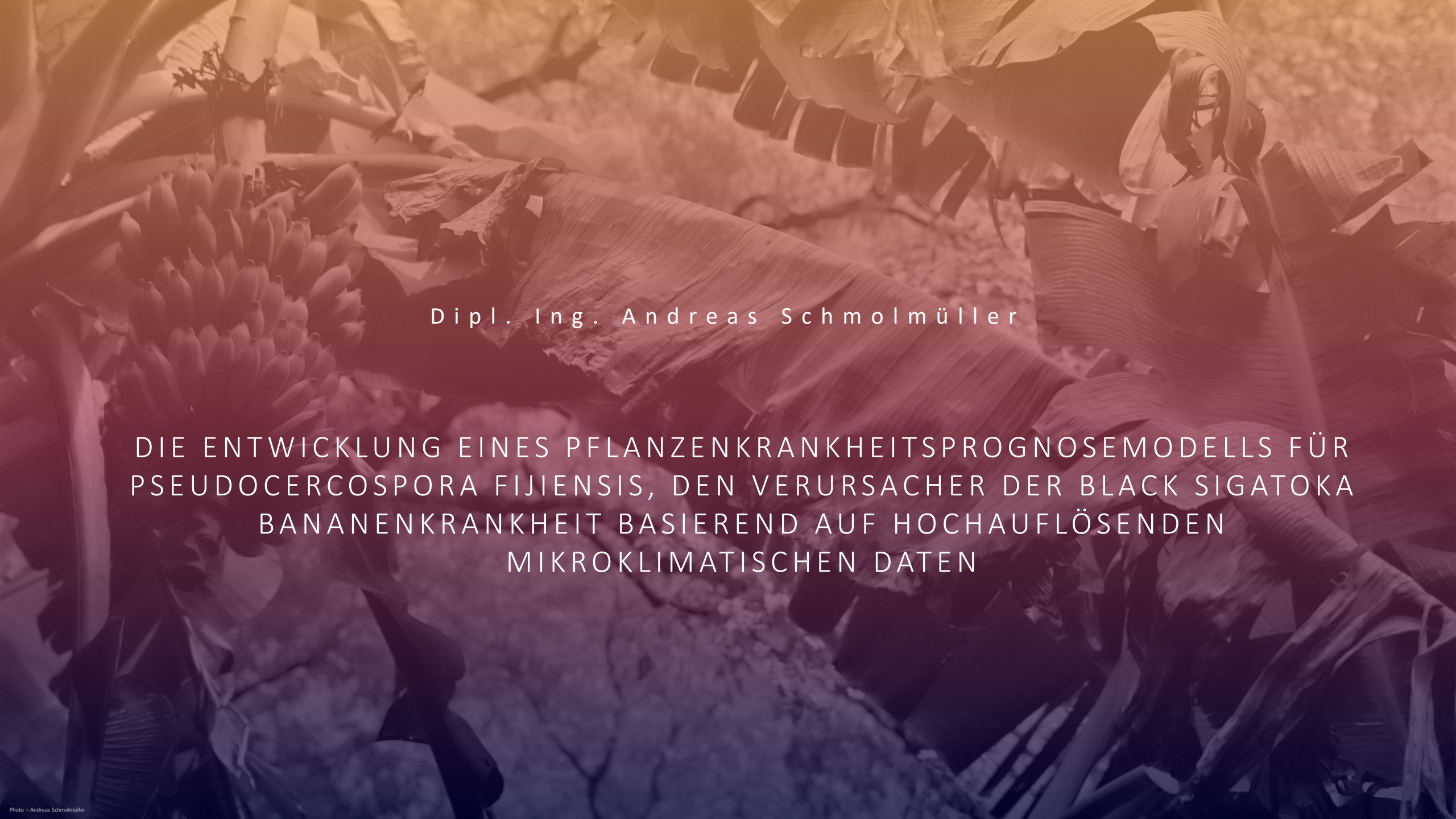




Dipl. Ing. Andreas Schmolmüller

DIE ENTWICKLUNG EINES PFLANZENKRANKHEITSPROGNOSEMODELLS FÜR
PSEUDOCERCOSPORA FIJIENSIS, DEN VERURSACHER DER BLACK SIGATOKA
BANANENKRANKHEIT BASIEREND AUF HOCHAUFLÖSENDEN
MIKROKLIMATISCHEN DATEN



K O O P E R A T I O N



AGENDA

- 🌙 Hypothesen und Fragestellung?
- 🌙 Die Banane
- 🌙 *Pseudocercospora fijiensis*
- 🌙 Integriert. Pflanzenschutz / Prognosemodelle
- 🌙 WWF Model
- 🌙 Material und Methoden
- 🌙 Resultate
- 🌙 Diskussion, Ausblick



BANANE

Musa spp.

BANANENKULTUREN

NACHHALTIG?

Monokulturen

Hohe Bestandesdichten

Im manchen Gebieten 60 Applikationen
pro Jahr

(Matthews, 2009)





LIVING

Bananas are at risk of extinction thanks to climate change

By Charlotte Edwards, The Sun

July 2, 2019 | 1:04pm | Updated





LIVING

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Banana-attacking fungus hits Florida, climate change not helping

New research suggests that climate change is aiding the spread of this highly destructive plant infection.

Tuesday, May 7th 2019, 11:00 AM EDT

Updated: Tuesday, May 7th 2019, 11:03 AM EDT



(CNN) -- A fungal plant disease from Asia has been spreading across banana-growing areas of Latin America and the

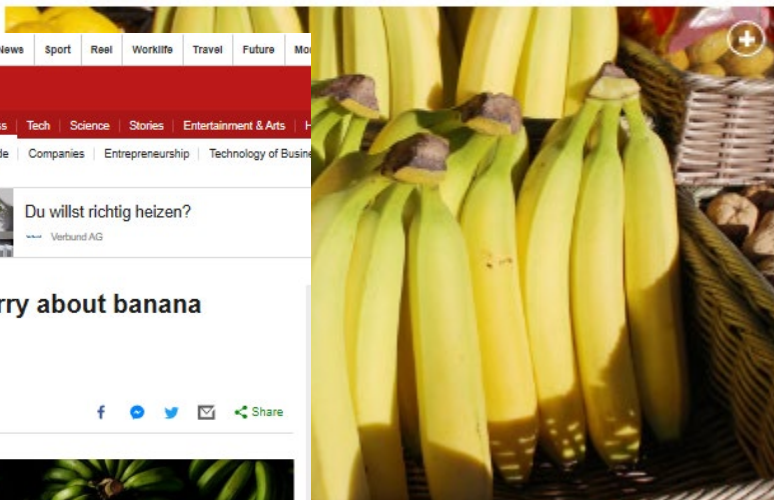


LIVING

Bananas are at risk of extinction thanks to climate change

By Charlotte Edwards, The Sun

July 2, 2019 | 1:04pm | Updated



Du willst richtig heizen?

Do we need to worry about banana blight?

By Tom Espiner
Business reporter, BBC News

15 August 2019



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Stop seeing this ad Why this ad?

Banana-attacking fungus hits Florida, climate change not helping

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? ? ?

Forschungsfrage?

Ist es möglich, die Anwendungszeitpunkte für Pflanzenschutzmittel gegen *Pseudocercospora fijiensis* auf Basis von Mikroklimadaten durch eine informatische Transkription und Implementierung des WWF Black Sigatoka Modells in eine entscheidungsunterstützende Software automatisch zu bestimmen?

Hypothesen

- Infektion gekoppelt an Umweltbedingungen
- Prognosemodelle innerhalb einer DSS-Software müssen so aufbereitet werden, dass sie einfach zu bedienen sind
- Datenerfassungsaufwand durch Automatisierung wird minimiert,
- Die Anzahl der Anwendungen / Zeitpunkte für diese, und damit die Menge der Pestizide kann reduziert werden.

WIRTSCHAFTLICHE

MUSA SPP.

7 Millionen Angestellte

10 Millionen ha

135 Ländern

Grundnahrungsmittel

(IISD, 2014)

BEDEUTUNG

URSPRUNG

MUSA SPP.

- ☾ Familie der Bananengewächse (Musaceae)
- ☾ Ursprung im Indo- Malaysischen Raum
- ☾ Zwei wilde Vorfahren – *Musa acuminata* und *Musa balbisana*
- ☾ Cavendish AAA die am weitesten verbreitete
- ☾ Parthenokarp und steril
- ☾ „Pseudostem“

BIOLOGIE

Heslop-Harrison, J. S., & Schwarzacher, T. (2007).

MUSA

MUSA SPP.

Verbreitet in tropischen und subtropischen Gebieten

Temperaturbereich von 26 ° C to 30 ° C (79 ° F - 86 ° F) und einen jährlichen Niederschlag im Bereich von 2000 mm

AAA Cavendish Nachfolger von Gros Michel → ausgerottet durch Fusarium Welke

(Nelson et al., 2006).

UMWELT



BESTANDESBEGRÜNUNG



Figure 2 -Sword Sucker – vegetative sprout which is growing beside the mother plant (Nelson et al., 2006).

SCHWERTSTECKLING

MUSA SPP.



