or tank mixes of both Spotlight and Gozai, were all similar, irrespective of timing, product or combination, but 2-4 days slower in killing leaves than Reglone in Expts 1, 2, 3 and 5 and both Demo 1 and Demo 2. The Spotlight/Gozai treatments were > 7 days slower at killing the canopy than Reglone in the Scottish seed trial (Expt 4). Finalsan (pelargonic acid) was slowest to act on leaves across all sites, often leaving appreciable (up to 67 %) green ground cover 14 days after T1 when many other chemical desiccants had killed most of the leaf area. There was still appreciable

ground cover in many chemical treatments 21 days after T1 in the seed crop in Scotland (Expt 4) and to a lesser extent in the ware crop at the same site (Expt 5) desiccated 6 weeks later. Stem desiccation data are still to be fully analysed, but there were large varietal and sites differences in speed of desiccation.

The ground cover data for each of the experiments and demonstrations are shown in Table 4 to Table 10.

In Expt 1, leaf death following treatment was rapid (< 2 weeks) in the chemical treatments, but Finalsan was slowest (Table 4). In Expt 2, leaf death following treatment was rapid (< 2 weeks) in all the chemical treatments, but Finalsan was slowest in dying (Table 5). In Expt 3, complete leaf death following treatment with Reglone and Saltex was rapid (< 2 weeks), but 7 days slower with Spotlight/Gozai and Finalsan slower still (Table 6). The latter three chemical desiccants still had 3-10 % leaf area left 3 weeks after T1. In Expt 4, leaf death was slow following chemical treatment (Table 7). There was still appreciable green leaf area in all chemical treatments (and some in the flail and halum pulling indicating both inadequate flailing and regrowth). Spotlight, Gozai and Finalsan all had > 50 % ground cover remaining 22 days after T1.

Table 4. Expt 1 Eastoft, Lincolnshire ground cover (%) following treatments

	T1	T2	T3	Date			
Treat	(1 Aug)	(7 Aug)	(14 Aug)	1 Aug	7 Aug	14 Aug	21 Aug
1	Reglone	Reglone		100	18	0	0
2	Flail+Spotlight			100	0	0	0
3	Flail+Spotlight+Gozai			100	0	0	0
4	Gozai	Spotlight		100	42	1	0
5	Spotlight	Gozai		100	41	10	2
6	Spotlight+Gozai	Spotlight+Gozai		100	42	2	0
7	Finalsan	Spotlight		100	71	21	9
8	No desiccant			100	99	97	95
9	Spotlight	Gozai	Spotlight	100	52	5	0
10	Haulm puller			100	0	0	0
S.E.	(27 D.F.)			0.2	6.4	3.6	1.7
	No desiccant			100	99	97	95
	Reglone			100	18	0	0
	Finalsan			100	71	21	9
	Spotlight/Gozai			100	44	5	1
	Flail/haulm pulling			100	0	0	0

Table 5. Expt 2 Eastoft, Lincolnshire ground cover (%) following treatments

Treat	T1 (5 Sep)	T2 (12 Sep)	T3 (19 Sep)	Date			
				5 Sep	12 Sep	19 Sep	26 Sep
1	Reglone	Reglone		99	7	0	0
2	Flail+Spotlight			98	0	0	0
3	Flail+Spotlight+Gozai			98	0	0	0
4	Gozai	Spotlight		99	21	1	0
5	Spotlight	Gozai		99	10	2	0
6	Spotlight+Shinkon	Gozai+Shinkon		98	14	0	0
7	Spotlight+Gozai	Spotlight+Gozai		99	12	0	0
8	No desiccant			99	87	46	32
9	Finalsan	Spotlight		99	38	2	0
10	Spotlight	Gozai	Spotlight	99	13	2	0
11	Saltex	Spotlight		99	2	0	0
S.E.	(30 D.F.)			0.5	3.0	2.0	1.1
	No desiccant			99	87	46	32
	Reglone			99	7	0	0
	Finalsan			99	38	2	0
	Spotlight/Gozai			99	15	1	0
	Flail			98	0	0	0
	Saltex			99	2	0	0

Table 6. Expt 3 Elveden Farms, Suffolk ground cover (%) following treatments

Treat	T1 (4 Sep)	T2 (11 Sep)	T3 (18 Sep)	Date			
				4 Sep	11 Sep	18 Sep	25 Sep
1	Reglone	Reglone		97	27	0	0
2	Flail+Spotlight			97	0	0	0
3	Flail+Spotlight+Gozai			99	0	0	0
4	Gozai	Spotlight		99	77	23	2
5	Spotlight	Gozai		98	74	25	8
6	Spotlight+Shinkon	Gozai+Shinkon		99	93	23	4
7	Spotlight+Gozai	Spotlight+Gozai		99	85	19	1
8	No desiccant			98	92	72	47
9	Finalsan	Spotlight		100	95	52	10
10	Spotlight	Gozai	Spotlight	97	83	20	1
11	Saltex	Spotlight		99	78	3	0
S.E.	(30 D.F.)			0.7	5.8	6.2	4.9
	No desiccant			98	92	72	47
	Reglone			97	27	0	0
	Finalsan			100	95	52	10
	Spotlight/Gozai			98	78	22	3
	Flail			98	0	0	0
	Saltex			99	78	3	0

Table 7. Expt 4 JHI East Pilmore, Dundee ground cover (%) following treatments

	T1	T2	T3	Date		
Treat	(30 Jul)	(6 Aug)	(13 Aug)	30 Jul	13 Aug	21 Aug
1	Reglone	Reglone		100	33	14
2	Flail+Spotlight			100	7	7
3	Flail+Spotlight+Gozai			100	0	2
4	Gozai	Spotlight		100	66	63
5	Spotlight	Gozai		100	67	72
6	Spotlight+Gozai	Spotlight+Gozai		100	43	21
7	Finalsan	Spotlight		100	67	58
8	No desiccant			100	81	85
9	Spotlight	Gozai	Spotlight	100	63	50
10	Haulm puller			100	0	9
S.E.	(27 D.F.)			0.0	9.8	6.3
	No desiccant			100	81	85
	Reglone			100	33	14
	Finalsan			100	67	58
	Spotlight/Gozai			100	60	51
	Flail/haulm pulling			100	2	6

In Expt 5, complete leaf death at 3 weeks after T1 only occurred with Saltex and even Reglone had a small area of green leaf cover remaining at this stage (Table 8). Spotlight, Gozai and Finalsan had a similar efficacy to Reglone. There was no regrowth in the flail treatments.

Table 8. Expt 5 Elveden Farms, Suffolk ground cover (%) following treatments

	T1	T2	T3	Date			
Treat	(10 Sep)	(17 Sep)	(24 Sep)	10 Sep	17 Sep	24 Sep	1 Oct
1	Reglone	Reglone		95	50	29	8
2	Flail+Spotlight			98	1	0	0
3	Flail+Spotlight+Gozai			95	0	0	0
4	Gozai	Spotlight		95	76	44	15
5	Spotlight	Gozai		99	67	21	1
6	Spotlight+Shinkon	Gozai+Shinkon		93	74	33	9
7	Spotlight+Gozai	Spotlight+Gozai		96	52	27	1
8	No desiccant			95	81	66	43
9	Finalsan	Spotlight		95	40	25	11
10	Spotlight	Gozai	Spotlight	95	69	40	9
11	Saltex	Spotlight		94	40	6	0
S.E.	(30 D.F.)			0.92	8.5	7.1	3.8
	No desiccant			95	81	66	43
	Reglone			95	50	29	8
	Finalsan			95	40	25	11
	Spotlight/Gozai			96	68	33	7
	Flail			97	1	0	0
	Saltex			94	40	6	0

In Demo 1, leaf death was very rapid across all chemical treatments, with all leaves dead withing 14 days of T1, but death was slower with Finalsan initially (Table 9).

In Demo 2, Reglone was the most rapid chemical desiccant to kill leaves (Table 10). Spotlight, Gozai and Saltex were all slower than Reglone, but all desiccated or defoliated canopies were completely dead 3 weeks after T1. Finalsan treated haulm was actually dead at 14 days after T1 (Table 10).

