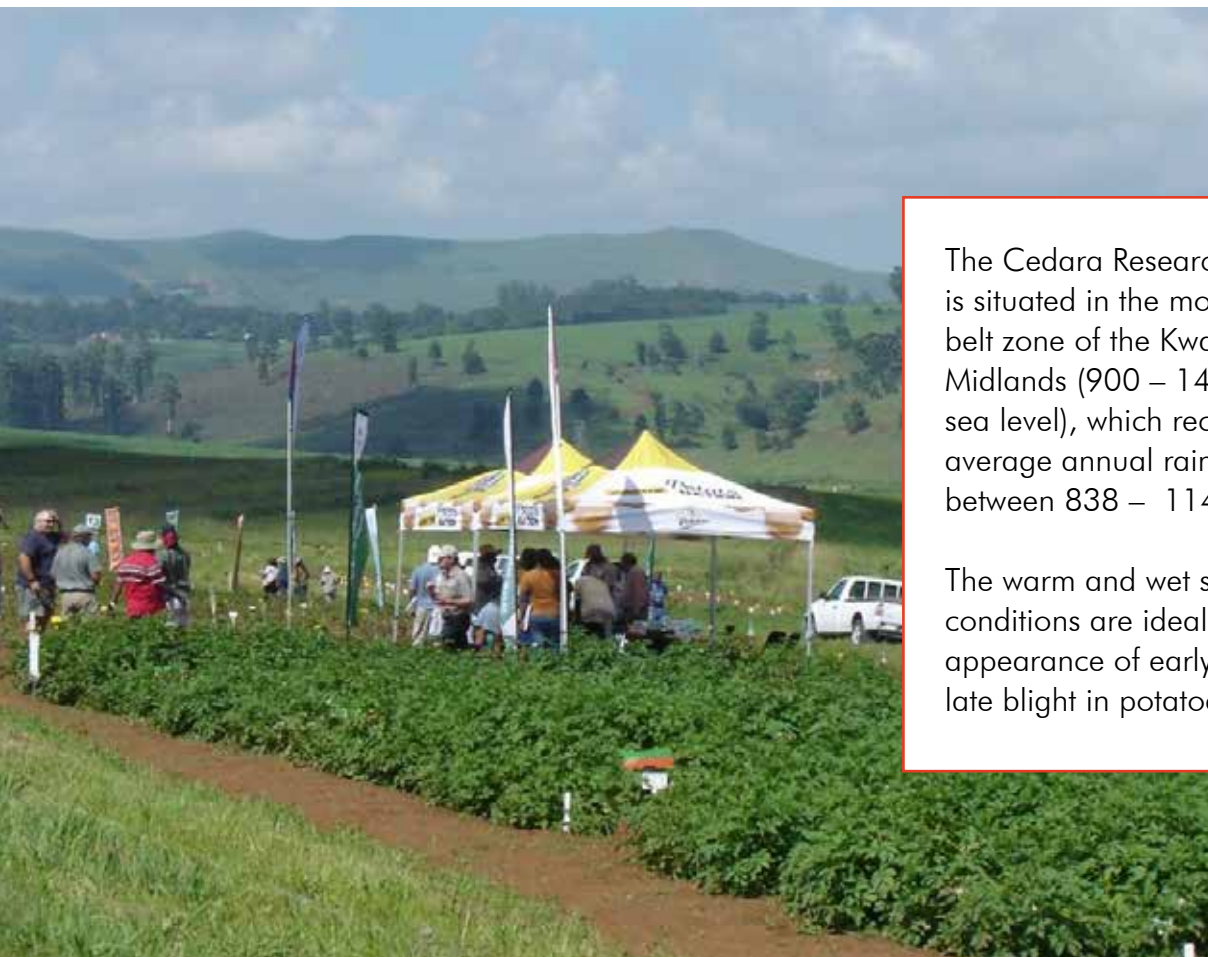


Effect of fungicide application on potato cultivars at Cedara

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The Cedara Research Station is situated in the moist mist-belt zone of the KwaZulu-Natal Midlands (900 – 1400 m above sea level), which receives an average annual rainfall of between 838 – 1140 mm.

The warm and wet summer conditions are ideal for the appearance of early blight and late blight in potatoes.

The severity of these diseases, especially late blight, can cause up to 100% crop loss if fungicides are not applied regularly. As a result, seed and table producers will incur large financial losses, whilst small-holder farmers, who do not always have the resources to purchase fungicides, could become food insecure if their crop fails. A solution for small-holder farmers is to grow cultivars with good tolerance to late blight.

A trial was conducted in the 2019/20 growing-season at the Cedara Research Station to identify cultivars with tolerance to late blight. Eighteen cultivars were evaluated under irrigation using a split-plot randomized complete block design with three replicates. The cultivar was the main plot, which was split into fungicide application and no fungicide application. Fungicide application was conducted