Figure 3 - Tissue culture from banana grown in laboratory (Sathes, 2010)

ZELLKULTUR



BLACK SIGATOKA

Pseudocercospora fijiensis

Pseudocercospora fijiensis

- ↪ Weltweit in allen Bananenanbaugebieten präsent
- ↪ Früher: *Mycosphaerella fijiensis*
- ↪ Ascomycete
- ↪ Hemibiotroph
- ↪ Teil des Sigatoka Disease Komplexes

Chang et al. 2016

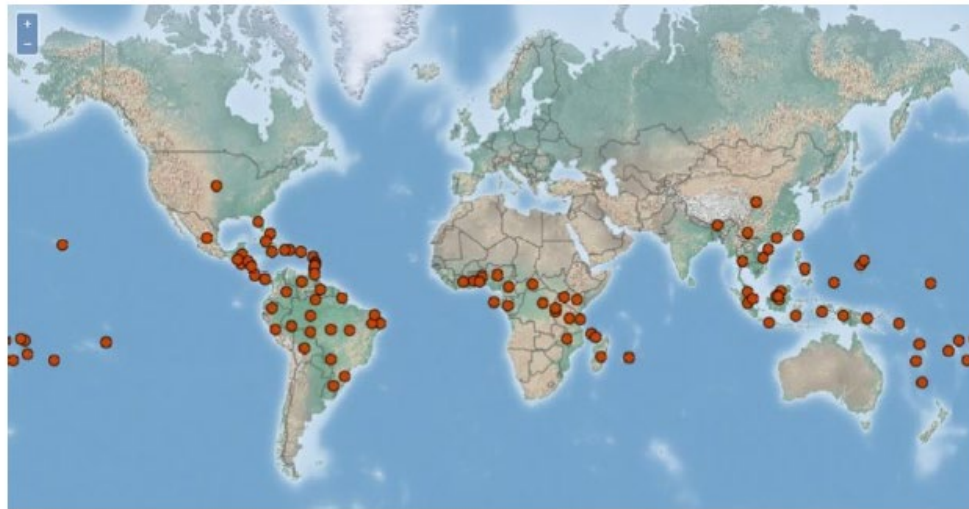


Figure 5 - Distribution of *Pseudocercospora fijiensis* according to (CABI, 2017)

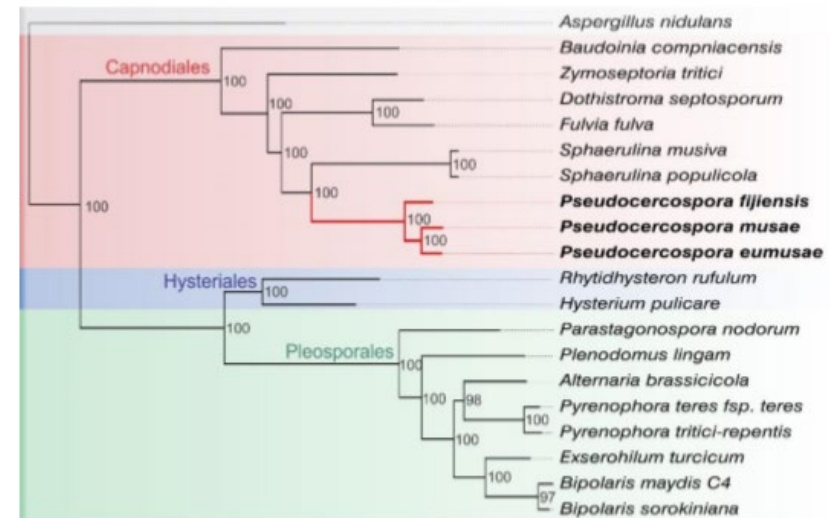


Figure 4 – Sigatoka Disease Complex within the genus of Capnodiales according to (Chang et al. 2016)

Pseudocercospora fijiensis

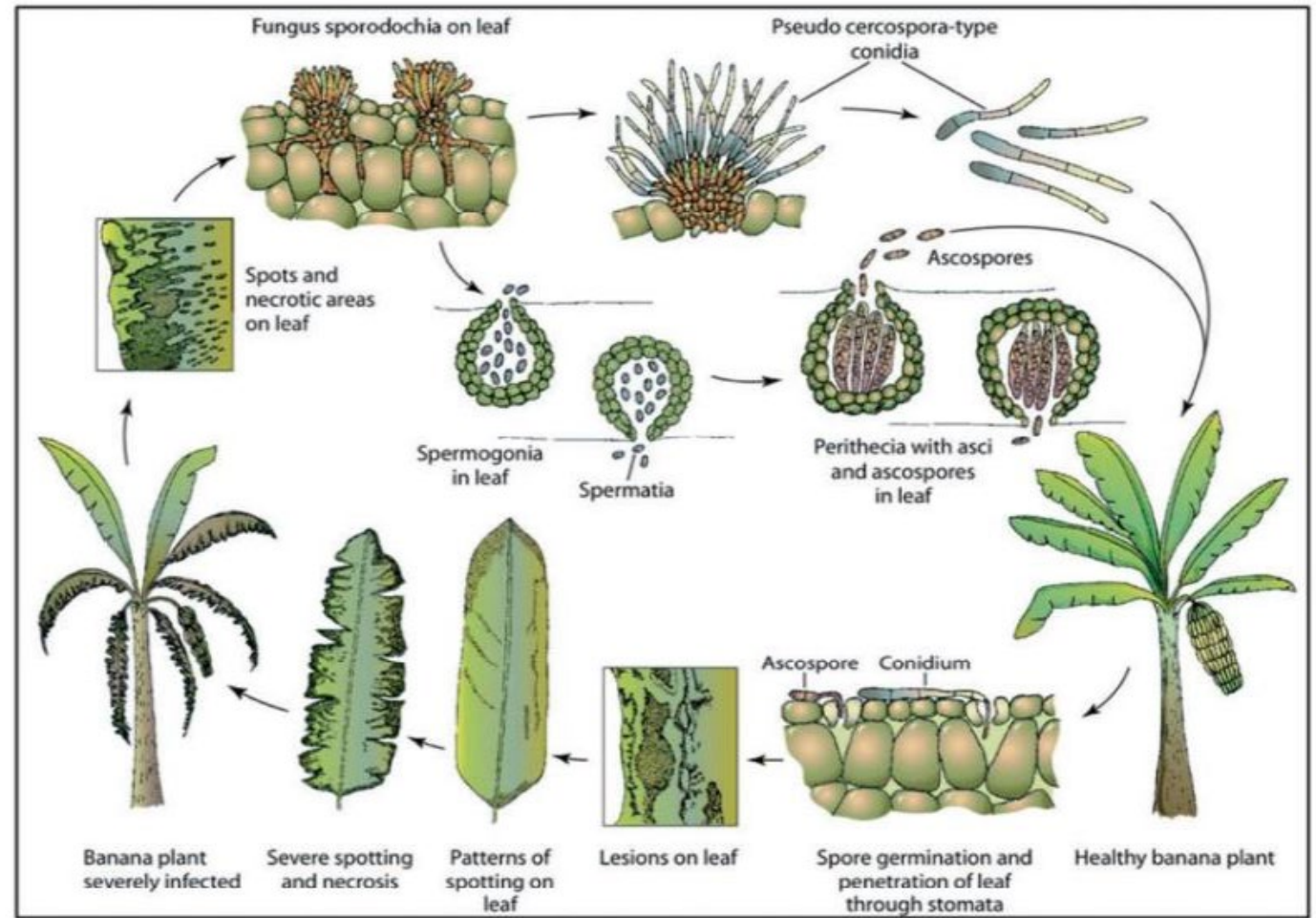
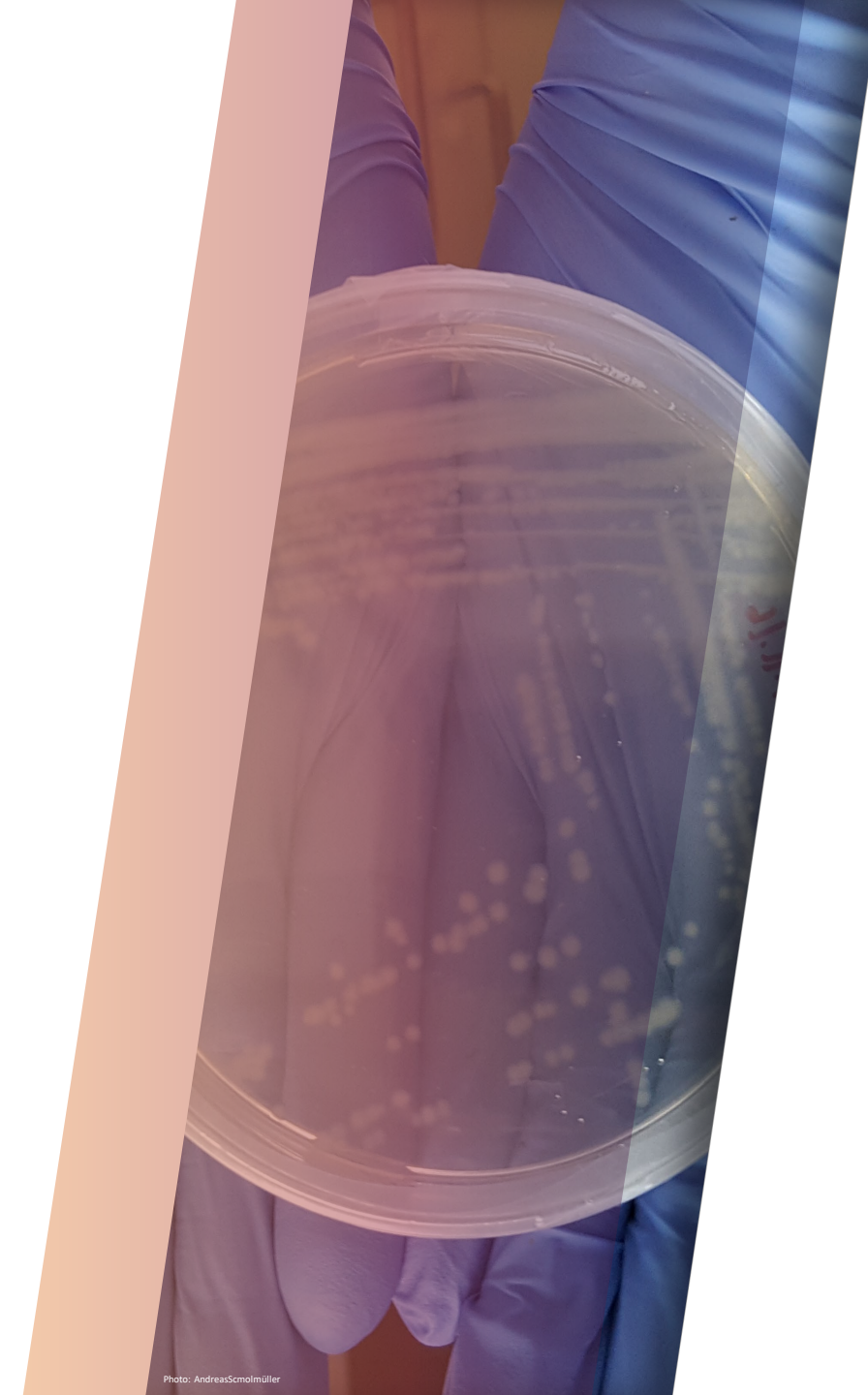