Table 9. Demo 1 Dillington Estate, Somerset ground cover (%) following treatments (unreplicated)

	T1	T2	T3	Date		
Treat	(12 Aug)	(19 Aug)	(26 Aug)	12 Aug	19 Aug	26 Aug
1	Reglone	Reglone		98	8	0
2	Flail+Spotlight			99	0	0
3	Flail+Spotlight+Gozai			99	0	0
4	Gozai	Spotlight		98	6	0
5	Spotlight	Gozai		95	9	0
6	Spotlight+Shinkon	Gozai+Shinkon		96	4	0
7	Spotlight+Gozai	Spotlight+Gozai		98	4	0
8	No desiccant			99	82	66
9	Finalsan	Spotlight		100	39	3
10	Spotlight	Gozai	Spotlight	98	9	0
11	Saltex	Spotlight		96	2	0
	No desiccant			99	82	66
	Reglone			98	8	0
	Finalsan			100	39	3
	Spotlight/Gozai			97	6	0
	Flail			99	0	0
	Saltex			96	2	0

Table 10. Demo 2 Heal Farms, Shropshire ground cover (%) following treatments (unreplicated)

	T1	T2	T3	Date			
Treat	(7 Aug)	(13 Aug)	(21 Aug)	7 Aug	13 Aug	21 Aug	28 Aug
1	Reglone	Reglone		86	11	0	0
2	Flail+Spotlight			87	5	0	0
3	Flail+Spotlight+Gozai			89	6	0	0
4	Gozai	Spotlight		100	48	6	0
5	Spotlight	Gozai		84	40	9	0
6	Spotlight+Shinkon	Gozai+Shinkon		100	46	8	0
7	Spotlight+Gozai	Spotlight+Gozai		95	22	0	0
8	No desiccant			83	48	38	38
9	Finalsan	Spotlight		97	32	0	0
10	Spotlight	Gozai	Spotlight	97	52	9	0
11	Saltex	Spotlight		100	70	18	0
	No desiccant			83	48	38	38
	Reglone			86	11	0	0
	Finalsan			97	32	0	0
	Spotlight/Gozai			95	42	6	0
	Flail			88	6	0	0
	Saltex			100	70	18	0

4.3. Stem desiccation

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.

In Expt 1, all stems were green at T1 (1 August). Less than 5 % of stems in chemical treatments had reached the brittle stage by 2 weeks after T1, but there were more bleached stems following Reglone than Finalsan or Spotlight/Gozai (Table 11). Flailed stems were mostly brittle at this stage.

Table 11. Expt 1 Eastoft, Lincolnshire desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

	T1	T2	T3	Date			
Treat	(1 Aug)	(7 Aug)	(14 Aug)	7 Aug		14 Aug	
				BL	BR	BL	BR
1	Reglone	Reglone		5.0	0.0	90.0	1.2
2	Flail+Spotlight			50.0	30.0	5.0	95.0
3	Flail+Spotlight+Gozai			46.2	32.5	10.0	90.0
4	Gozai	Spotlight		13.8	0.0	78.8	6.2
5	Spotlight	Gozai		17.5	0.0	66.2	5.0
6	Spotlight+Gozai	Spotlight+Gozai		12.5	0.0	65.0	8.8
7	Finalsan	Spotlight		0.0	0.0	61.2	1.2
8	No desiccant			0.0	0.0	0.0	0.0
9	Spotlight	Gozai	Spotlight	8.8	0.0	71.2	0.0
10	Haulm puller†			-	-	-	-
S.E.	(24 D.F.)			5.07	7.20	6.69	3.57
	No desiccant			0.0	0.0	0.0	0.0
	Reglone			5.0	0.0	90.0	1.2
	Finalsan			0.0	0.0	61.2	1.2
	Spotlight/Gozai			13.2	0.0	70.3	5.0
	Flail			48.1	31.3	7.5	92.5

†No stems to assess

In Expt 2, >97 % of stems were green at T1, with a little bleaching on some stems (data not shown). Two weeks after T1, Reglone and flail treatments had mostly brittle stems, with Saltex having a slightly lower proportion (Table 12). Spotlight/Gozai treatments had even fewer brittle stems than Saltex, with Finalsan the poorest in terms of stem desiccation and almost as poor as untreated crops (Table 12).

Table 12. Expt 2 Eastoft, Lincolnshire desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

Treat	T1 (5 Sep)	T2 (12 Sep)	T3 (19 Sep)	Date			
				12 Sep		19 Sep	
				BL	BR	BL	BR
1	Reglone	Reglone		68.8	13.8	8.8	91.2
2	Flail+Spotlight			65.0	17.5	2.5	97.5
3	Flail+Spotlight+Gozai			51.1	31.1	5.9	94.9
4	Gozai	Spotlight		41.2	7.5	57.5	35.0
5	Spotlight	Gozai		57.5	2.5	71.2	23.8
6	Spotlight+Shinkon	Gozai+Shinkon		17.5	0.0	53.8	46.2
7	Spotlight+Gozai	Spotlight+Gozai		28.8	5.0	35.0	63.8
8	No desiccant			7.5	1.3	12.5	5.0
9	Finalsan	Spotlight		32.5	5.0	85.0	12.5
10	Spotlight	Gozai	Spotlight	37.5	2.5	43.8	52.5
11	Saltex	Spotlight		61.2	12.5	23.7	76.2
S.E.	(29 D.F.)			8.74	5.65	4.63	4.39
	No desiccant			7.5	1.3	12.5	5.0
	Reglone			68.8	13.8	8.8	91.2
	Finalsan			32.5	5.0	85.0	12.5
	Spotlight/Gozai			36.5	3.5	52.3	44.3
	Flail			58.1	24.3	4.2	96.2
	Saltex			61.2	12.5	23.7	76.2

In Expt 3, flailed plots had the greatest proportion of brittle stems at 2 weeks after T1, and whilst Reglone and Saltex had killed the leaves by this stage, stems were still largely in the bleached rather than brittle category. There were more green stems in Spotlight/Gozai and particularly Finalsan than Reglone at this stage (Table 13). By 4 weeks after T1, Reglone, flail and Saltex plots had 100 % desiccated stems, but there was still a small proportion of bleached but not brittle stems in Spotlight/Gozai treatments, but stems in the Finalsan treatment were even less desiccated, with still some green stems visible (Table 13).

Table 13. Expt 3 Elveden Farms, Suffolk desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

Treat	T1 (4 Sep)	T2 (11 Sep)	T3 (18 Sep)		Date					
					11 Sep		17 Sep		2 Oct	
					BL	BR	BL	BR	BL	BR
1	Reglone	Reglone			50.0	0.0	68.8	30.0	0.0	100.0
2	Flail+Spotlight				51.3	5.0	16.2	83.8	0.0	100.0
3	Flail+Spotlight+Gozai				57.5	0.0	38.8	61.2	0.0	100.0
4	Gozai	Spotlight			15.0	0.0	83.8	8.7	3.8	96.2
5	Spotlight	Gozai			15.0	0.0	66.8	6.2	12.5	87.5
6	Spotlight+Shinkon	Gozai+Shinkon			27.5	0.0	70.0	2.5	12.5	87.5
7	Spotlight+Gozai	Spotlight+Gozai			17.5	0.0	78.8	7.5	0.0	100.0
8	No desiccant				0.0	0.0	23.7	1.2	48.8	38.8
9	Finalsan	Spotlight			8.8	0.0	48.8	0.0	41.2	56.2
10	Spotlight	Gozai		Sp/Go	23.8	0.0	80.0	6.2	0.0	100.0
11	Saltex	Spotlight			47.5	5.0	67.5	13.7	0.0	100.0
S.E.	(30 D.F.)				2.98	2.36	5.29	3.52	5.08	6.01
	No desiccant				0.0	0.0	23.7	1.2	48.8	38.8
	Reglone				50.0	0.0	68.8	30.0	0.0	100.0
	Finalsan				8.8	0.0	48.8	0.0	41.2	56.2
	Spotlight/Gozai				19.8	0.0	75.9	6.2	5.8	94.2
	Flail				50.4	2.5	27.5	72.5	0.0	100.0
	Saltex				47.5	5.0	67.5	13.7	0.0	100.0

In Expt 4, Reglone and Spotlight/Gozai treatments were similar in terms of stem desiccation 3 weeks after T1, but flail treatments still had 25 % green stems at this stage (Table 14). There was some regrowth in this experiment in flailed treatments. Finalsan had more green stems than Reglone, but not significantly fewer than Spotlight/Gozai.