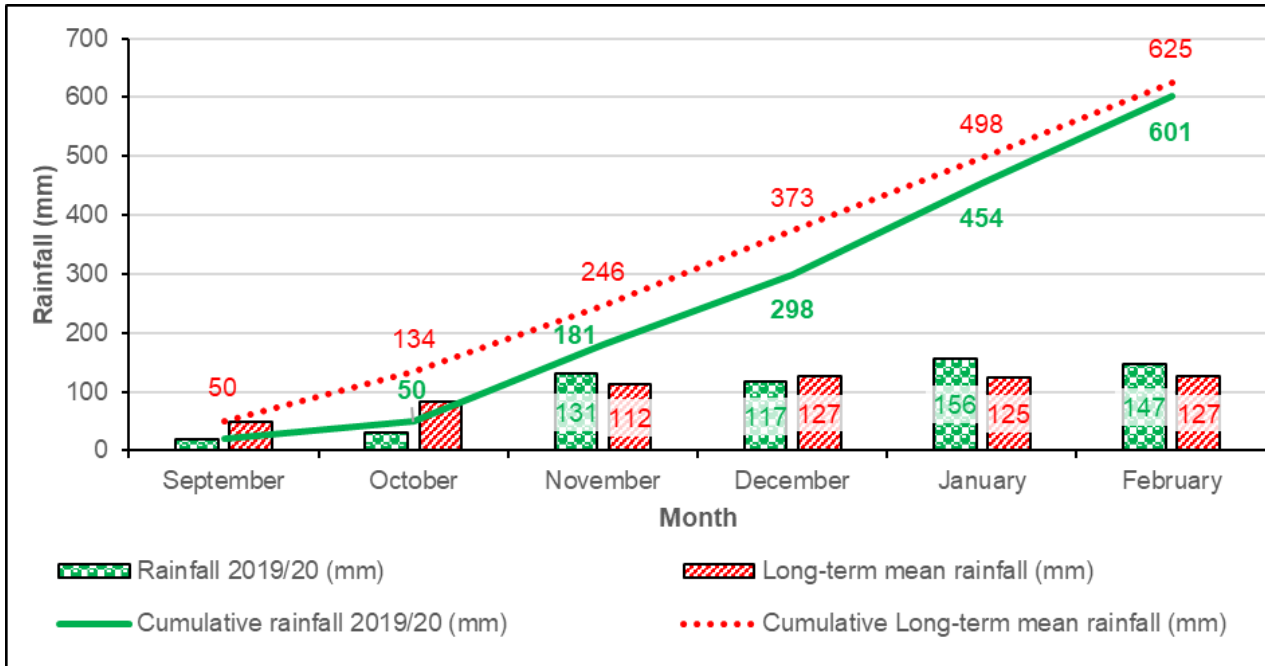


Figure 1 Monthly rainfall received at Cedara during the 2019/2020 growing season.

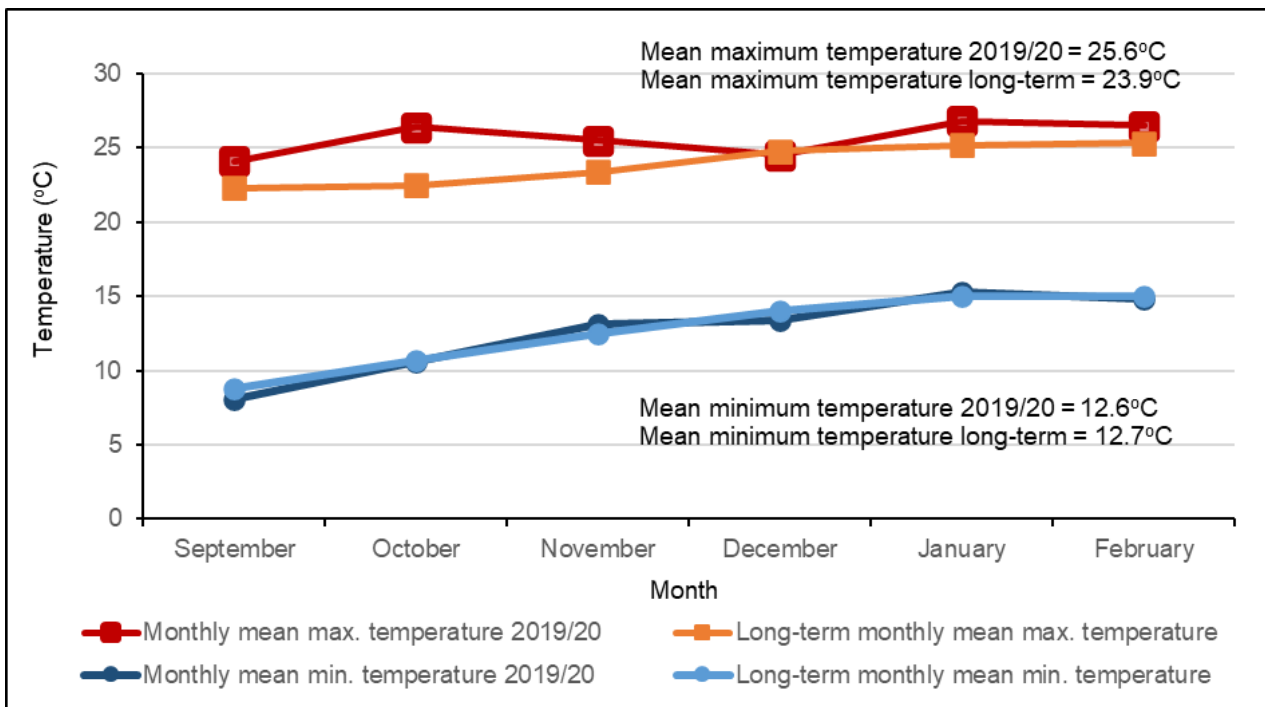


Figure 1 Monthly rainfall received at Cedara during the 2019/2020 growing season.

weekly from the onset of ridging (22 October 2019). Systemic and contact fungicides were applied weekly on a rotational basis. Insecticides were applied weekly to all the plots to control the major potato pests.

The trial was planted on 18 September 2019 at a seeding rate of 37 037 tubers/ha. Fertilizer was

applied according to Fertrec recommendations for a 70 t/ha yield based on the results of a soil analysis. In total, 85 kg/ha P, 115 kg/ha K and 240 kg/ha N were applied. Each split-plot consisted of four rows of 5 m length and spaced 0.9 m apart. Data were collected from the two middle rows. Sixteen disease severity and incidence ratings were conducted from 23 October until 6 January.

TABLE 1 Seed quality rating and the number of days after planting (DAP) to 75% emergence and harvesting.

Cultivar	Seed quality rating *	75% Emergence	Harvest	
			Fungicide	No fungicide
		(DAP)	(DAP)	
Allison	3.0	18	152	141
Bikini	3.0	17	152	125
Electra	3.0	18	152	148
El Mundo	3.0	19	143	134
Essenza	2.5	20	147	141
Fandango	3.0	17	138	131
Georgina	3.0	22	134	125
Jelly	3.0	22	138	134
Labadia	4.0	19	125	125
Lanorma	3.0	20	161	151
Mondeo	2.5	20	152	125
Mondial	3.0	20	157	150
Panamera	3.0	20	153	153
Sababa	3.0	18	148	150
Sifra	4.0	17	133	125
Taisiya	3.0	20	130	125
Tyson	3.0	20	130	125
Valor	3.0	21	154	153
Mean	3.1	19	144	137

*1 = fresh seed; 3 = well-sprouted; 5 = over-sprouted

Well below-average rainfall was received in September and November, but good rainfall was received thereafter (Figure 1). Overall, the mean maximum temperature was above the long-term mean, whilst the mean minimum temperature was almost similar to the long-term mean (Figure 2). From planting to harvest of the last cultivars (26 February 2020), 486.5 mm of rain were received and 236.9 mm of irrigation were applied, totalling 723.4 mm.

