Geophysical Research Abstracts
Vol. 19, EGU2017-4304, 2017
EGU General Assembly 2017

Proximal sensing of within-field mycotoxin variation - a case study in Northeast Germany

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Fusarium head blight is a global problem in agriculture that results in yield losses and, more seriously, produces harmful toxins that enter the food chain. This study (Müller et al. 2016) builds on previous research identifying within-field humidity as an important factor in infection processes by Fusarium fungi and its mycotoxin production. Environmental variables describing topographic control of humidity (topographic wetness index TWI), soil texture and related moisture by electrical conductivity (ECa), and canopy humidity by density (normalized difference vegetation index NDVI) were explored in their relationship to the fungal infection rates and mycotoxin accumulation. Field studies at four sites in NE German Lowlands were performed in 2009 and 2011. Sites differed slightly in soil textural properties and, more pronounced, mean annual precipitation. Sampling positions were selected by usage of NDVI values range from remote sensing data base.
Environmental data included elevation and its derivatives like topographic wetness index (TWI) from a DEM25, electrical conductivity distribution maps (5 x 5 m) based on EM38DD survey and, orthorectified RapidEye imagery (5 x 5 m^2) with resulting NDVI distributions across the field sites. Grain yield, fungal infection rate, microbiological characteristics and mycotoxin accumulation were determined at 223 field positions. Statistical analysis incorporated Spearman rank order correlations and three regression methods (censored regression models, linear mixed-effects models and spatial linear mixed-effects models). Kriging was used to visualize the spatial patterns and trends. All analyses were performed by R software.
In 2011, a more wet year than 2009, high Fusarium infection rates and a high concentration of mycotoxins were stated, the latter once exceeding EU threshold values. For both years associations between NDVI and microbiological variables were found, but being more pronounced and more often significant for 2011 than for 2009. ECa was only related with deoxynivalenol concentration (DON) and abundance of trichothecene-producing fusaria (tri6 gene copy number) in 2009 and, to DON and zearalenone (ZEA) in 2011. In contrast to former findings no correlations were found between TWI and mycological data.
NDVI and, less importantly, ECa were essential predictors in all three regression models. Mycotoxins DON and ZEA distribution maps could be interpolated by kriging with internal drift based on these two proximal predictor variables. Providing spatial patterns of mycotoxigenic fungi and its effects may be used to infer mycotoxin hot spots, to develop models for risk assessment and, to manage plant and crop treatments or even harvest.
Müller, M.E.H., Koszinski, S., Bangs, D.E. et al. Precision Agric (2016) 17: 698. doi:10.1007/s11119-016-9444-y