Table 14. Expt 4 JHI East Pilmore, Dundee desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

	T1	T2	T3	Date	
Treat	(30 Jul)	(6 Aug)	(13 Aug)	21 Aug	
				BL	BR
1	Reglone	Reglone		16.2	82.2
2	Flail+Spotlight			40.5	35.0
3	Flail+Spotlight+Gozai			45.0	30.0
4	Gozai	Spotlight		1.7	82.8
5	Spotlight	Gozai		5.7	68.0
6	Spotlight+Gozai	Spotlight+Gozai		6.0	74.0
7	Finalsan	Spotlight		9.5	63.8
8	No desiccant			0.0	0.0
9	Spotlight	Gozai	Spotlight	0.0	92.5
10	Haulm puller†			-	-
S.E.	(24 D.F.)			7.29	11.70
	No desiccant			0.0	0.0
	Reglone			16.2	82.2
	Finalsan			9.5	63.8
	Spotlight/Gozai			3.4	79.3
	Flail			42.8	32.5

†No stems to assess

In Expt 5, 3 weeks after T1, all stems had desiccated in flailed treatments, but Reglone was not significantly different in the proportion of bleached and brittle stems than Spotlight/Gozai or Finalsan treatments, but Saltex was significantly better in desiccating stems than other chemical treatments (Table 15).

Table 15. Expt 5 JHI East Pilmore, Dundee desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

Treat	T1 (12 Sep)	T2 (19 Sep)	T3 (26 Sep)	Date 1 Oct	
				BL	BR
1	Reglone	Reglone		55.0	38.5
2	Flail+Spotlight			0.0	100.0
3	Flail+Spotlight+Gozai			0.0	100.0
4	Gozai	Spotlight		41.8	35.2
5	Spotlight	Gozai		38.8	58.2
6	Spotlight+Shinkon	Gozai+Shinkon		45.8	41.8
7	Spotlight+Gozai	Spotlight+Gozai		43.2	46.8
8	No desiccant			17.5	28.3
9	Finalsan	Spotlight		33.2	49.0
10	Spotlight	Gozai	Spotlight	42.8	53.0
11	Saltex	Spotlight		12.3	87.8
S.E.	(29 D.F.)			9.16	7.60
	No desiccant			17.5	28.3
	Reglone			55.0	38.5
	Finalsan			33.2	49.0
	Spotlight/Gozai			42.5	47.0
	Flail			0.0	100.0
	Saltex			12.3	87.8

In Demo 1, 2 weeks after T1, 100 % of stems had reached the brittle stage in Reglone, flail and Saltex treatments, whilst Spotlight/Gozai treatments had 15 % of bleached, non-brittle stems remaining. Finalsan still had *c*. 55 % of stems that had not reached the brittle stage (Table 16).

Table 16. Demo 1 DillingtonEstate, Somerset desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

Treat	T1 (12 Aug)	T2 (19 Aug)	T3 (26 Aug)	Date			
				19 Aug		26 Aug	
				BL	BR	BL	BR
1	Reglone	Reglone		95	0	0	100
2	Flail+Spotlight			60	40	0	100
3	Flail+Spotlight+Gozai			20	80	0	100
4	Gozai	Spotlight		100	0	0	100
5	Spotlight	Gozai		50	0	15	85
6	Spotlight+Shinkon	Gozai+Shinkon		85	0	5	95
7	Spotlight+Gozai	Spotlight+Gozai		80	10	40	60
8	No desiccant			10	0	65	30
9	Finalsan	Spotlight		30	5	50	45
10	Spotlight	Gozai	Spotlight	65	0	15	85
11	Saltex	Spotlight		95	5	0	100
	No desiccant			10	0	65	30
	Reglone			95	0	0	100
	Finalsan			30	5	50	45
	Spotlight/Gozai			76	2	15	85
	Flail			40	60	0	100
	Saltex			95	5	0	100

In Demo 2, 3 weeks after T1, the majority of stems in chemical and mechanical treatments had reached the brittle stage, with full desiccation in Reglone and flail, but *c.* 10 % of stems were still not completely desiccated in Spotlight/Gozai, Saltex and Finalsan treatments (Table 17).

Table 17. Demo 2 Heal Farms, Shropshire desiccation of stems on sequential dates (% of stems bleached (BL) or brittle (BR))

Treat	T1 (7 Aug)	T2 (13 Aug)	T3 (21 Aug)	Date			
				21 Aug		28 Aug	
				BL	BR	BL	BR
1	Reglone	Reglone		100	0	0	100
2	Flail+Spotlight			6	94	0	100
3	Flail+Spotlight+Gozai			0	100	0	100
4	Gozai	Spotlight		11	89	16	84
5	Spotlight	Gozai		20	80	37	63
6	Spotlight+Shinkon	Gozai+Shinkon		20	80	13	80
7	Spotlight+Gozai	Spotlight+Gozai		59	41	10	90
8	No desiccant			0	0	9	9
9	Finalsan	Spotlight		15	85	11	89
10	Spotlight	Gozai	Spotlight	53	47	19	81
11	Saltex	Spotlight		27	73	9	91
	No desiccant			0	0	9	9
	Reglone			100	0	0	100
	Finalsan			15	85	11	89
	Spotlight/Gozai			33	67	19	80
	Flail			3	97	0	100
	Saltex			27	73	9	91

4.4. Skinset

A calibration was done against an old skinning barrel used in 1999-2003 for desiccation work. This showed that if tubers had < 15 % skinning in the cement mixer, then they should be capable of being harvested mechanically with a good driver and not excessively abrasive soil. This mean value for skinning was judged to be the point when tubers were judge as having set skin. When assessed at three weeks post T1 across all sites, Spotlight/Gozai combinations had poorer skinset than Reglone, flail or Saltex. Spotlight and Gozai were, in reality, only 2-3 days slower in setting skins adequately for harvesting than Reglone, but there was variation across sites. Georgina (Demo 1) and Maris Piper (Expt 2) were fully skinset at two weeks, whereas Jelly seed (Expt 1), Scottish crops (Expts 4 and 5) and the Royal crop (Expt 3) took 3 to 4 weeks. The individual experiment/demonstration results are presented in Table 18 to Table 24.

In Expt 1, most treatments has adequately set skin at 3 weeks after T1 and all chemical and mechanical methods of defoliation were similar (Table 18).

In Expt 2, skinset was very rapid across all treatments, being achieved *c*. 10 days after T1 (Table 19). Even allowing the crop to die naturally did not hinder skinset much,

despite the persistent foliage in undefoliated plots (32 % ground cover on 26 September).

In Expt 3, skins were, on average, set sufficiently for harvesting by 3 weeks after T1 across all treatments, with the exception of Finalsan, which was not quite set (Table 20). However, there was little change in mean skinset between 3 and 4 weeks after T1, with some tubers still exhibiting appreciable skinning (> 50 % skinned), even after 4 weeks from initial treatment.

In Expt 4, owing to delay in setting up the measuring equipment at the seed experiment in Scotland, only one assessment of skinset was made. This was 22 days after T1 and skins would not be set sufficiently for harvest for at least another 7-10 days. There was no significant effect of treatment other than the comparison with the undefoliated crop (Table 21).

In Expt 5, again only a single skinset measurement was made, 21 days after T1 and, like the seed experiment, skinset was poor when other crops in the programme had set skins sufficiently well for harvesting. Flail treatments had better skinset than chemical desiccation except Reglone and Saltex (Table 22). Reglone was not significantly better than Spotlight, Gozai or Finalsan.