The seed of all the cultivars was well-sprouted at planting (Table 1). As a result, the range in the number of days for the cultivars to reach 75% emergence was five days. Harvesting occurred from 21 January (125 days after planting) to 26 February (161 days after planting), which was about two to three weeks after the die-back of each plot.

No significant difference in mean plant population was measured between the fungicide treatments

(Table 2). However, Georgina had a significantly higher population in the fungicide sprayed treatment compared to the unsprayed fungicide treatment, while the opposite occurred with Jelly. Overall, plant population had a significant positive effect on yield.

The mean number of haulms/plant ranged from 2.68 for Panamera to 7.32 for Bikini (Table 2). However, the number of haulms/plant had no significant impact on yield, overall.

Georgina, Sifra and Taisiya had medium growth vigour and therefore took longer to canopy in comparison to the remaining cultivars, which had strong to very strong growth vigour (Table 2).

TABLE 2 Plant population per hectare, number of haulms per plant and growth vigour for the eighteen cultivars.

Cultivar	Plant population			Haulms (number/ plant)	Growth vigour*
	Sprayed	Unsprayed (number/ha)	Mean		
Allison	37 037	37 037	37 037	4.60	5
Bikini	37 037	37 037	37 037	7.32	5
Electra	37 037	37 037	37 037	4.17	5
El Mundo	37 037	37 037	37 037	5.27	5
Essenza	37 037	37 037	37 037	5.05	5
Fandango	36 674	37 037	36 855	5.92	5
Georgina	35 948	31 227	33 588	3.50	3
Jelly	31 227	35 221	33 224	5.78	5
Labadia	37 037	36 674	36 855	4.27	4
Lanorma	37 037	37 037	37 037	3.67	5
Mondeo	37 037	36 674	36 855	5.30	5
Mondial	37 037	37 037	37 037	3.52	5
Panamera	36 674	36 674	36 674	2.68	5
Sababa	37 037	36 674	36 855	3.95	5
Sifra	37 037	36 674	36 855	3.72	3
Taisiya	37 037	36 674	36 855	3.60	3
Tyson	36 674	37 037	36 855	3.27	5
Valor	36 674	37 037	36 855	3.80	5
Mean	36 573	36 492	36 533	4.41	4.6

LSD (P<0.05) Cultivar	579.2	0.674
LSD (P<0.05) Fungicide	NS	NS
LSD (P<0.05) Cultivar x fungicide	998.4	NS
CV%	1.9	11.8

* 5 = Very strong growth; 4 = Strong growth; 3 = Medium growth; 2 = Poor growth; 1 = Very poor growth

Bikini and Mondeo displayed low tolerance to late blight when no fungicides were applied and therefore the unsprayed plots for these two cultivars were harvested 27 days before the sprayed plots (Figure 3). Labadia and Panamera, in both the sprayed and unsprayed fungicide plots, were harvested on the same day.

Sixteen disease ratings were conducted after the onset of ridging until harvest. Late blight was noted at the beginning of November, whilst early blight was noted towards the end of December.

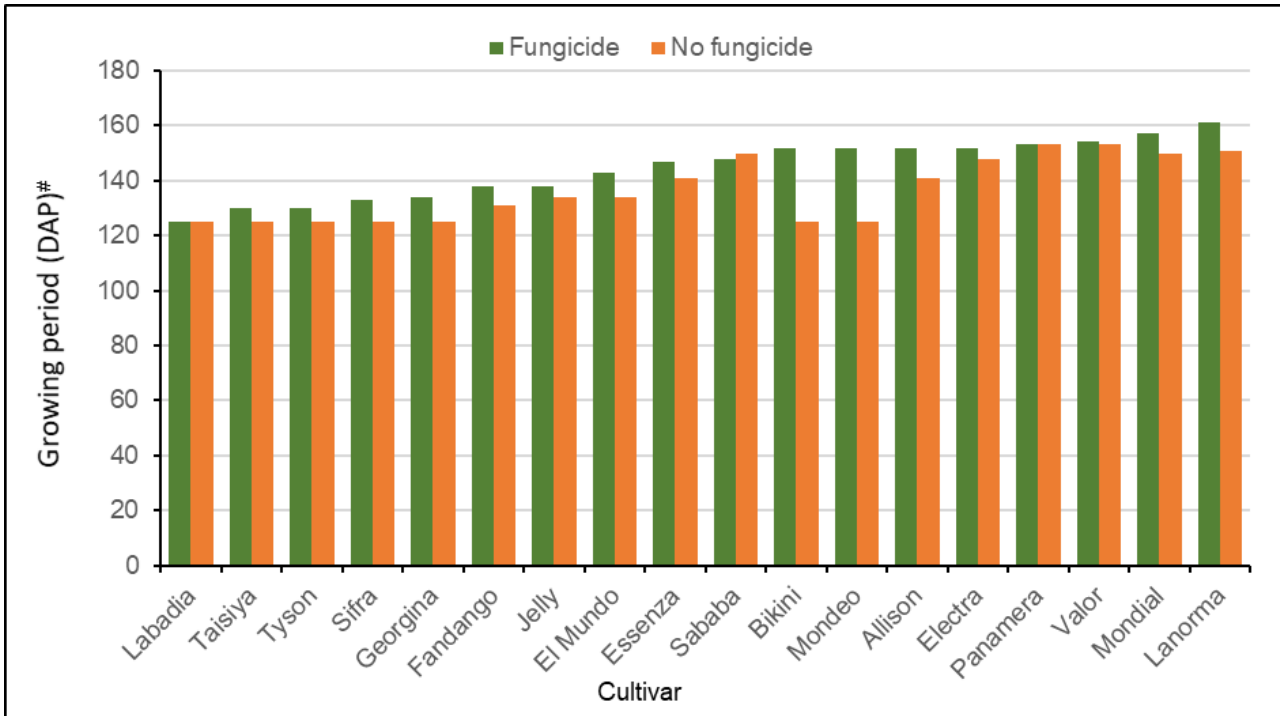
Percentage disease incidence was calculated by using the following formula:

