WUR – SPECIAL REPORT NO 19 – 2019, 63-68

Integrating cultivar resistance into a disease model for controlling early blight (*Alternaria solani*)

ISAAC KWESI ABULEY[1]

[1] Department of Agroecology, Aarhus University, Forsøgsvej 1, 4200, Slagelse

SUMMARY

Field experiments were conducted to integrate cultivar resistance to an early blight-forecasting model (TOMCAST). Three cultivars (cvs. Agata, Sava, and Kuras) that differed for their level of resistance to early blight were either sprayed at every 14 days (standard treatment) or according three different TOMCAST threshold (15, 20 and 25) with Signum WG (Pyraclostrobin + Boscalid). Untreated plots were also included to serve as a check of the disease progression during the season. Results obtained from this study showed that TOMCAST-15 is the best TOMCAST threshold for Sava and Agata. However, for Kuras sufficient control of early blight comparable to the standard treatment was obtained for all TOMCAST thresholds. In conclusion, this study found that fungicide application or model thresholds for recommending fungicide applications could be adjusted according to host resistance to control early blight with fewer numbers of fungicides.

KEYWORDS

Early blight, *Alternaria solani*, Potato, Cultivar resistance

INTRODUCTION

Early blight, caused by *Alternaria solani*, is an increasing problem in Denmark (Abuley and Nielsen, 2017; Nielsen, 2015). The disease can cause substantial yield losses of potatoes if not controlled properly. Generally, the average yield loss due to early blight is 7-20% (Abuley and Nielsen, 2017).

Usually, fungicides, which happens to be the most effective control method available, are used to control the disease at weekly or two-weekly intervals, regardless of the favorability of the environment for the disease development (Abuley and Nielsen, 2017). However, the increasing public concerns about the negative effects of fungicides in the environment, high cost and resistance development associated with frequent use of fungicides have necessitated the use of forecasting models to regulate the application of fungicides (Abuley and Nielsen, 2017; Leiminger and Hausladen, 2012). Generally, forecasting models predict critical times in the season when the weather is favorable for the pathogen to infect a susceptible host.

Because the development of early blight is dependent on weather variables like temperature and humidity, forecasting models have been developed to forecast when critical times for disease development occurs and thus fungicide application is recommended. For example, models like TOMCAST (Gleason *et al.*, 1995), FAST (Madden *et al.*, 1978), and physiological days (Pscheidt and Stevensen, 1988) have used to time the application of fungicide for controlling early blight.

The TOMCAST model was modified and validated in Denmark recently (Abuley and Nielsen, 2017). Briefly, fungicide application in the modified-TOMCAST model is based on the TOMCAST disease severity value (DSV) and the maturity of the crop. The maturity of the crop is estimated as thermal age (with units P-days) since emergence with the physiological day model (Sands *et al.*, 1979). For example, the first spray is recommended when the plant is 330 P-days and the cumulative TOMCAST DSV is at least 25 since crop emergence (Abuley and Nielsen, 2017). The subsequent spray depends on a predetermined cumulative TOMCAST DSV threshold (e.g. 15, 20). Shorter thresholds denote a shorter interval between subsequent spray and vice versa.

Even though several forecasting models have been used to early blight control successfully, the models omit cultivar resistance. Thus, an implicit assumption in most of the models is that all cultivars are equally susceptible to early blight. However, potato cultivars differ for their level of resistance to early blight and thus the need to include it into models (Abuley *et al.*, 2018). Therefore, the objective of this study was to integrate cultivar resistance into the TOMCAST model to adjust fungicide applications.

MATERIALS AND METHODS

A field experiment was carried out at Flakkebjerg Research Centre in Denmark in 2016. The experiment was designed as a factorial randomized complete block design (RCBD) replicated four times. The factors in the experiment were three levels of cultivar resistance and five levels of fungicide schedules. The cultivars used were cv. Agata (very susceptible, early maturing, ware potato), cv. Sava (moderately slow blighting, medium maturing and ware potato) and cv. Kuras (Slow blighting, late maturing, and starch potato). The order of increase of resistance of the cultivars to early blight is as follows cv. Agata< cv. Sava< cv. Kuras (Abuley *et al.*, 2018). The fungicide schedules were (1) Untreated, here no fungicide was applied; (2) Standard treatment, in which 0.25 kg/ha Signum WG (Pyraclostrobin + Boscalid) was sprayed at a 14-day interval beginning from row closure; (3) Three TOMCAST threshold (15, 20 and 25). For a given TOMCAST threshold treatments, first and subsequent sprayings were recommended based thermal age/physiological age of the crop as described previously (Abuley and Nielsen, 2017). As in the standard treatment, Signum WG (Pyraclostrobin + Boscalid) at a rate of 0.25 kg/ha was sprayed in the TOMCAST treatments.