Table 18. Expt 1 Eastoft Farm, Lincolnshire skinset (proportion of skin removed in cement mixer, %) at different time periods following T1

	T1	T2	T3	Date		
Treat	(1 Aug)	(7 Aug)	(14 Aug)	14-Aug	21-Aug	28-Aug
1	Reglone	Reglone		53	32	19
2	Flail+Spotlight			51	29	21
3	Flail+Spotlight+Gozai			46	33	18
4	Gozai	Spotlight		53	35	13
5	Spotlight	Gozai		55	40	16
6	Spotlight+Gozai	Spotlight+Gozai		54	36	12
7	Finalsan	Spotlight		54	35	17
8	No desiccant			65	52	52
9	Spotlight	Gozai	Spotlight	52	38	12
10	Haulm puller			44	21	13
S.E.	(27 D.F.)			3.6	3.0	3.4
	No desiccant			65	52	52
	Reglone			53	32	19
	Finalsan			54	36	12
	Spotlight/Gozai			54	37	13
	Flail/haulm pulling			47	28	17

Table 19. Expt 2 Eastoft Farm, Lincolnshire skinset (proportion of skin removed in cement mixer, %) at different time periods following T1

	T1	T2	T3	Date	
Treat	(5 Sep)	(12 Sep)	(19 Sep)	19-Sep	26-Sep
1	Reglone	Reglone		5.0	0.9
2	Flail+Spotlight			5.4	0.8
3	Flail+Spotlight+Gozai			5.4	0.9
4	Gozai	Spotlight		6.2	1.2
5	Spotlight	Gozai		5.6	1.2
6	Spotlight+Shinkon	Gozai+Shinkon		5.2	1.2
7	Spotlight+Gozai	Spotlight+Gozai		6.1	0.9
8	No desiccant			8.3	3.0
9	Finalsan	Spotlight		6.5	1.8
10	Spotlight	Gozai	Spotlight	5.9	1.2
11	Saltex	Spotlight		5.7	0.9
S.E.	(30 D.F.)			0.56	0.37
	No desiccant			8.3	3.0
	Reglone			5.0	0.9
	Finalsan			6.5	1.8
	Spotlight/Gozai			5.8	1.1
	Flail			5.4	0.9
	Saltex			5.7	0.9

Table 20. Expt 3 Elveden Farms, Suffolk skinset (proportion of skin removed in cement mixer, %) at different time periods following T1

	T1	T2	T3	Date		
Treat	(4 Sep)	(11 Sep)	(18 Sep)	18-Sep	25-Sep	02-Oct
1	Reglone	Reglone		43.6	11.7	8.8
2	Flail+Spotlight			56.2	11.7	11.9
3	Flail+Spotlight+Gozai			53.1	12.2	12.2
4	Gozai	Spotlight		54.7	10.9	10.5
5	Spotlight	Gozai		45.6	10.8	9.1
6	Spotlight+Shinkon	Gozai+Shinkon		53.2	12.3	13.0
7	Spotlight+Gozai	Spotlight+Gozai		49.2	12.5	10.7
8	No desiccant			54.6	23.0	26.3
9	Finalsan	Spotlight		57.6	16.2	11.5
10	Spotlight	Gozai	Spotlight	48.8	11.2	10.7
11	Saltex	Spotlight		56.5	13.1	13.0
S.E.	(30 D.F.)			3.77	2.42	1.12
	No desiccant			54.6	23.0	26.3
	Reglone			43.6	11.4	8.8
	Finalsan			57.6	16.2	11.5
	Spotlight/Gozai			50.3	11.5	10.8
	Flail			54.7	12.0	12.1
	Saltex			56.5	13.1	13.0

Table 21. Expt 4 JHI East Pilmore, Dundee skinset (proportion of skin removed in cement mixer, %) at different time periods following T1

	T1	T2	T3	Date
Treat	(30 Jul)	(6 Aug)	(13 Aug)	21-Aug
1	Reglone	Reglone		30.7
2	Flail+Spotlight			24.8
3	Flail+Spotlight+Gozai			23.3
4	Gozai	Spotlight		30.6
5	Spotlight	Gozai		33.9
6	Spotlight+Gozai	Spotlight+Gozai		25.6
7	Finalsan	Spotlight		33.3
8	No desiccant			47.8
9	Spotlight	Gozai	Spotlight	33.6
10	Haulm puller			19.4
S.E.	(27 D.F.)			4.00
	No desiccant			47.8
	Reglone			30.7
	Finalsan			33.3
	Spotlight/Gozai			30.9
	Flail/haulm pulling			22.5

Table 22. Expt 5 JHI East Pilmore, Dundee skinset (proportion of skin removed in cement mixer, %) at different time periods following T1

	T1	T2	T3	Date
Treat	(10 Sep)	(17 Sep)	(24 Sep)	1 Oct
1	Reglone	Reglone		33.6
2	Flail+Spotlight			26.4
3	Flail+Spotlight+Gozai			21.7
4	Gozai	Spotlight		34.2
5	Spotlight	Gozai		37.7
6	Spotlight+Shinkon	Gozai+Shinkon		36.9
7	Spotlight+Gozai	Spotlight+Gozai		40.8
8	No desiccant			38.7
9	Finalsan	Spotlight		39.4
10	Spotlight	Gozai	Spotlight	32.9
11	Saltex	Spotlight		29.4
S.E.	(30 D.F.)			3.74
	No desiccant			38.7
	Reglone			33.6
	Finalsan			39.4
	Spotlight/Gozai			36.5
	Flail			24.0
	Saltex			29.4

In Demo 1, skinset was rapid (15 days to skinset), with all chemical and mechanical defoliation treatments being similar (Table 23). Undefoliated crops were skinset only 4-5 days after crops which were defoliated.

In Demo 2, because of the lack of replication, only inferences can be made. Reglone had numerically the best skinset of the chemical treatments, but flail treatments were slowest to skinset (Table 24). Skins were still not set sufficiently to harvest 3 weeks after T1 and would have taken another 7 days to set at the rate measured between 21 and 28 August.

Table 23. Demo 1 Dillington Estate, Somerset skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (unreplicated)

	T1	T2	T3	Date		
Treat	(12 Aug)	(19 Aug)	(26 Aug)	27 Aug	3 Sep	10 Sep
1	Reglone	Reglone		13.9	3.3	0.1
2	Flail+Spotlight			13.9	3.7	0.0
3	Flail+Spotlight+Gozai			12.8	3.6	0.0
4	Gozai	Spotlight		15.2	3.7	0.0
5	Spotlight	Gozai		14.2	3.3	0.1
6	Spotlight+Shinkon	Gozai+Shinkon		15.2	3.5	0.0
7	Spotlight+Gozai	Spotlight+Gozai		13.0	3.3	0.0
8	No desiccant			28.2	5.6	0.6
9	Finalsan	Spotlight		14.2	3.9	0.1
10	Spotlight	Gozai	Spotlight	15.4	4.2	0.0
11	Saltex	Spotlight		14.9	4.1	0.0
	No desiccant			28.2	5.6	0.6
	Reglone			13.9	3.3	0.1
	Finalsan			14.2	3.9	0.1
	Spotlight/Gozai			14.6	3.6	0.0
	Flail			13.4	3.7	0.0
	Saltex			14.9	4.1	0.0

Table 24. Demo 2 Heal Farms, Shropshire skinset (proportion of skin removed in cement mixer, %) at different time periods following T1 (unreplicated)

	T1	T2	T3	Date	
Treat	(7 Aug)	(13 Aug)	(21 Aug)	21 Aug	28 Aug
1	Reglone	Reglone		49.3	27.3
2	Flail+Spotlight			54.3	42.5
3	Flail+Spotlight+Gozai			69.1	41.5
4	Gozai	Spotlight		67.8	37.7
5	Spotlight	Gozai		62.3	41.4
6	Spotlight+Shinkon	Gozai+Shinkon		62.2	41.1
7	Spotlight+Gozai	Spotlight+Gozai		67.8	40.0
8	No desiccant			64.4	60.5
9	Finalsan	Spotlight		61.6	36.2
10	Spotlight	Gozai	Spotlight	68.9	35.9
11	Saltex	Spotlight		53.9	34.5
	No desiccant			64.4	60.5
	Reglone			49.3	27.3
	Finalsan			61.6	36.2
	Spotlight/Gozai			65.8	39.2
	Flail			61.7	42.0
	Saltex			53.9	34.5

Whilst there was no significant effect between chemical or mechanical treatments in terms of skinset at 3 weeks post-T1 in individual experiments, when combining all similar treatments across experiments and demonstrations, there was a slight advantage for Reglone, Saltex and mechanical treatments compared with Spotlight, Gozai and Finalsan, which would amount to a harvest-acceptable skinset being reached 1-2 days earlier (Table 25).

Table 25. Summary of skinset at 3 weeks post-T1 (mean of all experiments and demonstrations)

Treatment	Skinning (% SA)
Control (None)	33.0
Reglone	19.9
Finalsan	23.8
Spotlight/Gozai	22.9
Flail/haulm pulling	19.7
(Saltex)†	(16.4)†

†Five trials only

4.5. Yield and crop quality at final harvest

4.5.1. Yield

Anecdotal evidence suggests that ‘passive bulking’ takes 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 Reglone, flail, haulm-pulling, Saltex, Spotlight and Gozai, suggesting that bulking ceased quickly and similarly across these treatments. The yield loss with Finalsan was smaller (*c.* 5 t/ha) and this could reflect the slower leaf kill with this chemical. The yield data are presented in Table 26 to Table 32.