Figure 6 - Life cycle of *Pseudocercospora fijiensis* according to Agrios (2005)



Pseudocercospora fijiensis

Sporenkeimung:

- Ascosporen und Konidien keimen bei einem Temperaturbereich von 20 bis 35 Grad Celsius / 68 – 95 Grad Fahrenheit
- Ascosporen keimen bei einer relativen Luftfeuchte von 98 bis 100%
- Konidien keimen bei einer relativen Luftfeuchte von 92 bis 100 %

Stover, 1980, Jacome 1991

Symptomentwicklung





KRANKHEITSMANAGEMENT



Kema Gerd (2016) in: Sequencing of fungal disease genomes may help prevent banana armageddon, *s Plos Genetics* August 11, 2016. DOI: [10.1371/journal.pgen.1005876](https://doi.org/10.1371/journal.pgen.1005876)



- ☾ Chemisch
- ☾ Phytosanitäre Maßnahmen
- ☾ Biologisch
- ☾ Integriert
- ☾ Pflanzenzucht

Kontrollmethoden





Integrierter Pflanzenschutz

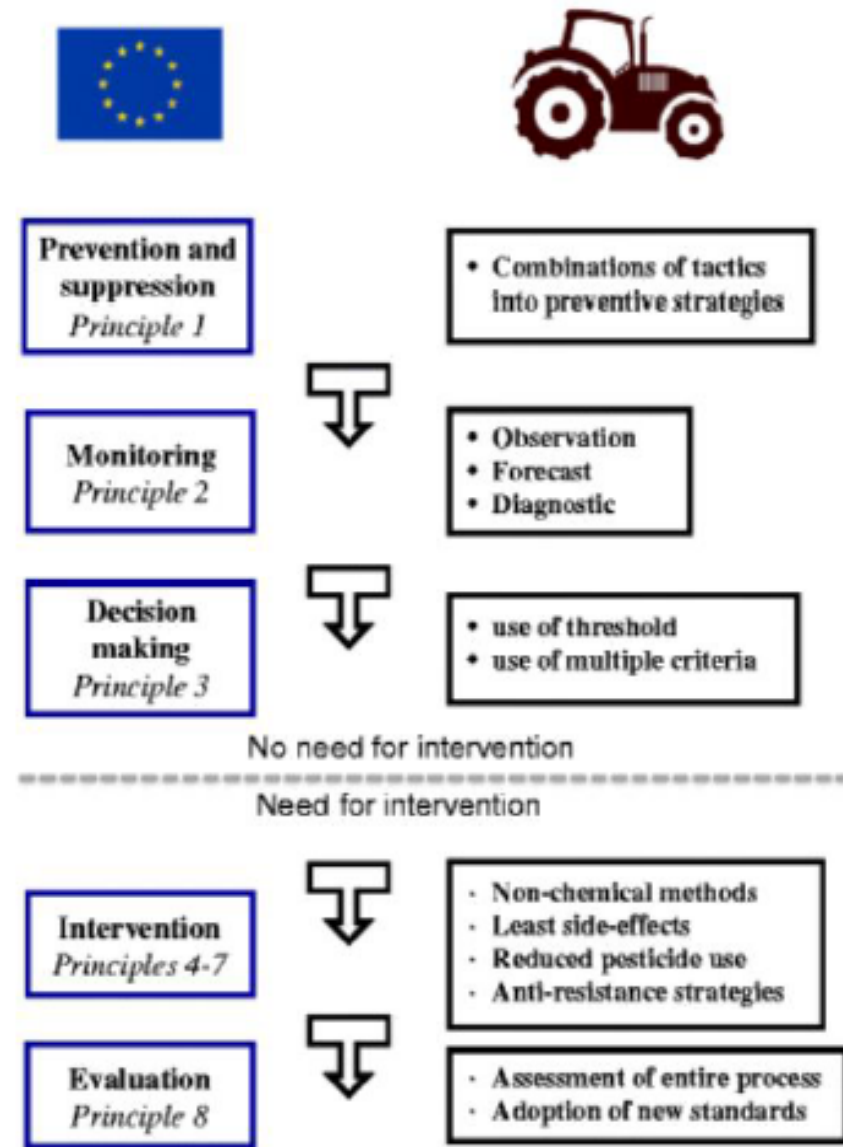


Figure 12 - The principles of IPM according to the European Commission (European Commission, 2018)

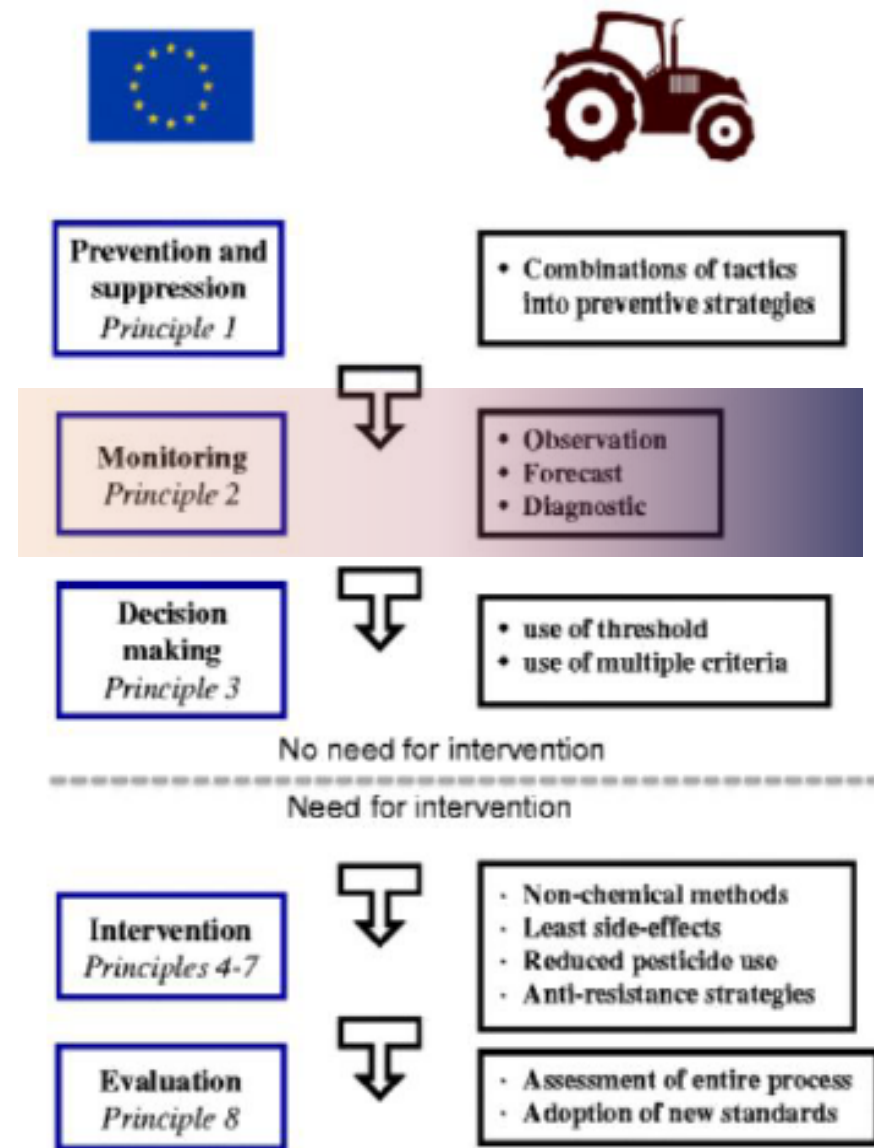


Figure 12 - The principles of IPM according to the European Commission (European Commission, 2018)

