Simple models to predict the incidence of premature ripening caused by Phoma macdonaldii as a function of sunflower crop management

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Premature ripening (PR) induced by *Phoma macdonaldii* Boerema is one of the most severe and widespread sunflower disease in France. PR could be responsible for the stagnation of seed yields around 2.5 $t.ha^{-1}$ during the two last decades. As no resistant variety and no fungicide are available, cultural control remains the alternative method to limit yield losses. High N availability, high plant density and water stress after flowering significantly increase the occurrence of PR in sunflower (Seassau *et al.*, 2010). In this paper, simple statistical models are suggested to represent PR incidence as a function of plant nitrogen status, plant population and water stress.

Methodology

Field experiments were carried out from 2006 to 2009 at INRA experimental station in Auzeville (SW France) on deep silty-clay to clay soils. Three N rates (N1 : 0 ; N2 : 50/75 ; N3 : 150 $kg.ha^{-1}$), three plant densities after thinning (d1: 4 ; d2 : 6.5 ; d3 : 9 plants m^{-2}) and two water regimes (rainfed ; irrigated) were applied to two cultivars differing in their susceptibility to PR (cv. Heliasol RM, susceptible and cv. Melody, with a higher level of partial resistance) in a split-plot design with 3 replications. On all treatments, 25 plants were either artificially inoculated (AI) at star bud stage with a disc of *P. macdonaldii* mycelium placed for 5 days at the plant stem base, or were subjected to natural infection (NI). The percentage of PR plants was assessed weekly from inoculation until 10 days before physiological maturity of disease-free plants. For each year, PR was subjected to variance component analysis to estimate the contribution of the 5 experimental factors (cultivar, nitrogen, irrigation and inoculation method in 2006-07; nitrogen, irrigation and plant density in 2008-09) to the total variance.

At anthesis, Nitrogen Nutrition Index (NNI) was calculated according to Debaeke and Raffaillac (2006) to characterize plant N status, N deficiency increasing with NNI falling. Stem base diameter (SD) was measured once at flowering in relation to plant density, SD being maximal at the lowest plant density. From inoculation to physiological maturity, water satisfaction index (WSI: $ET_{actual}/ET_{reference}$) was simulated using the SUNFLO crop model (Casadebaig, 2008). The influence of N, plant density, and irrigation on soil water depletion was thus simulated. The percentage of PR plants was related to NNI, SD and WSI by a stepwise regression model at $P < 0.05$.

Results and discussion

From the variance component analysis, it appears that nitrogen and cultivar are the main factors playing on PR (Table 1). In 2006 and 2009, as post-anthesis drought was pronounced, irrigation had a significant effect on PR. In comparison, the contributions of plant density and method of inoculation were minor.

A stepwise regression analysis was attempted for cv. Heliasol on AI treatments using 4-yr data and two plant indicators: NNI for nitrogen status and WSI for water status. The corresponding linear model for d2 conditions was:

PR (%) = 59.6 + 108.9 NNI – 118.7 WSI (n = 22 plots ; $r^2 = 0.714$).

On the 2008-09 data, where variations of plant density were introduced, the model was:

PR (%) = 94.0 + 98.4 NNI - 80.7 WSI – 2.6 SD (n = 36 plots ; r^2 = 0.577).

From these two models, it can be concluded that increasing N fertilization rate (high NNI), increasing water stress by omitting irrigation after anthesis (low WSI) and increasing plant density (low SD) all resulted in more PR plants.

	2006	2007	2008	2009
Genotype	26,5	23,4	-	-
Nitrogen	13,7	60,2	84,1	72,5
Irrigation	31,4	0	0	7,9
Plant density	-	-	3,9	7,8
Inoculation method	13,3	3,9	-	-
Error	*15,2*	*12,6*	*12,0*	*11,8*

Table 1. Components of total variance (%): effect of 5 factors on PR incidence.

As nitrogen was the most influencing factor of PR incidence, the relationship between PR (%) and NNI at anthesis was plotted (Fig.1). High N fertilizer rate or high soil N content, both resulting in high NNI values, were conducive to increase PR incidence. For a given value of NNI, more PR plants were observed at normal plant density (d2) under rainfed management than after irrigation or when sunflower was grown at low plant density (d1).

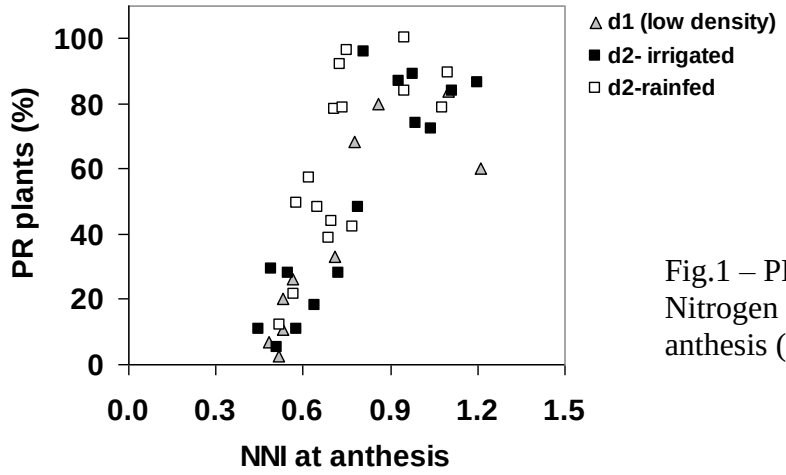

Fig.1 – PR plants (%) as related to Nitrogen Nutrition Index (NNI) at anthesis (2006-09)

Conclusion

Simple models were developed to represent the effect of sunflower crop management on PR incidence. Cumulative indicators of plant N and water status associated to stem base morphology can be used to predict the risk of PR in sunflower. High N tissue concentration may thus stimulate the spread of the fungus within the stem, the full invasion being favoured by low stem base diameter. Disease severity is increased by water stress leading to plant wilting 2-3 weeks before physiological maturity. N plant rationing and post-anthesis irrigation would be good practices to prevent heavy PR damages. The seed yield and oil content outputs of sunflower crop models (e.g. SUNFLO) might be corrected by simple models.

References

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