Verticillium dahliae transcription factors Som1 and Vta3 control microsclerotia formation and sequential steps of plant root penetration and colonisation to induce disease

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Summary

Verticillium dahliae belongs to the soil-borne ascomycete fungi. It causes wilt diseases and early senescence in more than 200 plant species including economically important crops. It can exist in the soil without a host for a decade by forming microsclerotia. Root exudates induce germination of microsclerotia. *V. dahliae* enters its hosts through root infection, colonises the root cortex and invades the xylem vessels. The host infection of pathogenic fungi requires penetration and colonisation processes. The penetration of the root surface needs adhesive proteins at several stages during the host-parasite interaction. Adhesion proteins are not well described in *V. dahliae* whereas they are well studied in *Saccharomyces cerevisiae*. *S. cerevisiae* Flo8 is a transcription factor of adhesion, which regulates the expression of flocculation genes such as *FLO1* and *FLO11*. The defective *FLO8* strain is unable to adhere to agar plates or to flocculate in liquid medium. *V. dahliae* nuclear transcription factors Som1 and Vta3 can rescue adhesion in a *FLO8*-deficient *S. cerevisiae* strain. Som1 and Vta3 induce the expression of *FLO1* and *FLO11* genes encoding adhesins. The *SOM1* and *VTA3* genes were deleted and their function in fungal induced plant pathogenesis was studied by genetic, cell biological, proteomic and plant pathogenicity experiments. *V. dahliae* Som1 and Vta3 are sequentially required for root penetration and colonisation of the plant host. Som1 supports fungal adhesion and root penetration and is required earlier than Vta3 in the colonisation of plant root surfaces and tomato plant infection. Som1 controls septa positioning, the size of vacuoles, and subsequently hyphal development including aerial hyphae formation and normal hyphal branching. Som1 and Vta3 control conidia and microsclerotia formation and antagonise in oxidative stress response. The molecular function of Som1 is conserved between the plant pathogen *V. dahliae* and the opportunistic human pathogen *Aspergillus fumigatus*. Som1 controls the expression of genes for adhesion and oxidative stress response. Som1, as well as Vta3, regulate a genetic network for conidia and microsclerotia formation and pathogenicity of *V. dahliae*.

Zusammenfassung

Verticillium dahliae gehört zu den bodenbürtigen Askomyceten. Dieser Pilz verursacht Welke-Erkrankungen und verfrühtes Altern in mehr als 200 verschiedenen, auch ökonomisch wichtigen Pflanzen. *Verticillium* kann im Boden ohne Wirtspflanze durch die Bildung von Mikrosklerotien bis zu 10 Jahre überleben. Wurzelexsudate induzieren die Auskeimung der Mikrosklerotien. *V. dahliae* infiziert seinen Wirt durch die Wurzel, besiedelt den Wurzelkortex und dringt dann in die Xylemgefäße ein. Die Infektion des Wirts durch pathogene Pilze erfordert Penetrations- und Kolonisierungsprozesse. Am Eindringen durch die Wurzeloberfläche sind adhäsive Proteine an verschiedenen Stellen der Wirt-Parasit-Interaktion beteiligt. Adhäsive Proteine sind in *S. cerevisiae* gut untersucht, während nur wenig über sie in *V. dahliae* bekannt ist. Der Adhäsions-Transkriptionsfaktor Flo8 aus Hefe reguliert die Expression der sogenannten „Flocculation"-Gene wie zum Beispiel *FLO1* und *FLO11*. Ein Stamm ohne *FLO8* ist nicht in der Lage an Agarmedium zu haften und in Flüssigmedium auszuflocken. Die im Zellkern lokalisierten Transkriptionsfaktoren Som1 und Vta3 können die Adhäsion in einem *S. cerevisiae* Stamm, welchem *FLO8* fehlt, wiederherstellen. Som1 und Vta3 induzieren die Expression von *FLO1* und *FLO11*, welche Adhäsine kodieren. Die *SOM1* und *VTA3* Gene wurden deletiert und ihre Funktion in der durch Pilze verursachten Pflanzenpathogenese wurde durch genetische, zellbiologische, Proteom- und Pflanzenpathogenitätsexperimente untersucht. *V. dahliae* Som1 und Vta3 sind sequenziell für die Penetration und Kolonisation des Pflanzenwirts erforderlich. Som1 unterstützt die pilzliche Adhäsion sowie das Eindringen in die Wurzel. Somit wird es früher für die Besiedlung der Pflanzenwurzeloberfläche und die Tomateninfektion benötigt als Vta3. Som1 kontrolliert darüber hinaus die Positionierung von Septen und die Größe von Vakuolen und folglich auch die Entwicklung von Hyphen inklusive der Bildung von Lufthyphen und normalen Hyphenverzweigungen. Som1 und Vta3 beeinflussen die Bildung von Konidien und Mikrosklerotien und wirken sich in der Antwort auf oxidativen Stress entgegen. Die molekulare Funktion von Som1 ist zwischen dem Pflanzenpathogen *V. dahliae* und dem opportunistischen Humanpathogen *Aspergillus fumigatus* konserviert. Som1 kontrolliert die Expression von Genen welche für Adhäsion und die Antwort auf oxidativen Stress benötigt werden. Sowohl Som1 als auch Vta3 regulieren ein genetisches Netzwerk für die Bildung von Konidien und Mikrosklerotien sowie die Pathogenität von *V. dahliae*.