The potato crops were not inoculated; however, the experimental plots were surrounded by other field experiments that were inoculated with both *A. solani* and *A. alternata*. Thus, an influx of conidia of both *A. solani* and *A. alternata* into the experimental plots was expected.

For running the TOMCAST model, hourly readings of temperature and relative humidity (RH) were taken from the Dalmose weather station (Abuley and Nielsen, 2017). Leaf wetness was estimated as an hour with RH>88%. The thermal age (Physiological age/days); with units P-days, of the potato cultivars were determined from 50% emergence equation described by

Sands *et al.* (1979). The estimated leaf wetness and temperature during the hours of leaf wetness were used to run the TOMCAST model as described in Abuley and Nielsen (2017).

Disease assessment and statistical analyses

The percentage covered by early blight on each plot weekly. The disease assessment data was fitted to the linearized logistic growth model to estimate the apparent rate of infection for comparisons between the treatments (Madden *et al.*, 2007). The starch yield was assessed for each treatment as described in Abuley and Nielsen (2017).

The rate of infection and starch and tuber were yield analyzed with generalized least squares with the "gls" function in the "nlme" package (Pinheiro *et al.*, 2016) in R (R Core Team, 2016).

RESULTS AND DISCUSSION

The statistical analysis showed that the effect of cultivar, fungicide schedule and the interaction between cultivar and fungicide schedule was statistically significant ($p<0.001$) for the rates of infection. This suggests that both cultivar resistance and fungicide application are important for controlling early blight. Moreover, the significant interaction between the fungicide schedules and cultivar resistance means that fungicide application could be adjusted according to cultivar the level of host resistance to manage early blight successfully.

The rate of infection or apparent rate of infection is an indication of how fast the disease develops on the cultivars and thus higher rate of infection means faster development of the disease on the cultivar in question. As expected, the rates of infection of early blight on the untreated cultivars were significantly higher compared to the cultivars that were treated with fungicide (Table 1). This is a confirmation of the importance of fungicide in controlling early blight, as it has been shown in previous papers (Abuley and Nielsen 2017; Leiminger and Hausladen, 2012). The rate of infection of the untreated cultivars depicts the natural development of early blight on the different cultivars and thus confirms the fact that the cultivars vary for their level of host resistance to early blight. This is evidenced by the significant differences between the rates of infection of the untreated cultivars (Table 1). As expected, Agata was the most susceptible cultivar to early blight, followed by cv. Sava (Table 1). Kuras was the most resistant cultivar compared to Agata and Sava (Table 1).

The results obtained in this study show that for Kuras no statistically differences were found between the standard treatment and the different TOMCAST thresholds (15, 20 and 25) (Table 1). This means that for Kuras, which is more resistant to early blight compared to the other cultivars, all three TOMCAST thresholds (15, 20 and 25) could be used to recommend fungicide application to control early blight. However, higher TOMCAST thresholds (e.g. TOMCAST 25) could be used for cultivars with higher level of resistance like cv. Kuras to control early blight with fewer numbers of sprays (Table 1).

Contrary to Kuras, the best control of early blight, which is the smallest rate of infection, on cvs. Agata and Sava was found on plots that were treated according to the standard treatment and TOMCAST-15 (Table 1).

Table 1. *Rate of infection of early blight and the total number of sprays Agata, Sava and Kuras treated according to the different fungicide schedules*

	Rate of infection (% day^{-1})			Number of sprays
Fungicide Schedule	**Agata**	**Sava**	**Kuras**	
Untreated	0.30 (0.005) a	0.26 (0.004) b	0.23 (0.008) c	-
Standard treatment	0.12 (0.002) g	0.12 (0.002) g	0.12 (0.004) g	6
TOMCAST-15	0.12 (0.004) g	0.11 (0.004) g	0.12 (0.007) g	4
TOMCAST-20	0.16 (0.002) e	0.15 (0.002) f	0.11 (0.004) g	3
TOMCAST-25	0.18 (0.002) d	0.16 (0.002) e	0.12 (0.004) g	2

For all cultivars, no significant differences were found between TOMCAST-15 (Table 1), which is an indication of the universality of this TOMCAST threshold. However, as the TOMCAST threshold increased (20 and 25), differences were more noticeable between the cultivars for the rate of infection. Whereas no differences were found between the rates of infection on cv. Kuras treated according to the different TOMCAST thresholds, the rate of infection between the TOMCAST threshold increased with TOMCAST thresholds, with the result that the lower the TOMCAST threshold the lower the rate of infection of early blight (Table 1).

