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Environmental conditions inducing black-point symptoms in durum wheat

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SUMMARY – Taking into account black-point susceptibility in a screening test lead to a better knowledge of the factors involved. Abiotic factors such as humidity or temperature contribute to inducing black-point and modelisation of their interactions allows threshold values to be determined.

Key words: Black-point, abiotic conditions, durum wheat, screening test.

RESUME – *"Conditions environnementales induisant des symptômes de moucheture chez le blé dur". La prise en compte de la sensibilité du blé dur au phénomène de moucheture dans un programme de sélection nécessite une meilleure connaissance des facteurs favorisant son apparition. Les facteurs abiotiques, hygrométrie et température, jouent un rôle important et la modélisation de leurs interactions permet de mettre en évidence des valeurs seuils nécessaires au déclenchement de la moucheture.*

Mots-clés : *Moucheture, conditions abiotiques, blé dur, test de sélection.*

Introduction

Symptoms of black point in grains of durum wheat (*Triticum durum* Desf.) can cause downgrading of the grain at marketing. A black-point screening process needs to be incorporated into all breeding programs. But to develop a screening test, it is necessary to identify the factors involved in black-point symptoms.

The literature ascribes different causes to black point: the development of fungi such as *Alternaria alternata*, *Cochliobolus sativus*… (Fernández *et al.*, 1994) or of thrips (Bournier and Bernaux, 1971) during anthesis period is often associated with the development of black point. But recent studies found no correlation between infection with these pathogens and black-point symptoms (Tabusse, 1986; Williamson, 1997). Humid atmospheric conditions since flowering periods are also associated with black-point symptoms (Conner *et al.*, 1992; Kashyap and Duhan, 1994). The objective of the present study was to evaluate the real impact of a high level of humidity on a broad range of cultivars known to be either susceptible or resistant to black point.

Materials and methods

The black-point suceptibility of 14 durum wheat cultivars was evaluated during two years in field trials conducted at the Station de Génétique et d'Amélioration des Plantes, Montpellier, France. Several treatments were made to apply different combinations of humidity and temperature from heading to milk stages. Stages lag were obtained by sowing lag or by plant forcing (with a cover net). A high level of humidity (>70%) was applied and maintained under a tunnel, using micro sprinklers. Control treatment was conducted without tunnel and irrigation. Climatological data were monitored througout each treatment.

Kernels were classified according to the level of black-point symptoms intensity (crease completely or partially discoloured) and to the spot colours (brown or black). 100 grams of kernels were studied per plot. The kernels with discoloured spots were weighed and black point was expressed in % of the total seed weight.

Black-point data were analysed using analysis of variance including year, treatments and cultivars. To focus on treatment, the year and cultivar effects were substracted to black-point data and then the relative contributions of humidity, temperature and their interactions were analysed using a mixed model (1): $B_{th} = \mu + \alpha_t + \beta_h + (\alpha\beta)_{th} + e_{th}$, where B_{th} is the black-point level under the temperature t and the humidity h, μ is the general mean, α_t is the temperature main effect, β_h is the humidity main effect, $(\alpha\beta)_{th}$ is the interaction between temperature and humidity and e is the standard error.

Results and discussion

The three main effects involved in black-point variances are in order of importance: the year, the treatments and the cultivars.

For a given year (Table 1), an increase of the humidity level leads to a significant increase of black-point rate.

Table 1. Black-point rate (%) measured under different levels of humidity (control and tunnel), during two years

Year	Control		Tunnel	
	Black point	Humidity	Black point	Humidity
1997	59 b	66%	79 a	72%
1998	39 b	77%	63 a	86%

[a,b]Within a year, means followed by the same letter are not significantly different at 5%.

During the second year (1998), although the average humidity was greater, the black-point rate was lower than in 1997. Therefore, a high level of humidity seems to be a necessary but not sufficient condition for inducing black point.