(Number of infected plants/Total number of plants assessed) x 100

Percentage disease incidence can be defined as the percentage of infected plants. Late blight infection occurred in all plots treated with and without fungicides by 71 days after planting. Thereafter there was a rapid increase in the presence of the pathogen on the plants. During this time, environmental

conditions were conducive to disease development at Cedara. Results showed a significant interaction between the time from planting and the fungicide spray treatments. Overall, no significant interaction was measured for percentage disease incidence

between the cultivars and fungicide treatments. Although the results indicate that there was a high disease incidence, one needs to look at the time taken for plants to become infected with the pathogen. As expected, most cultivars showed a quicker disease



Growing period is the number of days from planting to harvest (DAP)

Figure 3 Growing period of the eighteen cultivars with the two fungicide treatments in the 2019/20 growing season at Cedara.

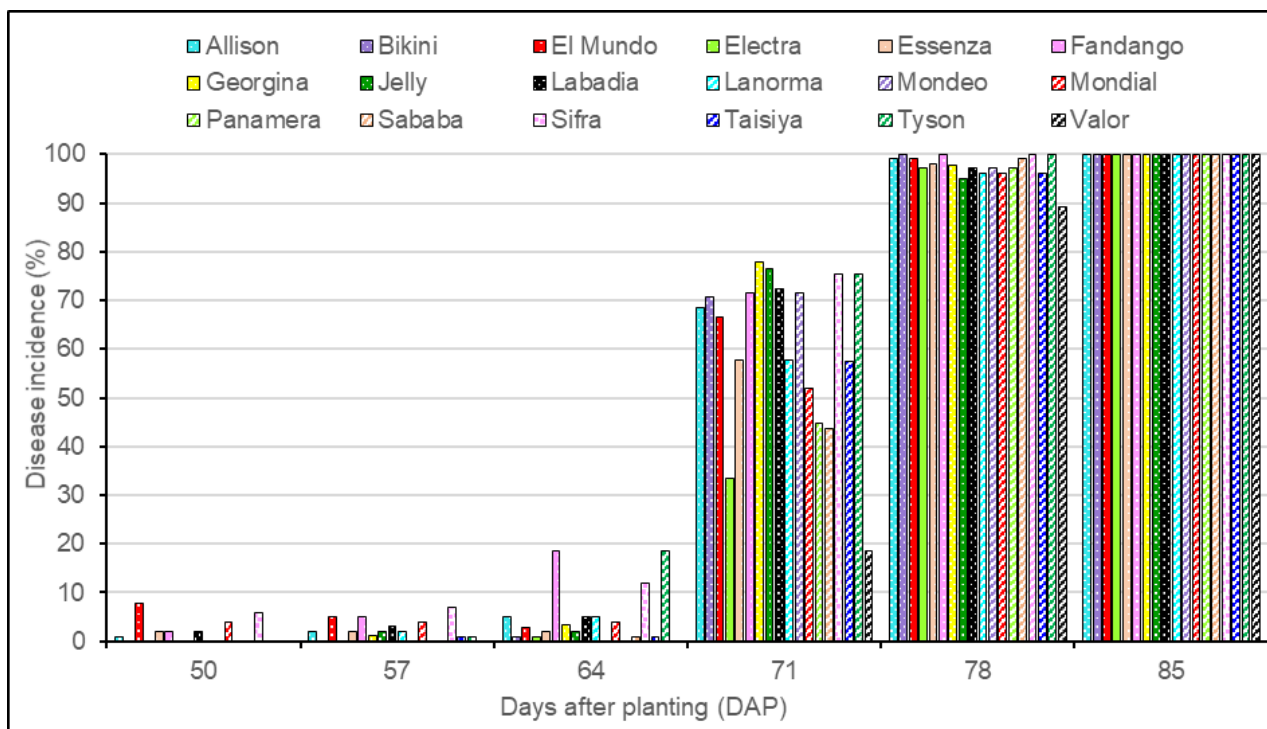


Figure 4 Percentage disease incidence on the different unsprayed potato cultivars at six ratings.

incidence when no fungicides were applied (Figure 4). At 85 days after planting, all the cultivars had 100% infection in the unsprayed treatment. However, the following cultivars, Valor, Electra, Jelly, Panamera and Sababa, took longer to become infected with the disease compared to the other cultivars. Hence, they had a lower disease incidence prior to 71 DAP when the disease conditions became conducive. Overall, Taisiya, Mondeo, Tyson and Georgina had higher late blight incidences. In the sprayed treatment, Labadia and Lanorma had the highest and lowest disease incidence, respectively (Figure 5).

The disease severity percentage of late blight for each cultivar was determined using the following formula:

- $\frac{\sum \text{Sum of all disease ratings}}{(\text{Total number of ratings} \times \text{maximum disease score})} \times 100$.

Disease severity is defined as the percentage of the plants covered by symptoms of the pathogen. It gives an indication of the extent of damage caused by the disease. The results showed a significant interaction between the different cultivars and spray treatments applied (Figure 6). Most of the cultivars had significantly higher disease severity index percentages in the unsprayed fungicide treatment. Bikini, Mondeo, Taisiya, Sifra, Tyson, Georgina and Labadia were particularly susceptible to late blight when no fungicides were applied. In the unsprayed

fungicide treatment, Valor, Panamera and Electra had lower disease severity indexes than the other cultivars. Individually, no significant differences in disease severity were measured between the spray treatments for these three cultivars together with Sababa and El Mundo, indicating that they displayed good tolerance to late blight. Valor had the lowest disease severity index in both the sprayed and unsprayed treatments. Variations in disease severity are mainly due to climatic factors and pathogen virulence. The increase in disease severity could be due to a change in the pathogen population. The reason that cultivars lose their tolerance to late blight is because the resistance level of the cultivars is being defeated due to the matching of new virulence genes in the pathogen.