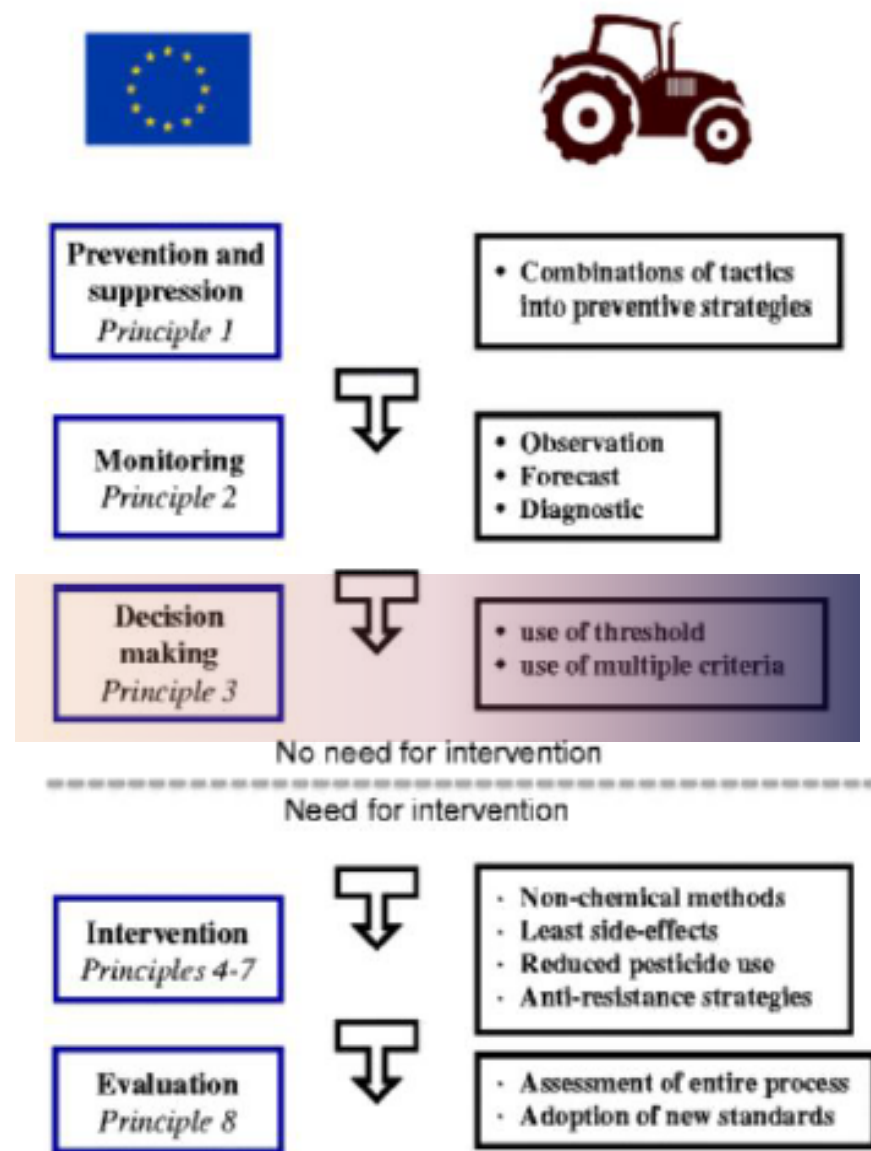
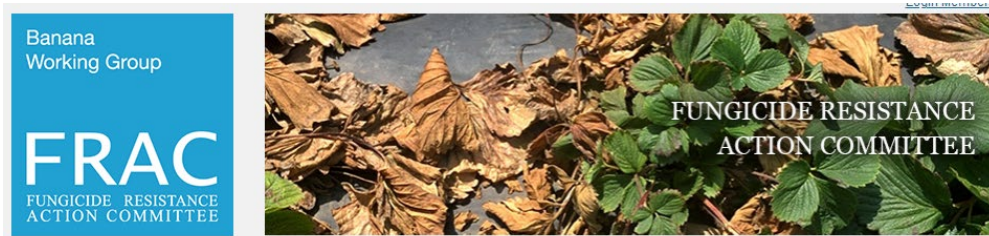


Figure 12 - The principles of IPM according to the European Commission (European Commission, 2018)



Working Groups > Banana Group > Banana FRAC Guidelines 2018 Summary Table

Chemical class	Solo or mixtures	Alternation or blocks	Maximum number of applications	Spray timing
Demethylation inhibitors (DMI)s	only in mixtures	only in full alternation	8 not more than 50% of total number of sprays	*
Amine fungicides	both, mixtures preferred	block of maximum 2 consecutive sprays, full alternation preferred	15 not more than 50% of total number of sprays	no restrictions within manufacturer's labels
Qo inhibitors (Qo)s	only in mixtures	only in full alternation	3 not more than 33% of total number of sprays	**

<https://www.frac.info/working-group/banana-group/banana-frac-guidelines-2016-summary-table>

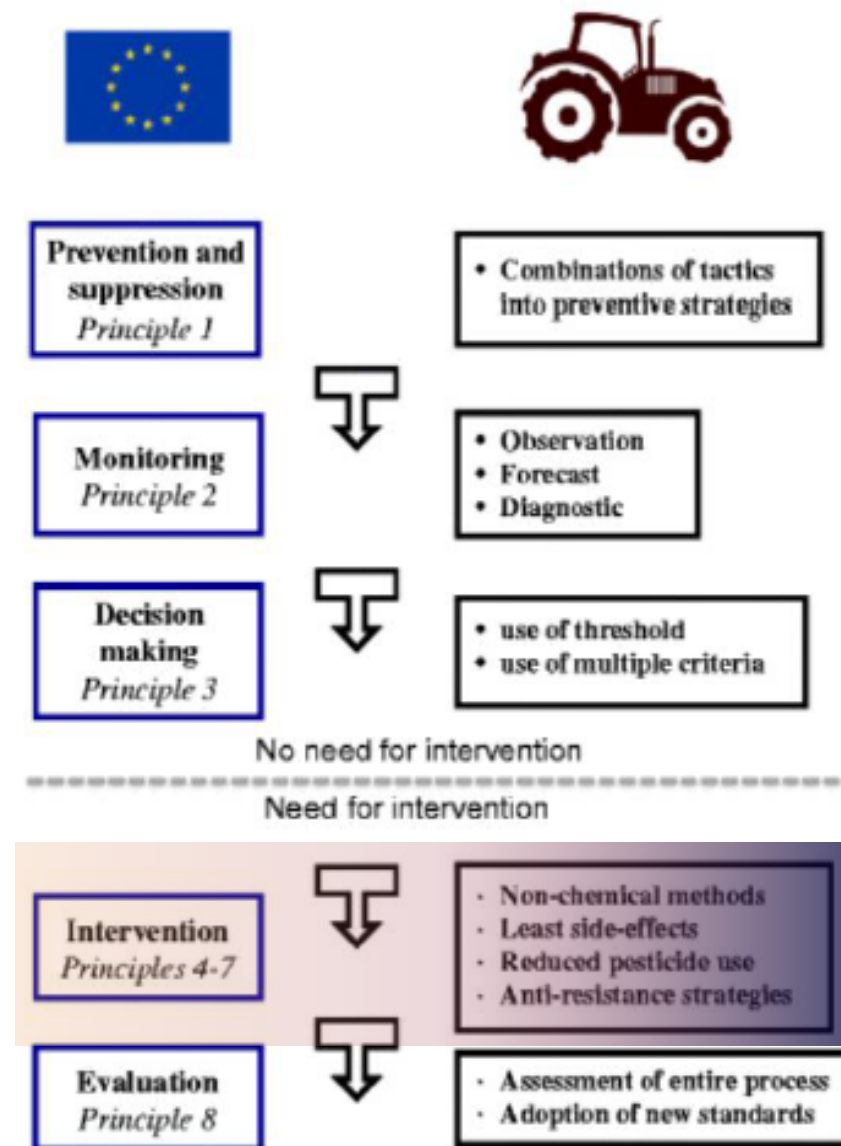


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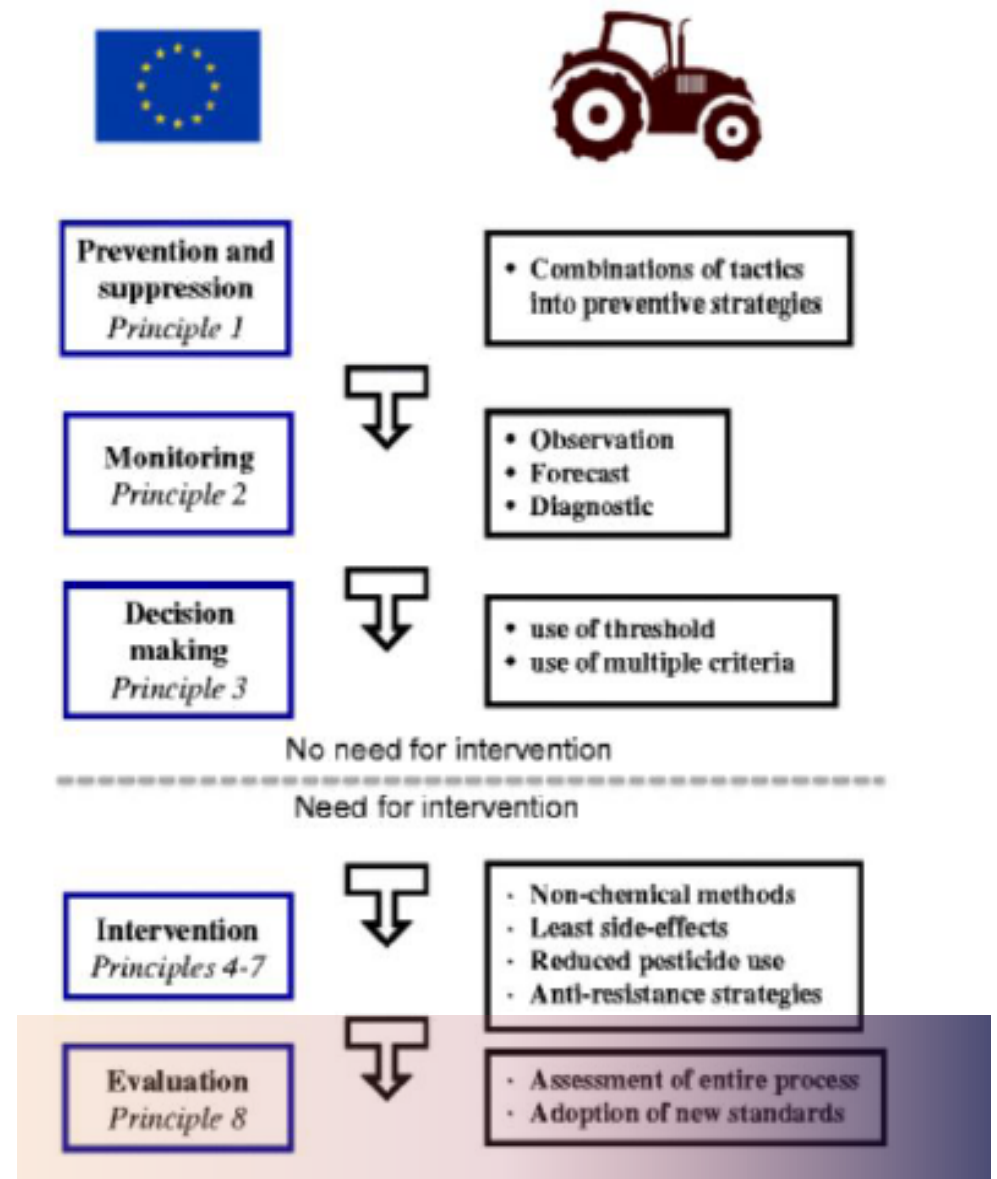