4.5.2. Internal defects and stolon detachment

The incidence and severity of internal defects (vascular browning and stem-end necrosis) was low and related to variety. With the exception of Expt 5, there was no effect of defoliation method, chemical or timing on internal defects (Table 26 to Table 32). In Expt 5, flail treatments had less vascular staining than the undefoliated, Saltex and three-application Spotlight/Gozai/Spotlight mix (Table 30). There was no obvious explanation for this effect.

Stolon detachment was not a problem in most trials, but there were some cases of adhesion in Royal (Expt 3) and the seed crop of Maris Piper (Expt 5). There was less attachment in undefoliated crops compared with defoliated, indicating that whilst defoliation may advance stolon death, it may not do so where it attaches to the tuber. Stolon plug removal was only observed to a significant extent in Expt 5 (Table 30).

Table 26. Expt 1 Eastoft Farm, Lincolnshire final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%)

Treat	T1 (1 Aug)	T2 (7 Aug)	T3 (14 Aug)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		47.4	1.3	0.3	0.0
2	Flail+Spotlight			45.7	1.8	1.0	0.0
3	Flail+Spotlight+Gozai			51.5	0.8	0.3	0.0
4	Gozai	Spotlight		49.8	2.5	0.0	0.3
5	Spotlight	Gozai		49.1	1.5	0.3	0.0
6	Spotlight+Gozai	Spotlight+Gozai		47.9	1.5	0.8	0.0
7	Finalsan	Spotlight		51.8	1.3	0.0	0.0
8	No desiccant			60.0	1.5	0.0	0.0
9	Spotlight	Gozai	Spotlight	43.9	1.5	0.8	0.0
10	Haulm puller			49.9	1.3	0.0	0.0
S.E.	(27 D.F.)			3.06	0.50	0.28	0.11
	No desiccant			60.0	1.5	0.0	0.0
	Reglone			47.4	1.3	0.3	0.0
	Finalsan			51.8	1.3	0.0	0.0
	Spotlight/Gozai			47.7	1.8	0.5	0.1
	Flail/haulm pulling			49.0	1.3	0.4	0.0

Table 27. Expt 2 Eastoft Farm, Lincolnshire final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%)

Treat	T1 (5 Sep)	T2 (12 Sep)	T3 (19 Sep)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		53.5	2.3	0.0	0.3
2	Flail+Spotlight			57.1	1.5	0.8	0.3
3	Flail+Spotlight+Gozai			55.8	1.0	0.0	0.0
4	Gozai	Spotlight		52.7	2.5	0.5	0.3
5	Spotlight	Gozai		54.0	1.3	1.3	0.0
6	Spotlight+Shinkon	Gozai+Shinkon		56.9	1.3	0.5	0.0
7	Spotlight+Gozai	Spotlight+Gozai		55.9	2.0	0.5	0.0
8	No desiccant			64.6	1.3	0.8	0.0
9	Finalsan	Spotlight		56.7	1.5	0.0	0.1
10	Spotlight	Gozai	Spotlight	58.7	1.5	0.0	0.3
11	Saltex	Spotlight		58.5	1.5	0.5	0.0
S.E.	(30 D.F.)			3.95	0.52	0.34	0.10
	No desiccant			64.5	1.3	0.8	0.0
	Reglone			53.5	2.3	0.0	0.3
	Finalsan			56.7	1.5	0.0	0.1
	Spotlight/Gozai			55.6	1.7	0.5	0.1
	Flail			56.5	1.3	0.4	0.1
	Saltex			58.5	1.5	0.5	0.0

Table 28. Expt 3 Elveden Farms, Suffolk final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%)

Treat	T1 (4 Sep)	T2 (11 Sep)	T3 (18 Sep)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		68.3	26.0	3.0	3.0
2	Flail+Spotlight			62.9	27.0	3.0	1.0
3	Flail+Spotlight+Gozai			65.3	34.0	1.0	0.0
4	Gozai	Spotlight		66.5	28.0	1.0	0.0
5	Spotlight	Gozai		72.6	27.0	2.0	2.0
6	Spotlight+Shinkon	Gozai+Shinkon		69.4	27.0	3.0	0.0
7	Spotlight+Gozai	Spotlight+Gozai		68.1	25.0	2.0	1.0
8	No desiccant			78.6	28.0	0.0	0.0
9	Finalsan	Spotlight		68.3	31.0	1.0	0.0
10	Spotlight	Gozai	Spotlight	72.5	32.0	4.0	2.0
11	Saltex	Spotlight		72.2	27.0	2.0	0.0
S.E.	(30 D.F.)			3.64	3.47	1.17	0.71
	No desiccant			78.6	28.0	0.0	0.0
	Reglone			68.3	26.0	3.0	3.0
	Finalsan			68.3	31.0	1.0	0.0
	Spotlight/Gozai			69.8	27.8	2.4	1.0
	Flail			64.1	30.5	2.0	0.5
	Saltex			72.2	27.0	2.0	0.0

Table 29. Expt 4 JHI East Pilmore, Dundee final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%)

Treat	T1 (30 Jul)	T2 (6 Aug)	T3 (13 Aug)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		26.0	6.5	1.5	6.5
2	Flail+Spotlight			27.5	8.5	1.5	8.5
3	Flail+Spotlight+Gozai			28.4	7.5	3.0.	8.0
4	Gozai	Spotlight		29.4	1.5	1.5	5.5
5	Spotlight	Gozai		30.7	4.5	1.0	8.0
6	Spotlight+Gozai	Spotlight+Gozai		26.3	5.0	2.0	6.5
7	Finalsan	Spotlight		27.1	6.0	2.5	10.0
8	No desiccant			34.7	3.5	0.5	5.5
9	Spotlight	Gozai	Spotlight	30.4	4.5	0.5	7.0
10	Haulm puller			23.2	5.0	1.5	5.0
S.E.	(27 D.F.)			2.35	1.62	1.02	2.70
	No desiccant			34.7	3.5	0.5	5.5
	Reglone			26.0	6.5	1.5	6.5
	Finalsan			27.1	6.0	2.5	10.0
	Spotlight/Gozai			29.2	3.9	1.3	6.8
	Flail/haulm pulling			26.4	7.0	2.06	7.2

Table 30. Expt 5 JHI East Pilmore, Dundee final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%)

Treat	T1 (10 Sep)	T2 (17 Sep)	T3 (24 Sep)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		53.2	22.8	2.6	9.0
2	Flail+Spotlight			50.9	17.7	5.0	9.5
3	Flail+Spotlight+Gozai			51.0	18.9	3.6	11.5
4	Gozai	Spotlight		50.5	26.5	2.1	5.5
5	Spotlight	Gozai		50.2	28.5	4.1	8.5
6	Spotlight+Shinkon	Gozai+Shinkon		50.6	23.6	10.4	16.0
7	Spotlight+Gozai	Spotlight+Gozai		48.8	23.5	4.5	8.0
8	No desiccant			56.4	33.4	3.4	14.5
9	Finalsan	Spotlight		53.7	20.6	3.8	8.0
10	Spotlight	Gozai	Spotlight	54.3	30.0	3.5	9.0
11	Saltex	Spotlight		50.5	35.5	2.7	7.0
S.E.	(30 D.F.)			2.52	3.79†	1.70†	2.07
	No desiccant			56.4	33.4	3.4	14.5
	Reglone			53.2	22.8	2.6	9.0
	Finalsan			53.7	20.6	3.8	8.0
	Spotlight/Gozai			50.9	26.4	4.9	9.4
	Flail			50.9	18.3	4.3	10.5
	Saltex			50.5	35.5	2.7	7.0

†29 D.F.