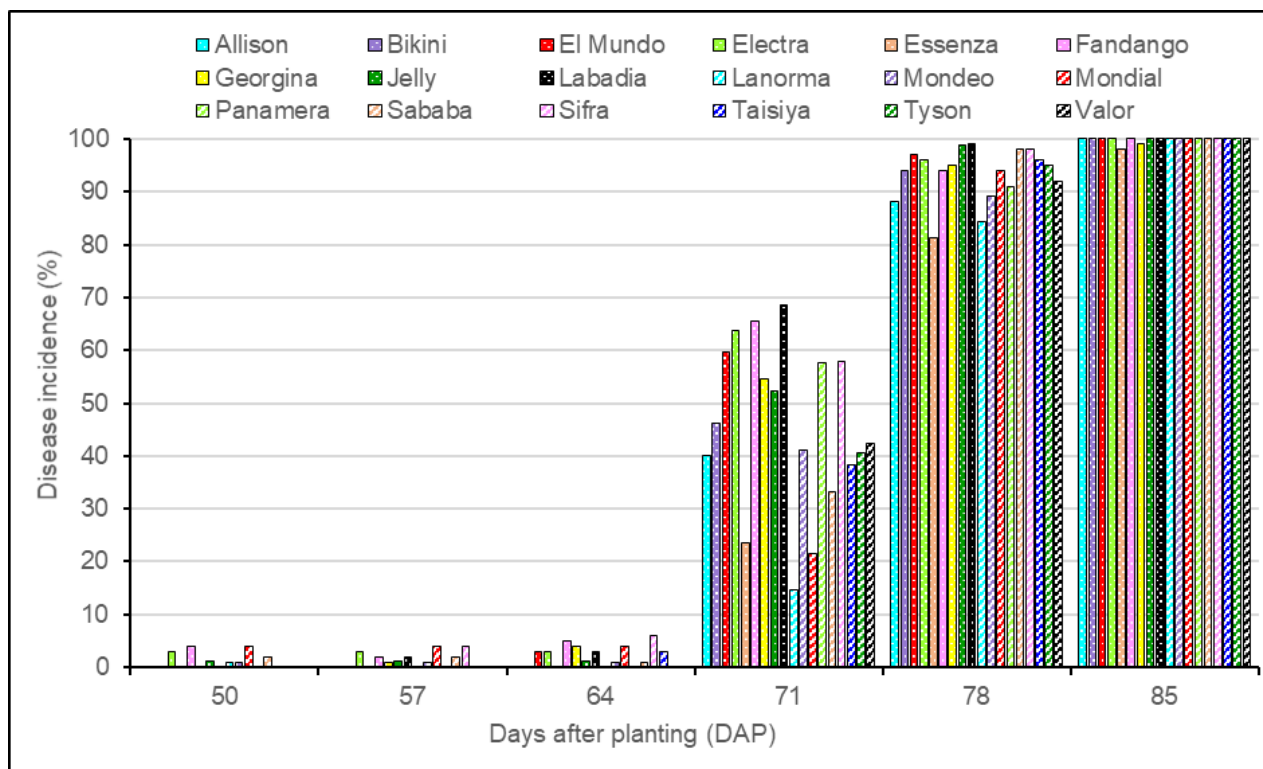
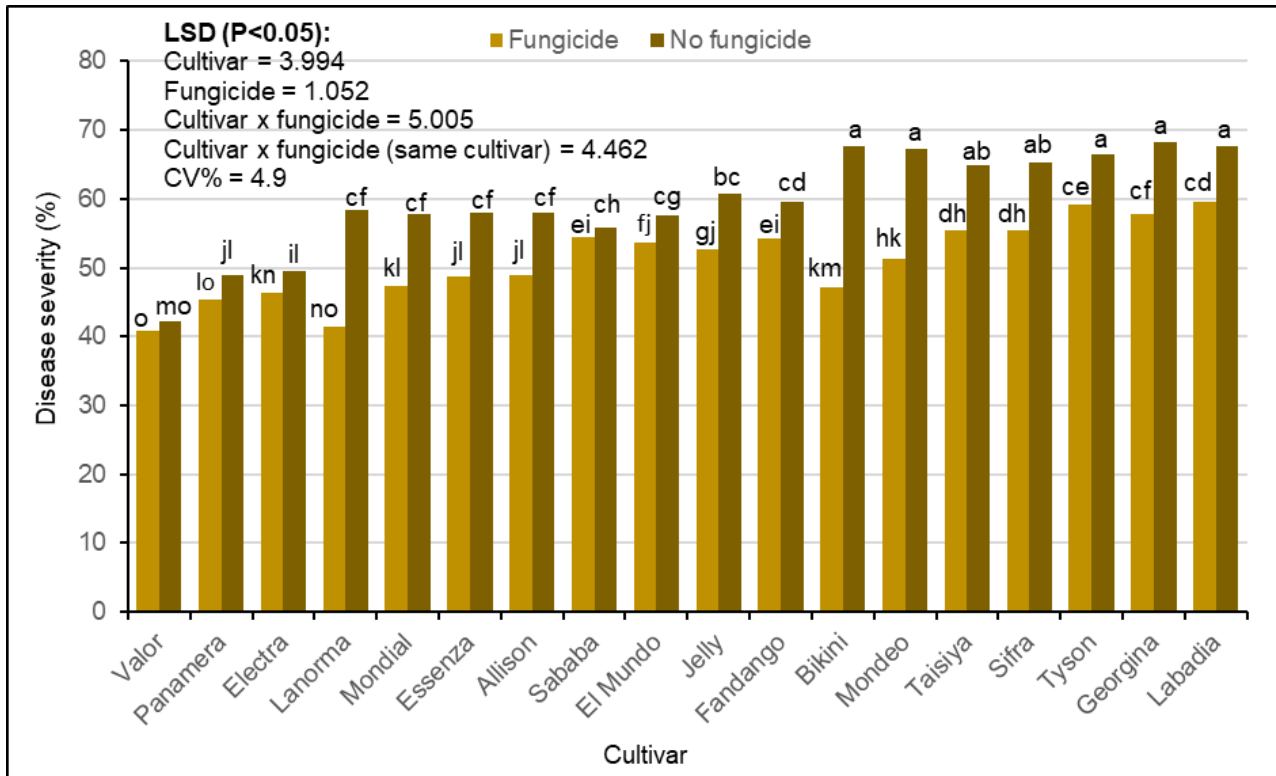


Figure 5 Percentage disease incidence on the different sprayed potato cultivars at six ratings.