Figure 12 - The principles of IPM according to the European Commission (European Commission, 2018)

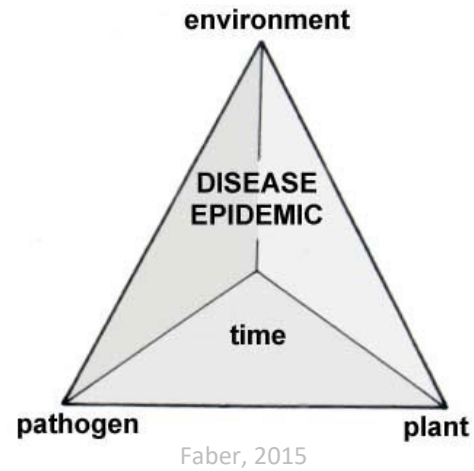
DSS

Decision Support System

Decision Support System

- Unterstützt AnwenderInnen bei Fragen rund um den Anbau
- Bewässerung
- Pflanzenernährung
- Pflanzenschutz
- Arbeiten mit Schwellwerten

(Sunil et al., 2015)



- Modell der Krankheitspyramide
- Viele Krankheiten sind an bestimmte Wetterbedingungen gebunden → Macht sie modellierbar
- Wetterstationen sind geeignet, um das Mikroklima im Feld zu messen

Margarey, Sutton, 2007 / Hardwick 1998



Table 1 – Calculation scheme for the DSV Parameters: Leaf Wetness (DSV_{LW}), Relative Humidity (DSV_{RH80} , DSV_{RH95}) and Wetness due to rainfall (DSV_{H2O})

PARAMETER	Number of hours (hours range)			
	1 - 3 hours	4 - 7 hours	8 - 11 hours	12 ≤ hours
1st Temperature Condition	EFI	EFI	EFI	EFI
2nd Temperature Condition	EFI	EFI	EFI	EFI
3rd Temperature Condition	EFI	EFI	EFI	EFI

EFIEnvironmental Favourability Index

DSV....Disease Severity Value

EFI * Number of hours within 1st Temperature condition = Result 1

EFI * Number of hours within 2nd Temperature condition = Result 2

EFI * Number of hours within 3rd Temperature condition = Result 3

Result 1 + Result 2 + Result 3 = DSV Parameter



Table 2 - Table for the calculation of the DSV Leaf Wetness (DSV_{LW}) - Schmolmüller 2018a

LW	Hours Range			
	1 - 3	4 - 7	8 - 11	12≤
$T < 78^{\circ}F$	10	14	18	22
$78^{\circ}F \leq T \leq 82^{\circ}F$	14	18	22	26
$T > 82^{\circ}F$	12	16	20	24

→ DSV Leaf Wetness

Table 3- Table for the calculation of the DSV Relative humidity from between more or equal to 80 % and less than or equal to 98 %. (DSV_{RH80}) – Schmolmüller 2018

$80\% \leq RH \leq 98\%$	Hours Range			
	1 - 3	4 - 7	8 - 11	12≤
$T < 78^{\circ}F$	2	6	10	14
$78^{\circ}F \leq T \leq 82^{\circ}F$	6	10	14	18
$T > 82^{\circ}F$	4	8	12	16

→ DSV Relative Humidity 80 – 98%

Table 4 --Table for the calculation of the DSV Relative humidity from between over 98 % and less than or equal to 100 %. (DSV_{RH98}) – Schmolmüller 2018a

$98\% < RH \leq 100\%$	Hours Range			
	1 - 3	4 - 7	8 - 11	12≤
$T < 78^{\circ}F$	6	10	14	18
$78^{\circ}F \leq T \leq 82^{\circ}F$	10	14	18	22
$T > 82^{\circ}F$	8	12	16	20

→ DSV Relative Humidity 98 – 100%

Table 5 - Table for the calculation of the DSV free available surface water due to rainfall (DSV_{H2O}) – Schmolmüller 2018a

Free H2O	Hours Range			
	1 - 3	4 - 7	8 - 11	12≤
$T < 78^{\circ}F$	10	14	18	22
$78^{\circ}F \leq T \leq 82^{\circ}F$	14	18	22	26
$T > 82^{\circ}F$	12	16	20	24

Table 6 - Rain event table for the calculation of the DSV Rain Events (DSV_{RE}) – Schmolmüller 2018a

Rain	Days						
	1	2	3	4	5	6	7
1 event	10	9	8	7	6	5	4
> 1 event	100	90	80	70	60	50	40

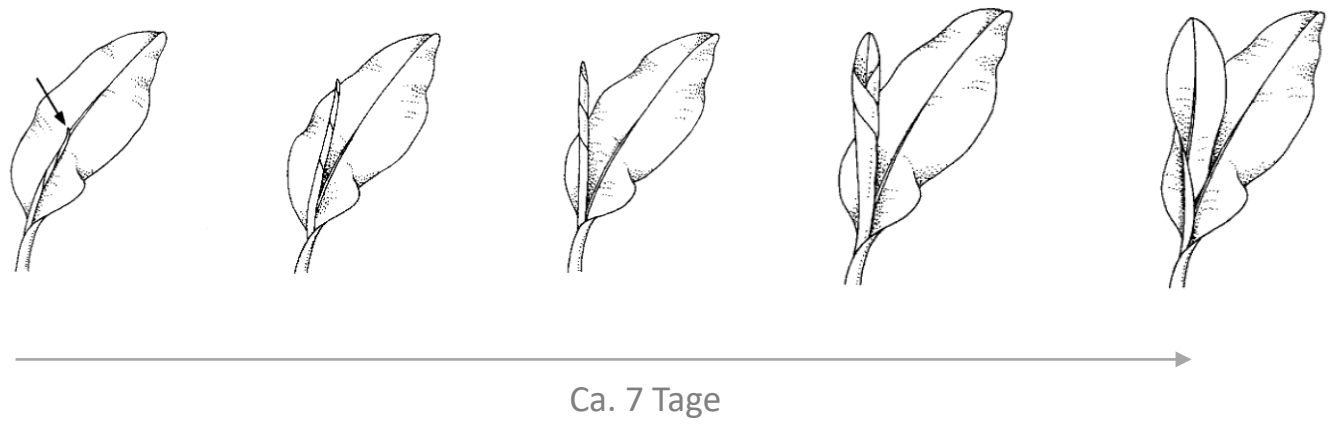
2 getrennte Regenereignisse sind durch mindestens 4 Stunden gekennzeichnet

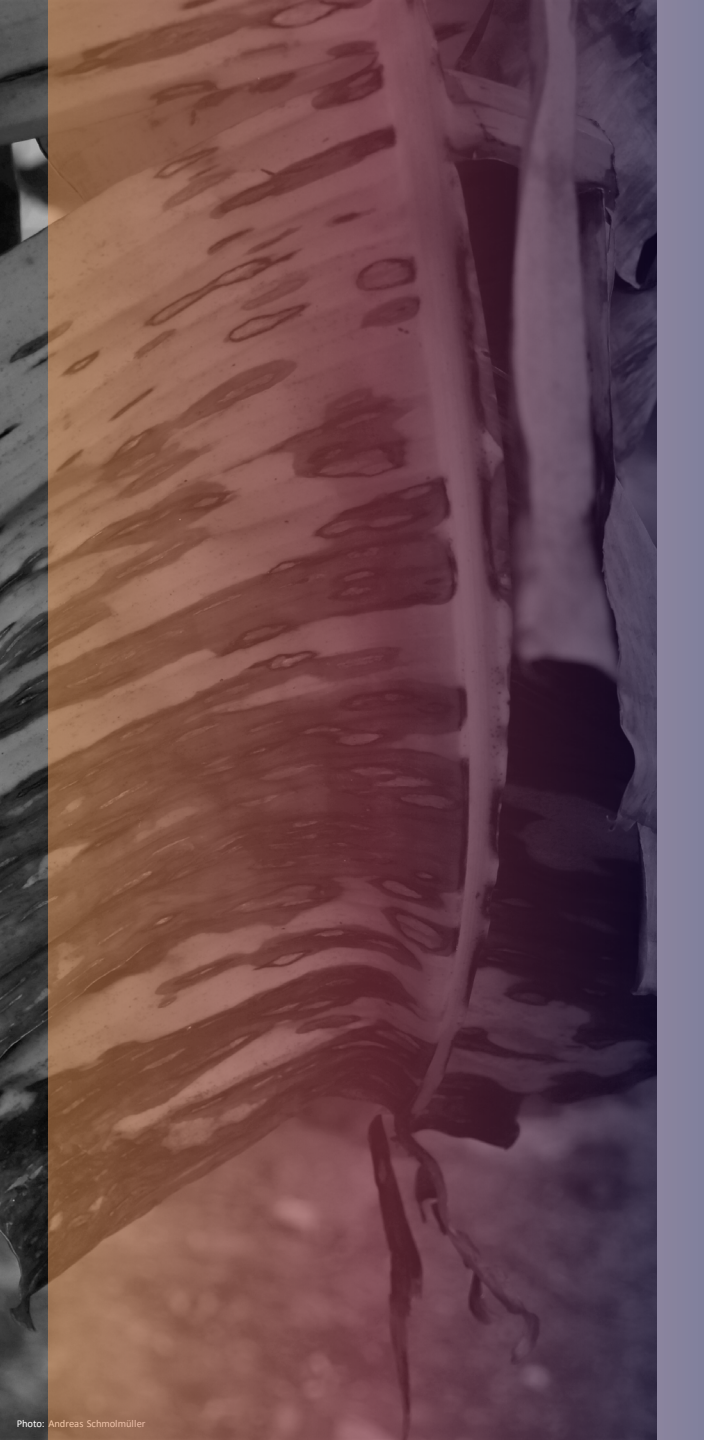
Table 5 - Table for the calculation of the DSV free available surface water due to rainfall (DSV_{H_2O}) – Schmolmüller 2018a