Table 31. Demo 1 Dillington Estate, Somerset final tuber yield (t/ha) and incidence of vascular staining, stem end necrosis and stolon plug removal (%, unreplicated)

Treat	T1 (12 Aug)	T2 (19 Aug)	T3 (26 Aug)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		61.3	0.0	1.0	0.0
2	Flail+Spotlight			58.5	0.0	3.0	0.0
3	Flail+Spotlight+Gozai			59.9	0.0	0.0	0.0
4	Gozai	Spotlight		72.5	0.0	2.0	2.0
5	Spotlight	Gozai		71.4	0.0	0.0	0.0
6	Spotlight+Shinkon	Gozai+Shinkon		58.7	0.0	0.0	0.0
7	Spotlight+Gozai	Spotlight+Gozai		62.3	0.0	3.0	0.0
8	No desiccant			71.3	0.0	2.0	1.0
9	Finalsan	Spotlight		71.0	0.0	1.0	0.0
10	Spotlight	Gozai	Spotlight	57.8	0.0	0.0	0.0
11	Saltex	Spotlight		57.7	0.0	2.0	0.0
	No desiccant			71.3	0.0	2.0	1.0
	Reglone			61.3	0.0	1.0	0.0
	Finalsan			71.0	0.0	1.0	0.0
	Spotlight/Gozai			64.5	0.0	1.0	0.4
	Flail			59.2	0.0	1.5	0.0
	Saltex			57.7	0.0	2.0	0.0

Table 32. Demo 2 Heal Farms, Shropshire final tuber yield (t/ha) and incidence (%) of vascular staining, stem end necrosis and stolon plug removal (%, unreplicated)

Treat	T1 (7 Aug)	T2 (13 Aug)	T3 (21 Aug)	Yield	Vasc. staining	Stem end necrosis	Stolon plug
1	Reglone	Reglone		41.6	28.0	0.0	2.0
2	Flail+Spotlight			54.1	30.0	0.0	6.0
3	Flail+Spotlight+Gozai			47.5	76.0	0.0	4.0
4	Gozai	Spotlight		49.8	8.0	2.0	4.0
5	Spotlight	Gozai		47.5	30.0	0.0	8.0
6	Spotlight+Shinkon	Gozai+Shinkon		49.9	72.0	0.0	4.0
7	Spotlight+Gozai	Spotlight+Gozai		51.8	56.0	2.0	4.0
8	No desiccant			57.1	12.0	0.0	4.0
9	Finalsan	Spotlight		55.7	20.0	0.0	4.0
10	Spotlight	Gozai	Spotlight	49.0	24.0	0.0	0.0
11	Saltex	Spotlight		38.4	10.0	0.0	4.0
	No desiccant			57.1	12.0	0.0	4.0
	Reglone			41.6	28.0	0.0	2.0
	Finalsan			55.7	20.0	0.0	4.0
	Spotlight/Gozai			49.6	38.0	0.8	4.0
	Flail			50.8	53.0	0.0	5.0
	Saltex			38.4	10.0	0.0	4.0

4.5.3. Rotting and surface blemishing diseases

There were virtually no rots (blight or other) at harvest in any trial and post-storage assessments found only 0.4 % of tubers with rot symptoms. There were no defoliation treatment effects in any experiment or demonstration (data not shown). The surface blemishing diseases black dot and black scurf were generally low and unaffected by treatment. Samples destined for storage at Demonstration 2 were lost and no storage disease data was collected.

In Expts 1, 3, 4 and 5, there were no effects of defoliation treatment on surface blemishing diseases (Table 33, Table 35, Table 36, Table 37). Most levels of disease were low after storage, but the Royal in Expt 3 had much greater severity of infection of black dot. In Expt 2, there was an odd effect of Finalsan having a significantly higher severity of black dot than other treatments (Table 34).

Table 33. Expt 1 Eastoft Farm, Lincolnshire severity (% surface area affected) of surface blemishing diseases after storage

Treat	T1 (1 Aug)	T2 (7 Aug)	T3 (14 Aug)	Black dot	Black scurf
1	Reglone	Reglone		0.35	0.0
2	Flail+Spotlight			0.68	0.0
3	Flail+Spotlight+Gozai			0.40	0.0
4	Gozai	Spotlight		0.56	0.0
5	Spotlight	Gozai		0.50	0.0
6	Spotlight+Gozai	Spotlight+Gozai		0.28	0.0
7	Finalsan	Spotlight		0.54	0.0
8	No desiccant			0.16	0.0
9	Spotlight	Gozai	Spotlight	0.40	0.0
10	Haulm puller			0.90	0.0
S.E.	(27 D.F.)			0.256	-
	No desiccant			0.16	0.0
	Reglone			0.35	0.0
	Finalsan			0.54	0.0
	Spotlight/Gozai			0.44	0.0
	Flail/haulm pulling			0.66	0.0

Table 34. Expt 2 Eastoft Farm, Lincolnshire severity (% surface area affected) of surface blemishing diseases after storage

Treat	T1 (5 Sep)	T2 (12 Sep)	T3 (19 Sep)	Black dot	Black scurf
1	Reglone	Reglone		4.9	0.0
2	Flail+Spotlight			4.1	0.0
3	Flail+Spotlight+Gozai			6.7	0.0
4	Gozai	Spotlight		6.7	0.0
5	Spotlight	Gozai		4.4	0.0
6	Spotlight+Shinkon	Gozai+Shinkon		3.7	0.0
7	Spotlight+Gozai	Spotlight+Gozai		5.5	0.0
8	No desiccant			7.9	0.0
9	Finalsan	Spotlight		16.8	0.0
10	Spotlight	Gozai	Spotlight	5.5	0.0
11	Saltex	Spotlight		8.5	0.0
S.E.	(30 D.F.)			1.70	0.01
	No desiccant			7.9	0.0
	Reglone			4.9	0.0
	Finalsan			16.8	0.0
	Spotlight/Gozai			5.2	0.0
	Flail			5.4	0.0
	Saltex			8.5	0.0

Table 35. Expt 3 Elveden Farms, Suffolk severity (% surface area affected) of surface blemishing diseases after storage

Treat	T1 (4 Sep)	T2 (11 Sep)	T3 (18 Sep)	Black dot	Black scurf
1	Reglone	Reglone		30.0	0.0
2	Flail+Spotlight			23.0	0.0
3	Flail+Spotlight+Gozai			25.0	0.0
4	Gozai	Spotlight		26.0	0.0
5	Spotlight	Gozai		26.5	0.0
6	Spotlight+Shinkon	Gozai+Shinkon		28.0	0.0
7	Spotlight+Gozai	Spotlight+Gozai		29.0	0.0
8	No desiccant			29.5	0.0
9	Finalsan	Spotlight		20.5	0.0
10	Spotlight	Gozai	Spotlight	22.0	0.0
11	Saltex	Spotlight		29.5	0.0
S.E.	(30 D.F.)			2.99	-
	No desiccant			29.5	0.0
	Reglone			30.0	0.0
	Finalsan			20.5	0.0
	Spotlight/Gozai			26.3	0.0
	Flail			24.0	0.0
	Saltex			29.5	0.0

Table 36. Expt 4 JHI East Pilmore, Dundee severity (% surface area affected) of surface blemishing diseases after storage

Treat	T1 (30 Jul)	T2 (6 Aug)	T3 (13 Aug)	Black dot	Black scurf
1	Reglone	Reglone		0.50	0.0
2	Flail+Spotlight			0.00	0.0
3	Flail+Spotlight+Gozai			0.25	0.0
4	Gozai	Spotlight		0.30	0.0
5	Spotlight	Gozai		0.25	0.0
6	Spotlight+Gozai	Spotlight+Gozai		0.00	0.0
7	Finalsan	Spotlight		0.00	0.0
8	No desiccant			0.00	0.0
9	Spotlight	Gozai	Spotlight	0.25	0.0
10	Haulm puller			0.25	0.0
S.E.	(27 D.F.)			0.206	-
	No desiccant			0.00	0.0
	Reglone			0.50	0.0
	Finalsan			0.00	0.0
	Spotlight/Gozai			0.40	0.0
	Flail/haulm pulling			0.17	0.0

Table 37. Expt 5 JHI East Pilmore, Dundee severity (% surface area affected) of surface blemishing diseases after storage

Treat	T1 (10 Sep)	T2 (17 Sep)	T3 (24 Sep)	Black dot	Black scurf
1	Reglone	Reglone		1.19	0.0
2	Flail+Spotlight			0.90	0.0
3	Flail+Spotlight+Gozai			1.12	0.0
4	Gozai	Spotlight		0.90	0.0
5	Spotlight	Gozai		1.21	0.0
6	Spotlight+Shinkon	Gozai+Shinkon		1.44	0.0
7	Spotlight+Gozai	Spotlight+Gozai		1.08	0.0
8	No desiccant			0.95	0.0
9	Finalsan	Spotlight		0.71	0.0
10	Spotlight	Gozai	Spotlight	1.12	0.0
11	Saltex	Spotlight		1.25	0.0
S.E.	(30 D.F.)			0.150	-
	No desiccant			0.95	0.0
	Reglone			1.19	0.0
	Finalsan			0.71	0.0
	Spotlight/Gozai			1.15	0.0
	Flail			1.01	0.0
	Saltex			1.25	0.0

There was no incidence of black dot or black scurf at harvest in Demo 1 (data not shown). No samples were consequently stored for later assessment. The incidence of both black dot and black scurf in Demo 2 was high at harvest, and there was large variation in black scurf between similar treatments, but it is unlikely that these were related to desiccation treatment (Table 38). Unfortunately, the samples destined for storage assessment from Demo 2 were lost in transit.