Means with the same letter are not significantly different at $P \leq 0.05$, e.g. ac = a, b and c.
 Figure 6 Disease severity index (%) of late blight on the eighteen cultivars in the 2019/2020 growing season at Cedara.

Overall, the majority of the yield was comprised of large and large/medium tubers (Figure 7). Without fungicide applications, the percentage of large sized tubers decreased significantly, while the percentage of

smaller sized tubers increased significantly (Figures 8 and 9). Electra and Essenza had significantly higher and lower mean percentages of large tubers than the other cultivars, respectively. Overall, yield increased

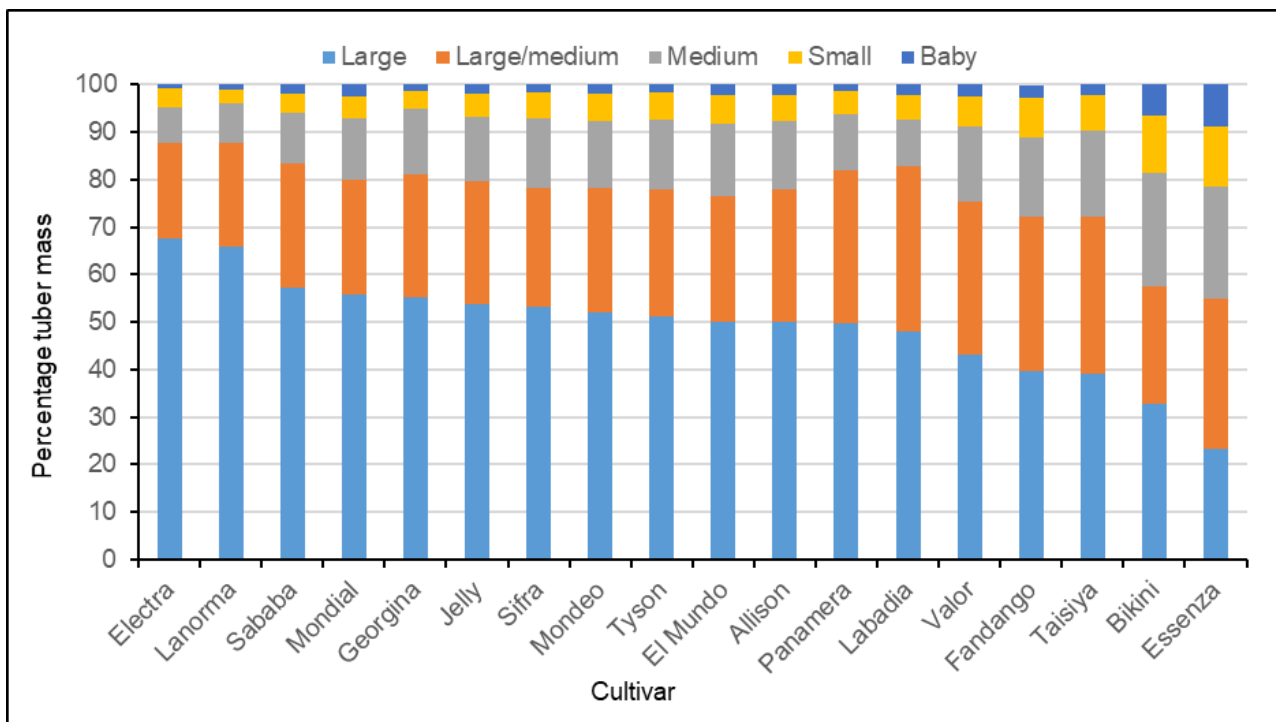


Figure 7 Percentage tuber mass of the total yield at the five size grades for the eighteen cultivars sprayed with fungicides.

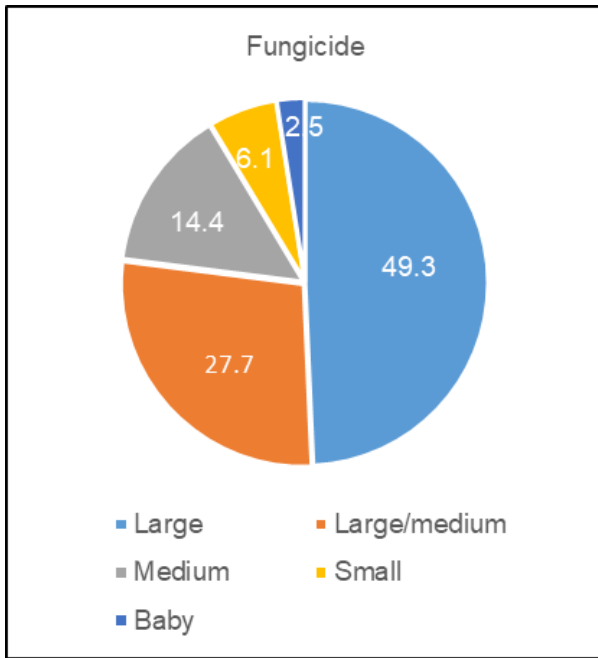


Figure 8 Percentage of the five grade sizes combined for the eighteen cultivars with fungicides applied.