Free H ₂ O	Hours Range			
	1 - 3	4 - 7	8 - 11	12≤
T < 78 ° F	10	14	18	22
78 ° F ≤ T ≤ 82 ° F	14	18	22	26
T > 82 ° F	12	16	20	24

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Rain	Days						
	1	2	3	4	5	6	7
1 event	10	9	8	7	6	5	4
> 1 event	100	90	80	70	60	50	40




$$DSV_{\text{total}} = DSV_{\text{LW}} + DSV_{\text{RH80}} + DSV_{\text{RH98}} + DSV_{\text{H2O}} + DSV_{\text{RE}}$$

$$DSV_{\text{total}} / DSV_{\text{max}} = DSV_{\text{Index}}$$

$DSV_{\text{Index}} \geq 0.5 \rightarrow$ Treatment recommendation

Berechnungsintervall = 24 Stunden

$$DSV_{\text{max}} = 1000$$

Behandlungsempfehlung

5 Tage Pause

Wirkdauer der Spritzmittel





Installation of the weatherstation at crop height (WWF Mejia, 2012)





Daten und Informationsfluss

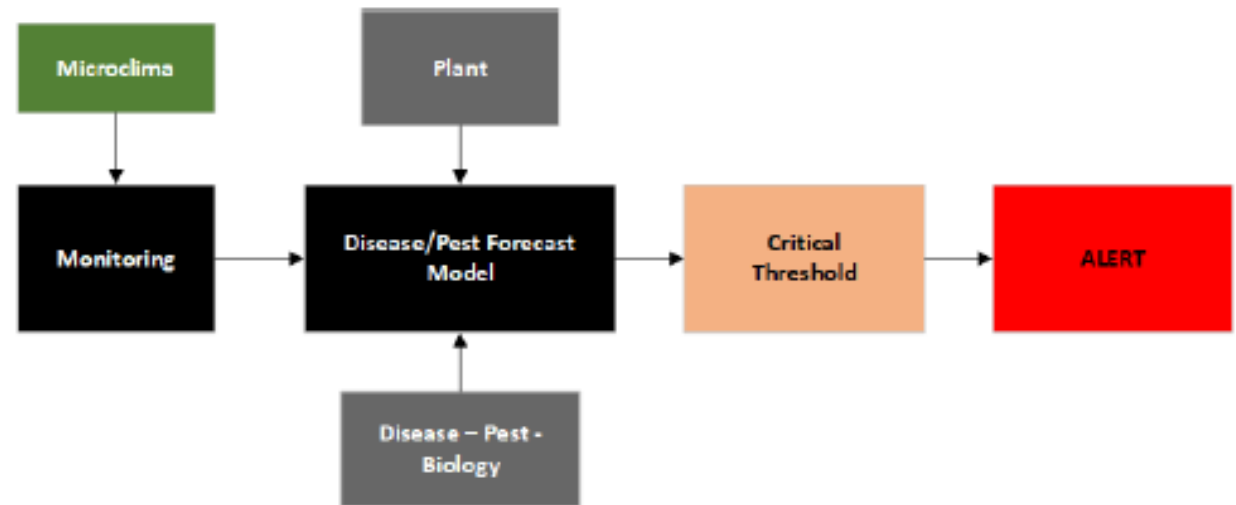
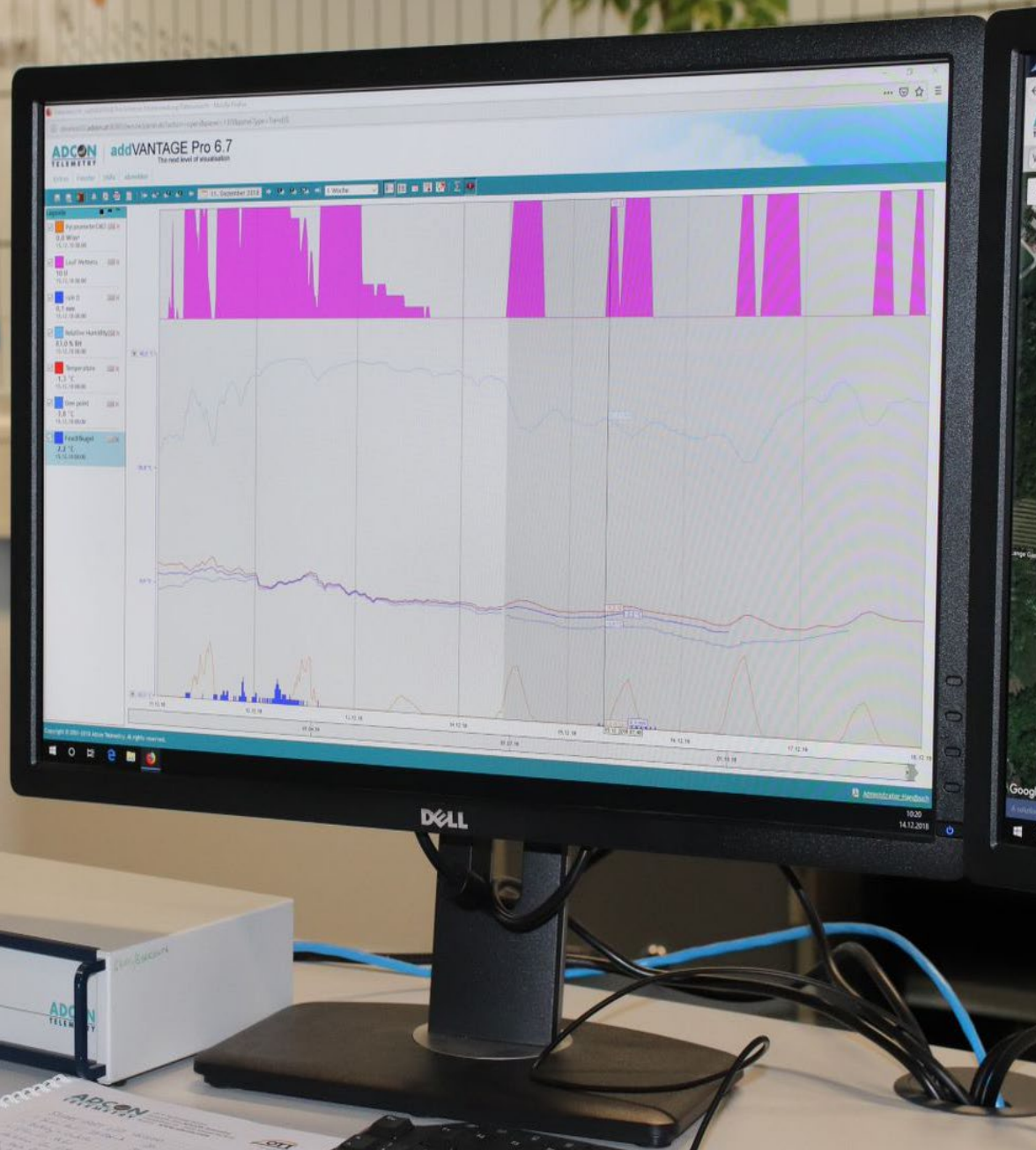
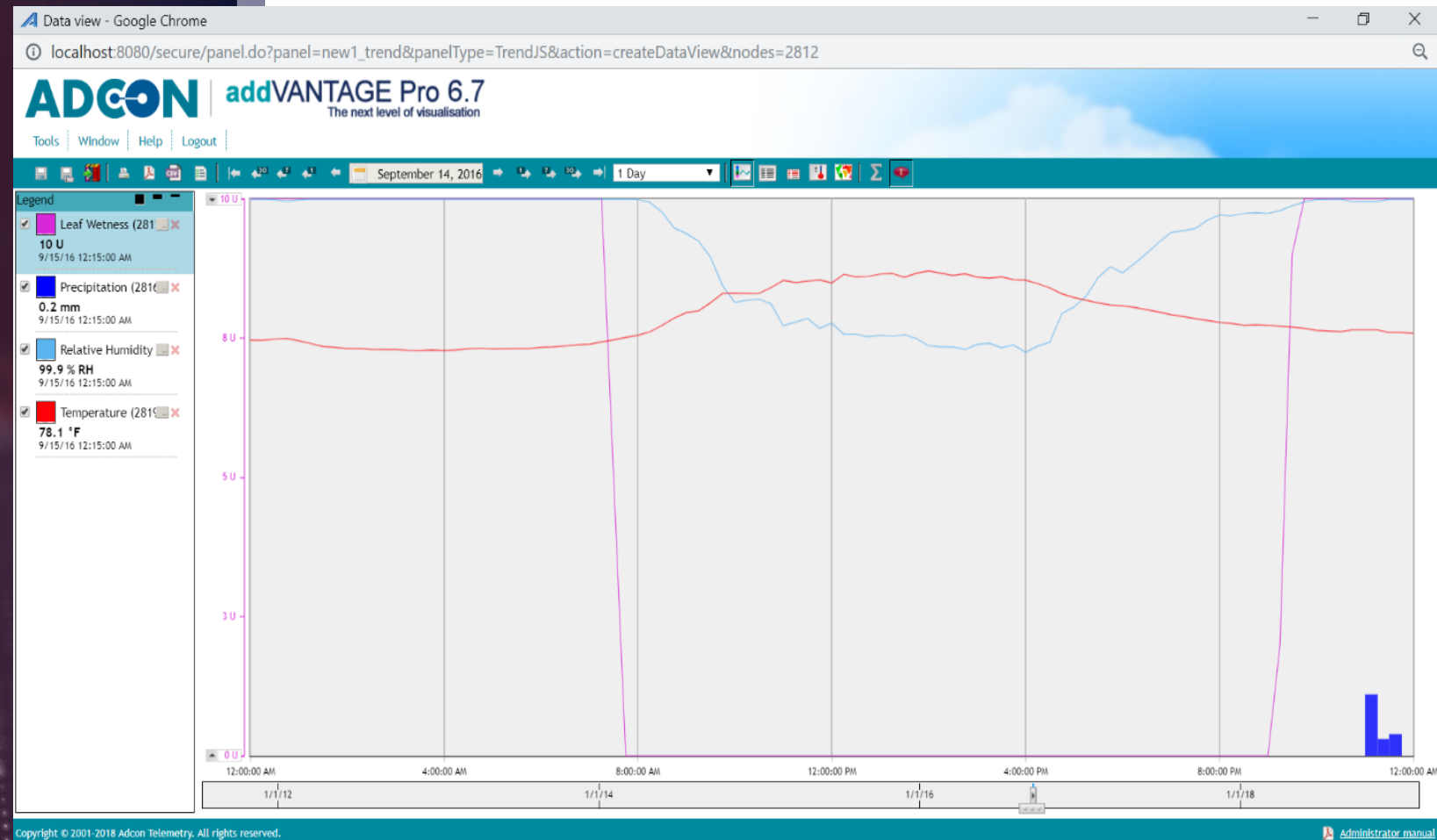