Table 38. Demo 2 Heal Farms, Shropshire incidence (%) of surface blemishing diseases at harvest

Treat	T1 (10 Sep)	T2 (17 Sep)	T3 (24 Sep)	Black dot	Black scurf
1	Reglone	Reglone		86	80
2	Flail+Spotlight			56	82
3	Flail+Spotlight+Gozai			66	74
4	Gozai	Spotlight		72	28
5	Spotlight	Gozai		56	74
6	Spotlight+Shinkon	Gozai+Shinkon		70	4
7	Spotlight+Gozai	Spotlight+Gozai		78	66
8	No desiccant			74	36
9	Finalsan	Spotlight		70	0
10	Spotlight	Gozai	Spotlight	72	54
11	Saltex	Spotlight		64	6
	No desiccant			74	36
	Reglone			86	80
	Finalsan			70	0
	Spotlight/Gozai			70	45
	Flail			61	78
	Saltex			64	6

4.5.4. Germination

Germination tests were performed on the two seed experiments (Expt 1 and Expt 4) following storage. All tubers germinated successfully and produced a viable sprout. There were no effects of desiccation treatments on the germination performance in either experiment (Table 39).

Table 39. Expt 1 (Eastoft Farm, Lincolnshire) and Expt 4 (JHI East Pilmore, Dundee) germination (days to 100 % germination from placement at 16 °C) after storage at 3 °C

Treat	T1	T2	T3	Expt 1	Expt 4
1	Reglone	Reglone		17.5	22.3
2	Flail+Spotlight			17.8	22.3
3	Flail+Spotlight+Gozai			17.5	24.8
4	Gozai	Spotlight		17.8	26.0
5	Spotlight	Gozai		19.3	24.8
6	Spotlight+Gozai	Spotlight+Gozai		20.3	25.0
7	Finalsan	Spotlight		19.3	24.5
8	No desiccant			19.5	24.8
9	Spotlight	Gozai	Spotlight	17.5	23.5
10	Haulm puller			17.8	23.5
S.E.	(27 D.F.)			1.83	1.22
	No desiccant			19.5	24.8
	Reglone			17.5	22.3
	Finalsan			19.3	24.5
	Spotlight/Gozai			18.7	24.8
	Flail/haulm pulling			17.7	23.5

5. CONCLUSIONS

Flail and haulm-pulling produced instant leaf removal, but stems were difficult to cut to the required length on the indeterminate variety Royal, slowing stem desiccation. There was no regrowth from flail or haulm-pulled treatments at the sites in England, but some did occur at the site in Scotland, particularly the seed experiment. With the soils generally being wet at T1, there was significant soil compaction in the wheeled furrows and edges of ridges following flailing, particularly on the silty clay loam soils. The level of compaction observed would increase the risk of bruising at harvest owing to clods.

As might be expected, Reglone was most effective chemical in removing leaves, but Saltex was as effective as Reglone under hotter, brighter conditions and there was rapid leaf wilting in most experiments with the volume of Saltex applied. The protoporphyrinogen oxidase (PPO) desiccants, Spotlight and Gozai were both similar in terms of leaf kill, but in general these PPO products (applied individually or in combination) were 2-4 days slower in killing leaves than Reglone. However, they were more than 7 days slower than Reglone in the seed experiment in Scotland, despite being desiccated in July when the weather was bright and warm. There was no advantage of one PPO product over the other and tank mixes were not additive in their effects. There was also no advantage in using one PPO in sequence with the other or the order of application. Most chemical treatment received two applications and no benefits were noted from a third application 2 weeks after the initial one. There is more work to be done on application of the PPO desiccants to improve their efficacy, e.g. time of application during the day, time between sequential applications based on canopy death rather than fixed days, water volumes, etc. Gozai treatments, upon recommendation of the manufacturer, were applied with the adjuvant Toil. Using the fungicide Ranman (which contains a wetter) did not alter the speed of kill of canopy compared with a non-wetter containing fungicide (Shinkon).

Finalsan (pelargonic acid) was the slowest to act on leaves and stems across all experiments and plots with this treatment often had some leaf area left when skins were close to setting. Allowing leaf material to remain or the slow death of leaves is clearly a risk for late blight, particularly tuber infection, so growers must be aware of the consequences of the slower kill in relation to blight control programmes.

There were greater varietal differences in speed of desiccation of stems than leaves, but the efficacy of different chemicals followed the same pattern as for leaf death.

Despite the differences in canopy death across treatments, there were only small differences in the time taken from initial defoliation until the tubers were judged suitable for harvesting. Leaving the crop to grow on slowed the achievement of adequate skinset for harvesting, but chemical or mechanical treatments did not always have an immediate effect on skinset 2 weeks after the initial spray or mechanical treatment. Taken across all experiments and demonstration, Spotlight/Gozai combinations were slightly worse in terms of skinset 3 weeks post-T1 compared with Reglone, flail or haulm-pulling, but this would only equate to 1-3 days delay in reaching skinset suitable for harvesting. Haulm pulling in the two seed experiments resulted in the fastest skinset, with flail intermediate between pulling and chemical (but not significantly different to either). Where the crops were defoliated when canopies were just beginning to senesce naturally, skinset was rapid, in some cases within 2 weeks. This is clearly the target for nitrogen and irrigation management, so that skinset is achieved as rapidly as possible. The two seed crops were only skinset after 4 weeks.

Plots that were left to grow on without defoliation increased in yield by 8-10 t/ha in 3 weeks compared with plots which were desiccated or flailed. There was no evidence to support large differences in 'passive bulking' (yield increase after T1 applications) between chemical treatments, but flail and haulm-pulling caused an immediate cessation in bulking.

The incidence and severity of vascular browning, stem-end necrosis and stolon adhesion was low and related to variety. There was no effect of defoliation method, chemical or timing on these variables. Similarly, there was no effect of defoliation treatment on rotting or blemishing diseases at harvest or after storage, nor on the viability or rate of sprouting in seed stocks placed under conducive conditions for sprouting.

In should be noted that these results, albeit from multi-site experiments of similar design and a range of indeterminate, vigorous canopy cultivars, 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 2019. A tender has been issued by AHDB for further work in 2020 examining PPO and Saltex desiccants in combination with standard RB209 and reduced nitrogen fertilizer rates.