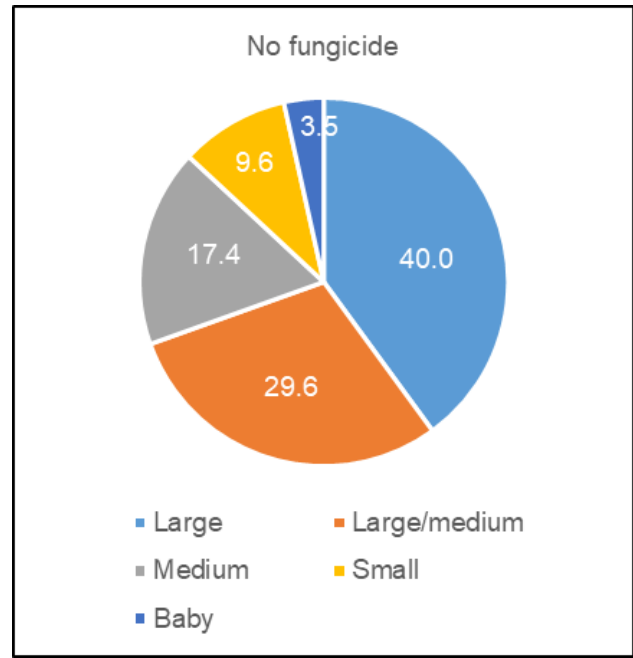
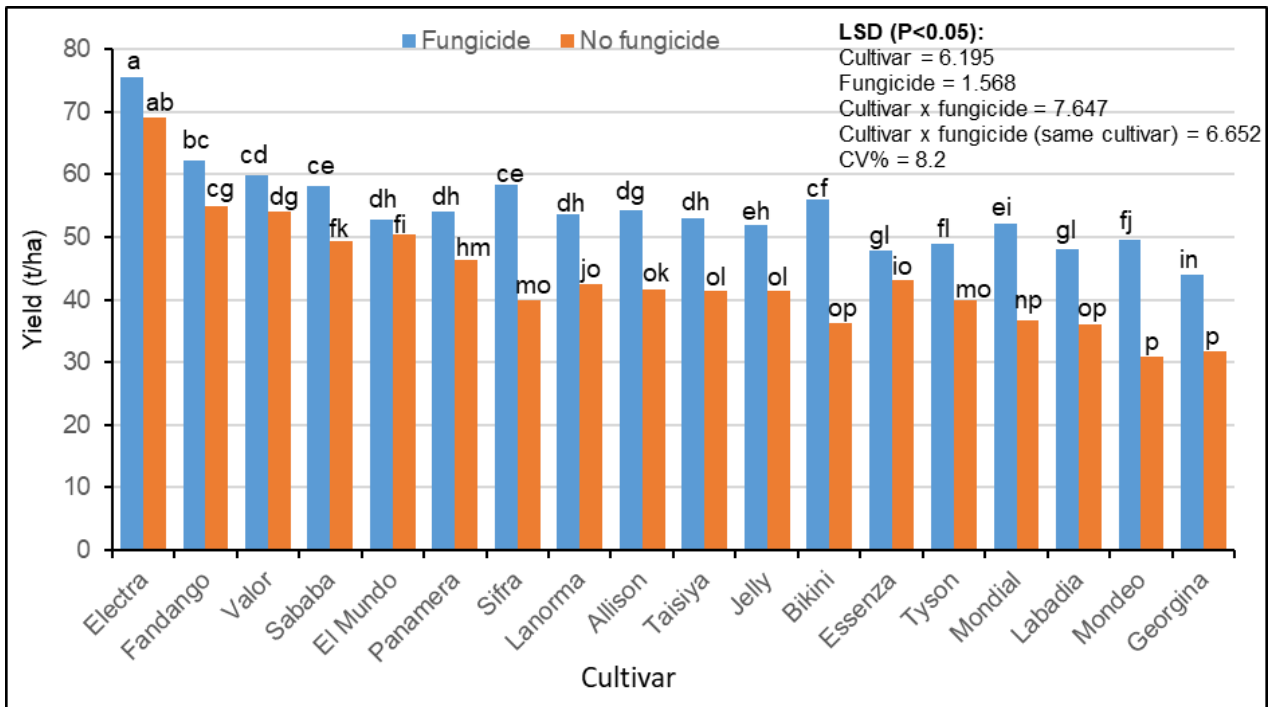


Figure 9 Percentage of the five grade sizes combined for the eighteen cultivars without fungicides applied.

significantly as the percentage mass of large tubers increased. Electra, Fandango, Valor, Sababa, El Mundo and Panamera produced the highest mean yields and no significant differences in the percentage mass of large tubers were measured between the fungicide treatments for these cultivars.

The range in mean yield varied considerably from 72.3 t/ha for Electra to 38.0 t/ha for Georgina. When comparing the fungicide treatment effects on the yield of individual cultivars, no significant differences were measured for Electra, Valor, El Mundo and Essenza (Figure 10). Overall, yield



Means with the same letter are not significantly different at P≤0.05.

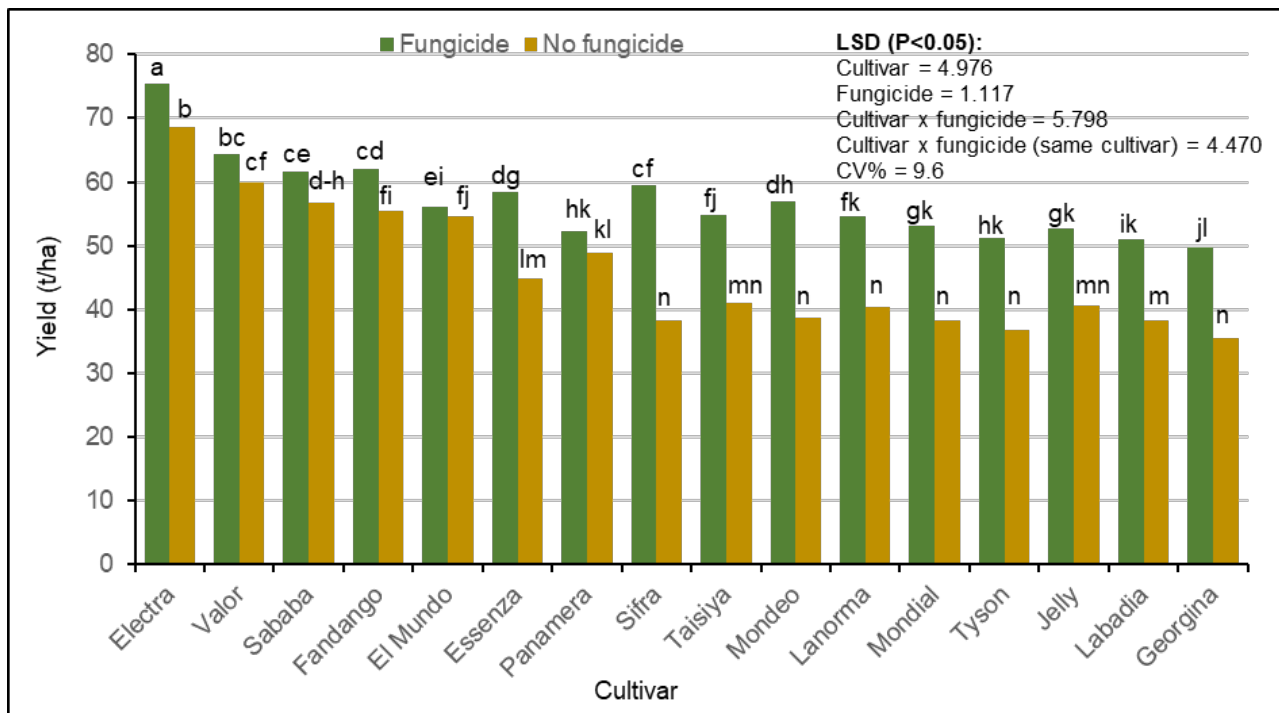
Figure 10 Yield of the eighteen cultivars resulting from the two fungicide treatments in the 2019/20 growing season.