Figure 22 - Operating principle of the forecast model - own illustration according to Mestre et al., (2015)



Daten und Informationsfluss





-Screenshot of the visualization of the sensor data from the weather station located in the BGA Farm 09 - ADCON

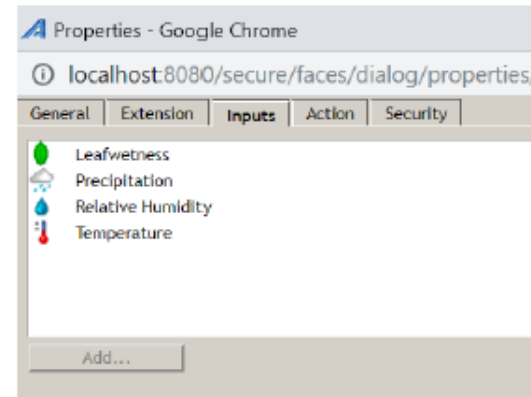
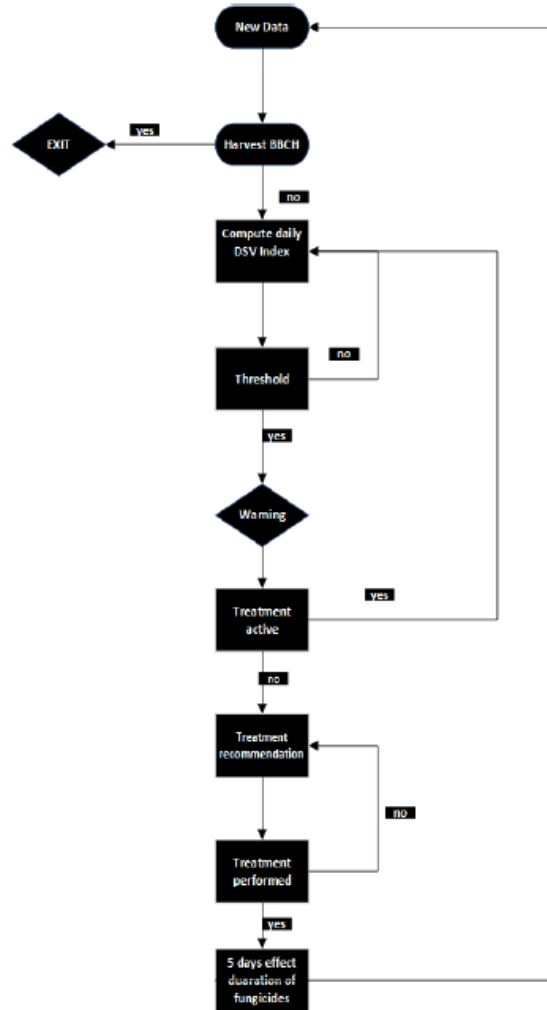


Figure 33 – Input data for the forecast model ADCON

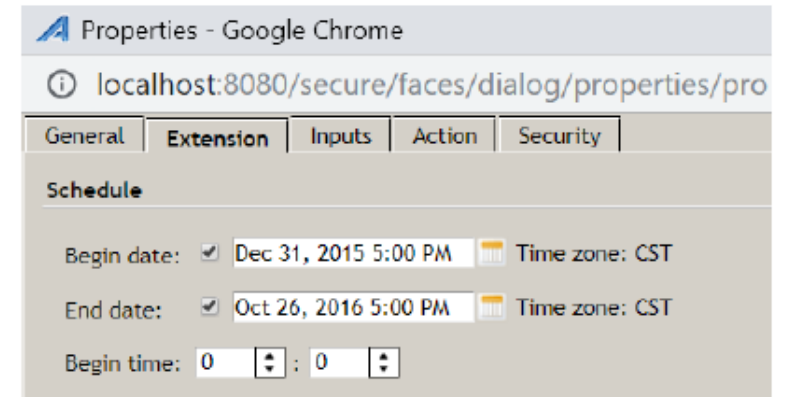


Figure 34 - Selection of the time point for the beginning of the calculation of the forecast model in the disease forecast model properties menu - ADCON

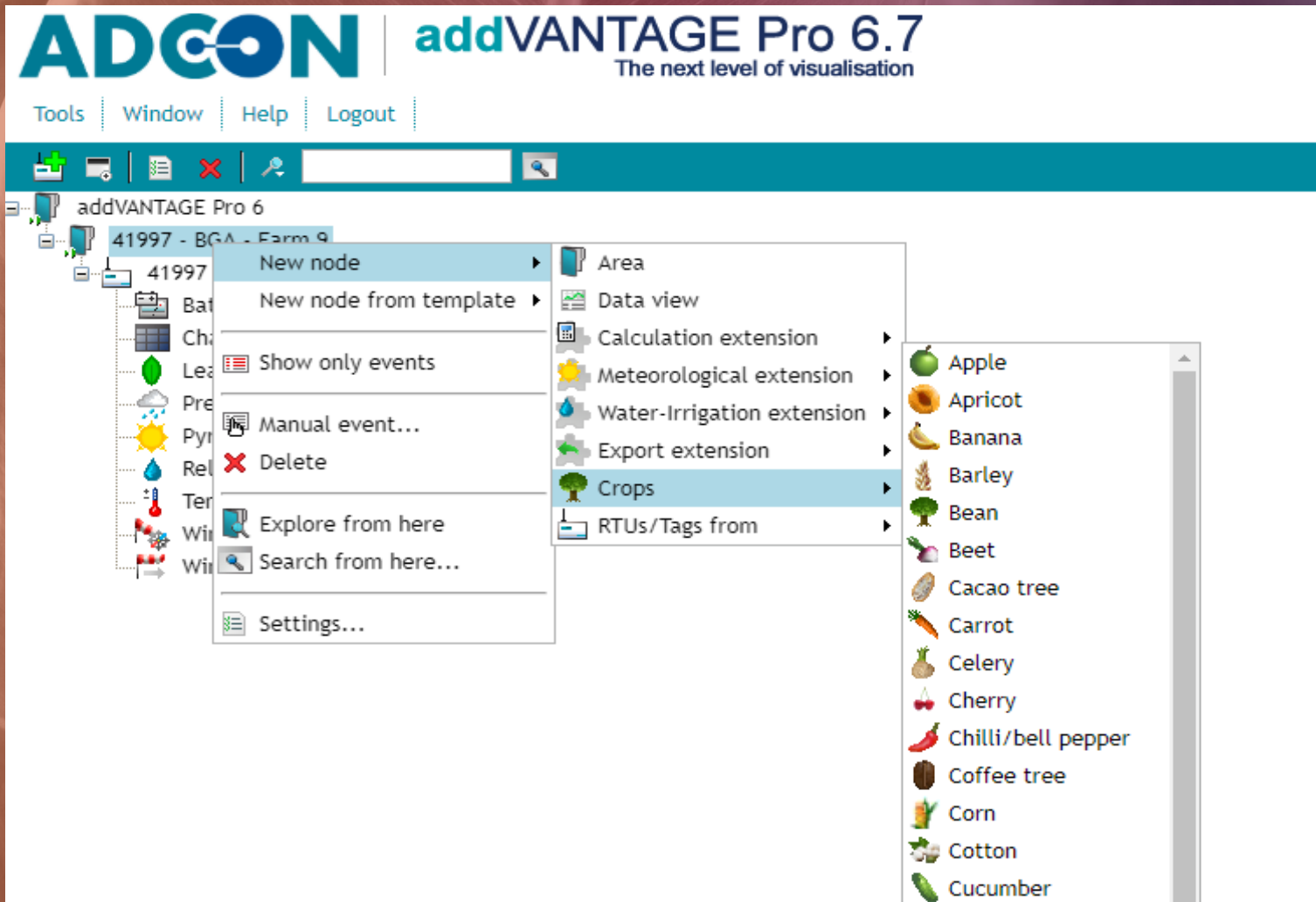


Zeitreihe der Daten im Stundenintervall der kompletten Bewirtschaftungsperiode 2019, 2017, 2018