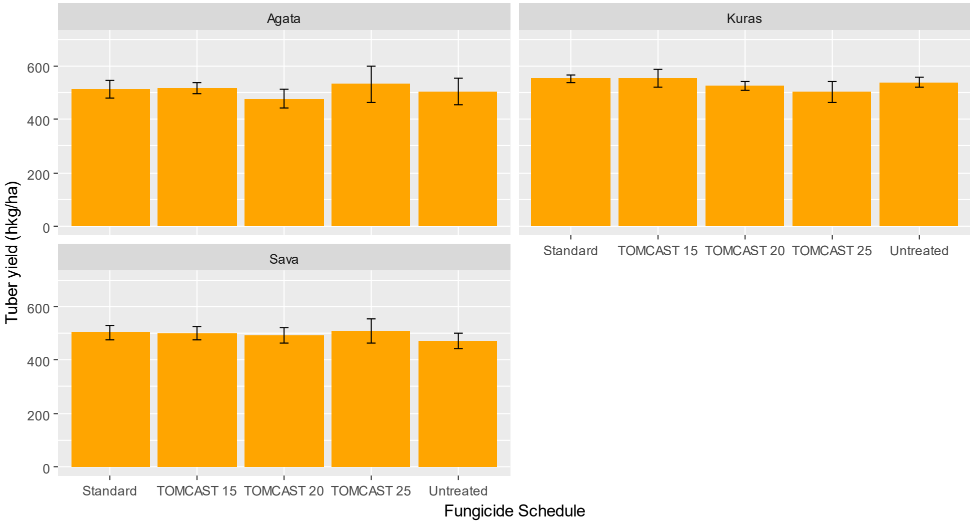

Figure 1. *Mean tuber yield of Agata, Kuras, and Sava sprayed according different fungicide schedules. Means followed by the same letters are not significantly different and vice versa*

Contrary to rates of infection, the statistical analyses showed that neither the effect of cultivar, fungicide nor their interaction was significant ($p>0.05$) (Figure 1).

CONCLUSION

This study showed that both cultivar resistance and fungicide are important components for controlling early blight. Moreover, fungicide application or forecasting models could be adjusted according to cultivar resistance to reduce fungicide applications. For TOMCAST, this study showed that a longer threshold could be used for resistant cultivars to reduce the number of sprayings.

REFERENCES

Abuley, I.K., Nielsen, B.J. (2017). Evaluation of models to control potato early blight (*Alternaria solani*) in Denmark. Crop Protection, 102**,** 118-128.

Abuley, I.K., Nielsen, B.J., Labouriau, R. (2018). Resistance status of cultivated potatoes to early blight (*Alternaria solani*) in Denmark. Plant Pathology, 67**,** 315-326.

Gleason, M.L., Macnab, A.A., Pitblado, R.E., Ricker, M.D., East, D.A., Latin, R.X. (1995). Disease warning systems for processing tomatoes in eastern North America: are we there yet? Plant disease, 79**,** 113-121.

Leiminger, J.H., Hausladen, H. (2012). Early blight control in potato using disease-orientated threshold values. Plant Disease 96, 124–30.

Madden, L.V., Hughes, G., van den Bosch, F. (2007). The Sudy of Plant Disease Epidemics. St Paul, MN, USA: APS Press.

Madden, L., Pennypacker, S.P., Macnab, A.A. (1978). Fast, A Forecast System For *Alternaria solani* on tomato. Phytopathology, 68**,** 1354-1358.

Nielsen, B.J. (2015). Control of late blight (Phytophthora infestans) and early blight (*Alternaria solani* & *A. alternata*) in potatoes. Applied Crop Protection, 8**,** 69-120.

Pinheiro, J., Bates, D., Debroy, S., Sarkar, D. & Team, R.C. (2016). nlme: Nonlinear Mixed Effects Models_R Package. version 3.1-124 ed.

Pscheidt, J.W., Stevenson, W.R. (1988). The critical period for control of early blight (*Alternaria solani*) of potato. American potato journal, 65**,** 425-438.

R Core Team (2016). R: A Language and Environment for Statistical Computing. 3.1.1 ed. Vienna, Austria.

Sands, P.J., Hackett, C., Nix, H.A. (1979). A model of the development and bulking of potatoes (*Solanum tuberosum* L.) I. Derivation from well-managed field crops. Field Crops Research, 2, 309-331.