To go further into the analysis and to investigate the effect of treatments, each treatment was characterized by the average temperature and the average humidity during the period ranging from heading to milk stage.

The contribution of the temperature and humidity to the total sum of squares of the model (1) is shown in Fig. 1.

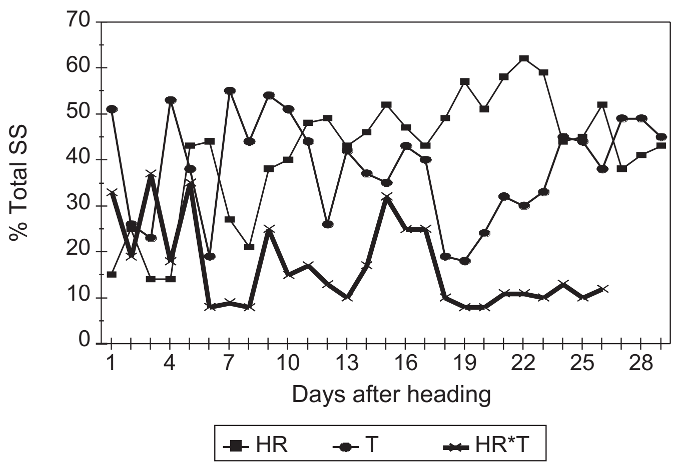

Fig. 1. Part of the total sum of squares (SS) explained by the humidity effect (HR), temperature effect (T) and the interactions between the two effects (HR*T).

From heading to flowering (10 days), the variance of black-point rate is essentially linked to the temperature. After flowering, humidity seems to be the main factor. The interaction between humidity and temperature, although lower, is significant.

This interaction can be decomposed by the model (2) of Mandel as following: $B_{th} = \mu + \alpha_t + \beta_h + \Sigma(\theta_r.\gamma_{rt}.\delta_{rh}) + e_{th}$, where B_{th}, μ, α_t, β_h are the same than in model (1) but the interaction $\Sigma(\theta_r.\gamma_{rt}.\delta_{rh})$ is here decomposed into a sum of multiplicative terms linked to the temperature (γ_{rt}) or to the humidity (δ_{rh}).

Therefore, each temperature can be characterised by two parameters (its main effect and its multiplicative term) and each humidity also. Figure 2 shows temperature and humidity plotted according to their two parameters.

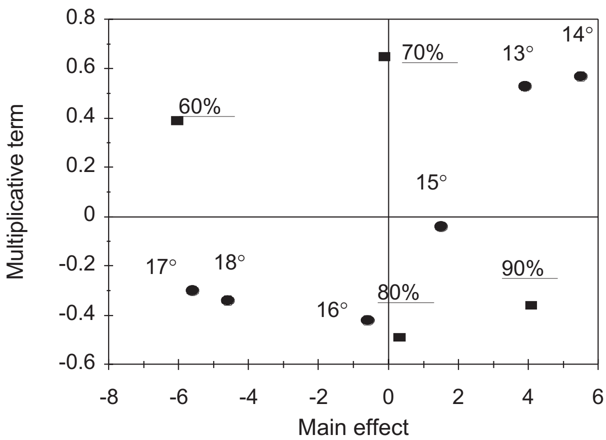

Fig. 2. Black-point incidence (Xaxis) due to humidity (■) or to temperature (●) and contribution to the interaction (Yaxis).

The higher main effect and thus the higher black-point incidence is obtained with high humidity (80-90%) and low temperature (13, 14ºC). Multiplicative term must be analysed jointly: temperature with a multiplicative positive term (13, 14ºC) may induce black point if it occurred with humidity also having a positive multiplicative term (60, 70%).

Conclusion

High humidity was known to induce black point but rarely was the interaction with temperature was displayed. A screening test may be proposed by placing plants during the period “heading to milk stage” under high humidity and low temperatures. A field screening can be envisaged with a tunnel set up during this period.

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