6. REFERENCES

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

7. KNOWLEDGE TRANSFER ACTIVITIES

Presentations

- AHDB SPot North Field Walk, Eastoft, 6th June 2019
- AHDB SPot North Open Day, Eastoft, 16th July 2019
- Branston Field Day, Eastoft, 15th August 2019
- AHDB SPot North Field Walk, Eastoft, 5th September 2019
- AIPC SPot North Field Walk, Eastoft, 6th September 2019
- AHDB Elveden Field Walk, Elveden, 17th September 2019
- AHDB Agronomists Conference, Leicester, 4th December 2019
- CUPGRA Conference Workshop, Cambridge, 16th December 2019
- AHDB SPot East Results Day, Newmarket, 8th January 2020
- AHDB Winter Forum, Escrick, 23rd January 2020
- AHDB Winter Forum, Knutsford, 18th February 2020

Press

- What potato growers need to consider before diquat is banned, Adam Clarke, Farmers Weekly, June 2019
- Non-flail potato desiccation still viable post-diquat, Adam Clarke, Farmers Weekly, September 2019
- Desiccation without diquat, AHDB Grower Gateway, November 2019
- Theory to Field, Lucy de la Pasture, CPM, June 2020

AHDB Potatoes Website

- Online (Skype-enabled) Desiccation Discussion, 27 August 2019
- Desiccation 2020- what to consider before you plant, 31 January 2020
- The cost of desiccation without diquat, 31 January 2020

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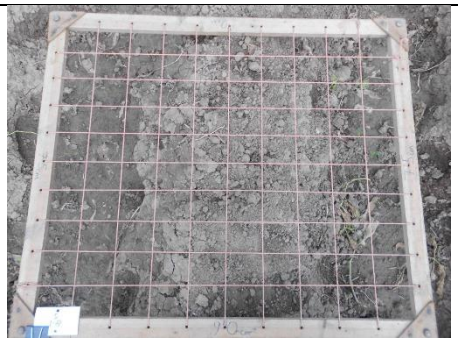
9. APPENDIX 1

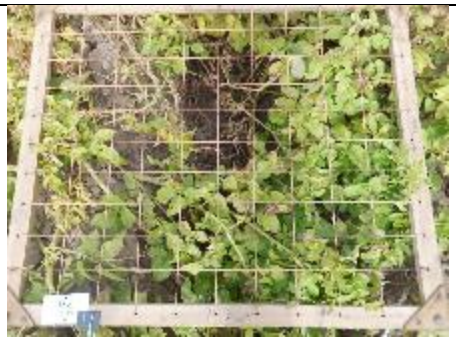
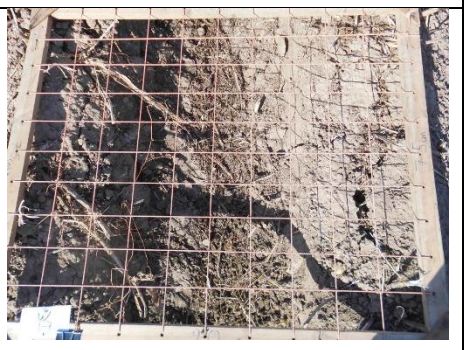
Photographic images of the representative plots for each treatment at each sample date are shown in the Figures below.

Figure 2. Expt 1 photographs of ground cover

1 Aug Pre-T1		1 Aug Post-flail	
1 Aug Post-haulm-pulling			
7 Aug Control		7 Aug Flail	
7 Aug Haulm-puller		7 Aug Reglone	

7 Aug Spotlight /Gozai		7 Aug Finalsan	
14 Aug Control		14 Aug Flail	
14 Aug Haulm-puller		14 Aug Reglone	
14 Aug Spotlight /Gozai		14 Aug Finalsan	

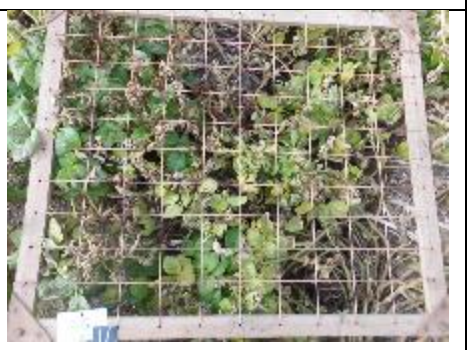
Figure 3. Expt 2 photographs of ground cover

5 Sep Pre-T1		5 Sep Post-flail	
12 Sep Control		12 Sep Flail	
12 Sep Reglone		12 Sep Spotlight /Gozai	
12 Sep Finalsan		12 Sep Saltex	
19 Sep Control		19 Sep Flail	

19 Sep Reglone		19 Sep Spotlight /Gozai	
19 Sep Finalsan		19 Sep Saltex	

Figure 4. Expt 3 photographs of ground cover

4 Sep Pre-T1		4 Sep Post-flail	
11 Sep Control		11 Sep Flail	

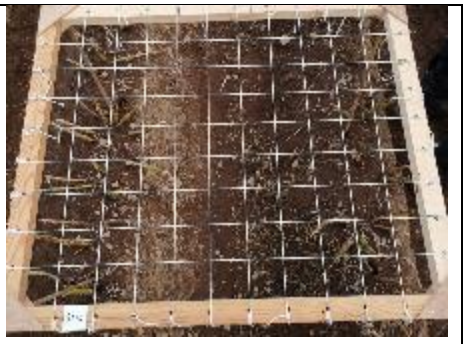
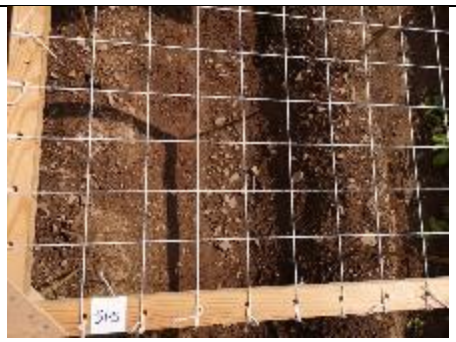
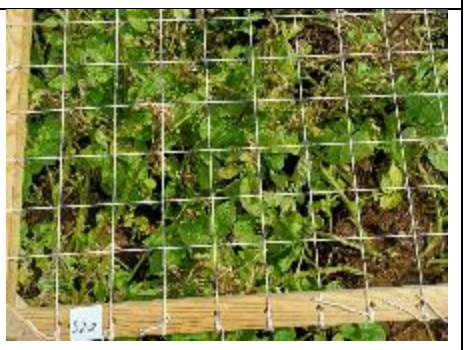
11 Sep Reglone		11 Sep Spotlight /Gozai	
11 Sep Finalsan		11 Sep Saltex	
18 Sep Control		18 Sep Flail	

18 Sep Reglone		18 Sep Spotlight /Gozai	
18 Sep Finalsan		18 Sep Saltex	

25 Sep Control		25 Sep Flail	
25 Sep Reglone		25 Sep Spotlight /Gozai	
25 Sep Finalsan		25 Sep Saltex	

Figure 5. Expt 4 photographs of ground cover

31 Jul Pre-T1			

13 Aug Control		13 Aug Flail	
13 Aug Haulm-puller		13 Aug Reglone	
13 Aug Spotlight /Gozai		13 Aug Finalsan	
21 Aug Control		21 Aug Flail	
21 Aug Haulm-puller		21 Aug Reglone	

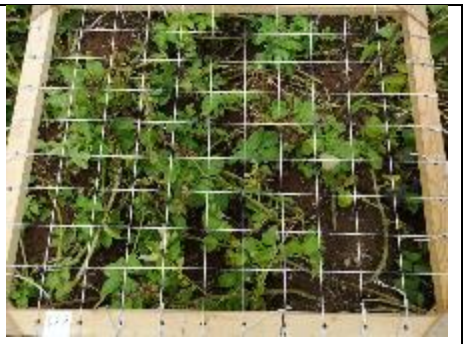
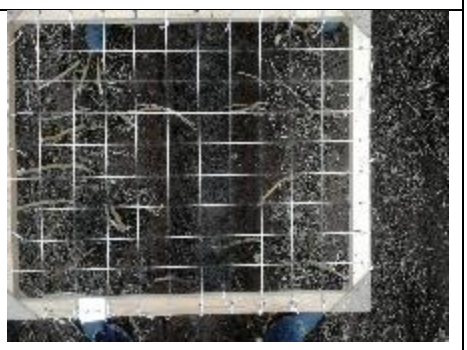
21 Aug Spotlight /Gozai		21 Aug Finalsan	

Figure 6. Expt 5 photographs of ground cover

10 Sep Pre-T1			
17 Sep Control		17 Sep Flail	
17 Sep Reglone		17 Sep Spotlight /Gozai	

17 Sep Finalsan		17 Sep Saltex	
24 Sep Control		24 Sep Flail	
24 Sep Reglone		24 Sep Spotlight /Gozai	
24 Sep Finalsan		24 Sep Saltex	
1 Oct Control		1 Oct Flail	

1 Oct Reglone		1 Oct Spotlight /Gozai	
1 Oct Finalsan		1 Oct Saltex	

Figure 7. Demo 1 photographs of ground cover

12 Aug Pre-T1		12-Aug Post-flail	
19 Aug Control		19 Aug Flail	

19 Aug Reglone		19 Aug Spotlight /Gozai	
19 Aug Finalsan		19 Aug Saltex	
26 Aug Control		26 Aug Flail	

26 Aug Reglone		26 Aug Spotlight /Gozai	
26 Aug Finalsan		26 Aug Saltex