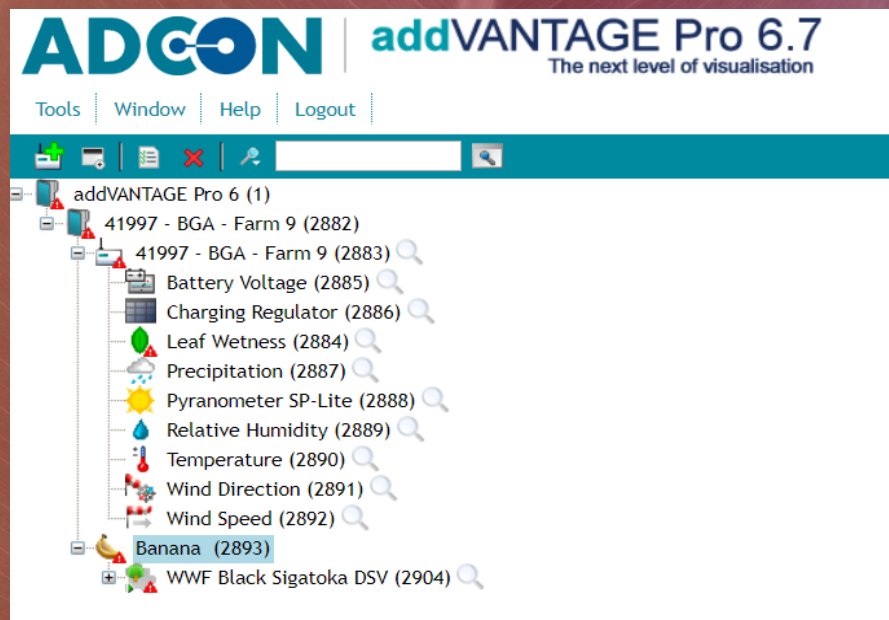
Es wurden aus den jeweiligen Jahren 3 zufällige Wochen ausgewählt (jeweils 7 Tage aus den Jahren 2016, 2017 und 2018)

Die Wochen wurden händisch mit den von ADCON gelieferten Originaldaten nachgerechnet und anschließend verglichen, ob die gleichen Ergebnisse von der Software berechnet wurden

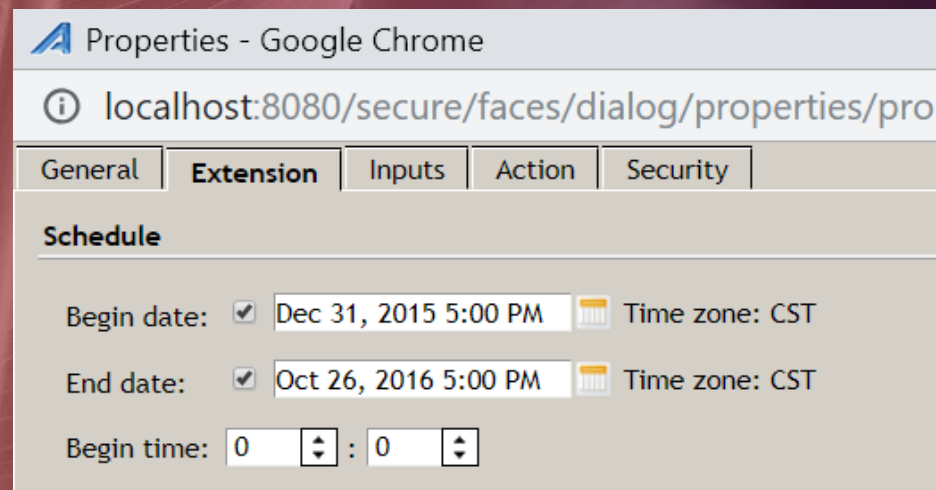
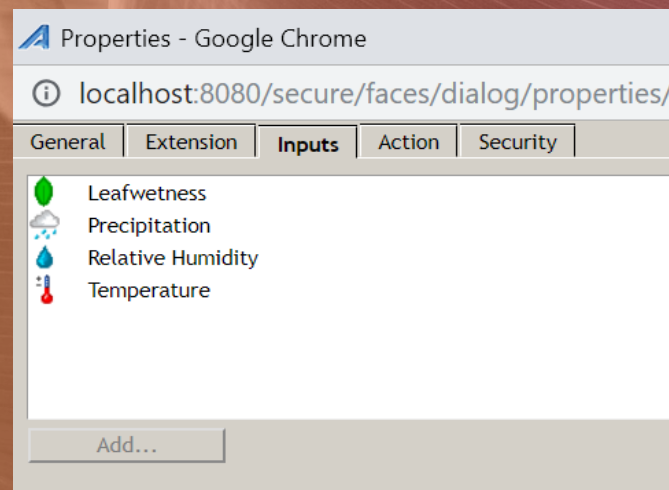




RESULTATE



RESULTATE



Date	DSV H2O	DSV Index	DSV Leaf Wetness	DSV RH80	DSV RH98	DSV Rain Events	DSV Total	Rain Events
Sep 11, 2016 4:00:00 PM	0	0.318	188	30	100	0	318	0
Sep 12, 2016 4:00:00 PM	14	0.457	252	28	156	7	457	1
Sep 13, 2016 4:00:00 PM	84	0.484	212	28	154	6	484	1
Sep 14, 2016 4:00:00 PM	24	0.403	176	72	126	5	403	1
Sep 15, 2016 4:00:00 PM	102	0.518	206	82	124	4	518	1
Sep 16, 2016 4:00:00 PM	112	0.512	192	72	126	10	512	1
Sep 17, 2016 4:00:00 PM	34	0.576	200	126	126	90	576	2

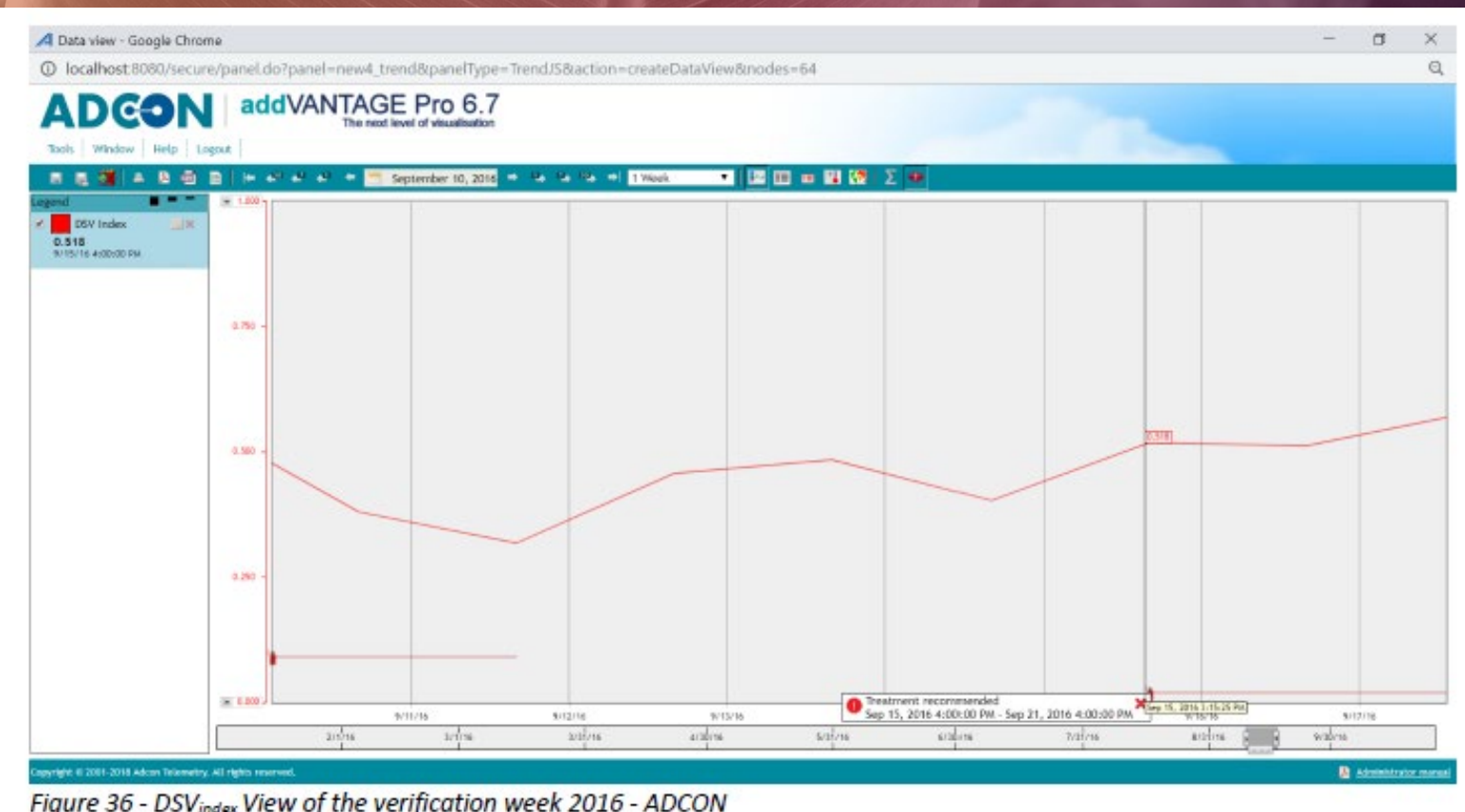


Figure 36 - DSV_{index} View of the verification week 2016 - ADCON

RESULTATE





Diskussion

Anforderungen für ein Vorhersagemodell?

Welche Daten ? Woher? So korrekt wie möglich?

Margarey, Sutton 2007

Voraussetzungen für ein Vorhersagemodell?

Economic Interest / Threshold based / Verwendbar innerhalb einer DSS

Esker et al. 2008

Integrierte Ansätze im Black Sigatoka Management?

Zeitpunkt / Fungizide

Ganry et al. 2012



Zusammenfassung und Ausblicke

- Modell an Krankheitsdruck anpassen (Weekly Avarage / DSV max variable/adaptable)
- Nachvollziehbarkeit von Pflanzenschutz im Bananenbau sehr intransparent
- Symptombehandlung statt Ursachen

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VIELEN DANK

?? FRAGEN ??

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