decreased by 19.83% when no fungicides were applied. The largest decreases in yield were obtained by Mondeo (37.5%), Bikini (35.2%), Sifra (31.5%) and Mondial (29.8%).

Sixteen cultivars were evaluated in the 2018/19 and 2019/20 growing seasons. No significant interaction was measured for yield between the cultivars, growing-seasons and fungicide treatments. However, a significant interaction was measured for yield between the cultivars and fungicide treatments (Figure 11). When comparing cultivars individually, no significant differences in yield were measured between the fungicide treatments for Valor, El Mundo and Panamera.

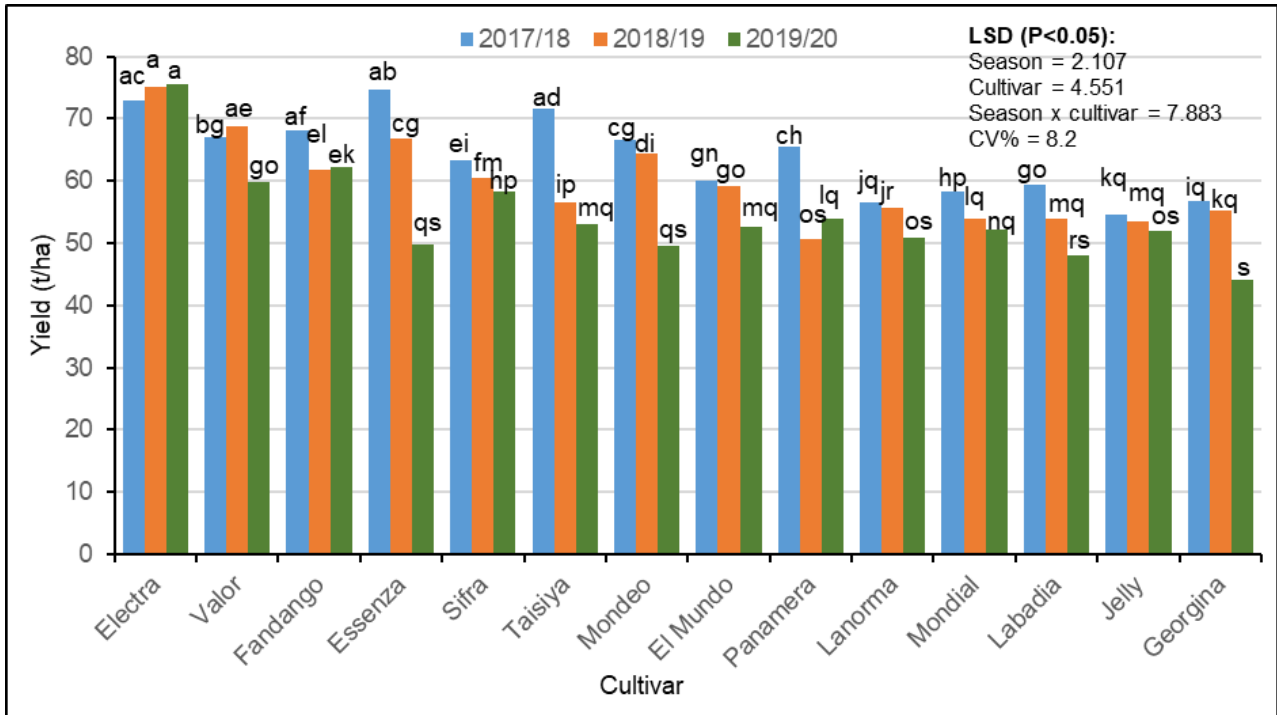
Fourteen cultivars were evaluated with fungicide applications during the three growing-seasons from 2017/18 to 2019/20. A statistical analysis indicated that some cultivars produced significantly variable yields over the growing-seasons, whilst others were more consistent (Figure 12)). Electra produced consistently high yields (mean = 74.52 t/ha), while Georgina produced the lowest mean yield (51.98 t/ha). Mondial, Sifra and Valor are grown on a large scale in KwaZulu-Natal. However, Mondial did not yield as well as some of the other cultivars.

As most of the high yielding cultivars showed good tolerance to late blight, these cultivars show promise for growing in the KwaZulu-Natal Midlands. They are especially suitable for rural small-holders, who cannot afford to purchase fungicides to control late blight. ©



Means with the same letter are not significantly different at $P \leq 0.05$.

Figure 11 Yield of the sixteen cultivars resulting from the two fungicide treatments for the 2018/19 and 2019/20 growing seasons combined.



Means with the same letter are not significantly different at $P \leq 0.05$.

Figure 12 Yield of the fourteen cultivars evaluated with fungicides applied in the 2017/18, 2018/19 and 2019/20 growing seasons.

