

## Genotype Difference in Kernel Discolorations in CWRS and CWAD Wheats

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### Abstract

Kernel discolorations of wheat, such as black point (including smudge and penetrated smudge), red smudge and Fusarium-damaged kernel (FDK), are important downgrading factors in western Canada. This study was undertaken to determine cultivar differences in incidences of these kernel discolorations and their downgrading effects in CWRS and CWAD wheats. Grain samples were taken at maturity from six CWRS and four CWAD cultivars in a four-year (1997-2000) field study at six sites: one in the Grey soil zone, two in the Brown soil zone and three in the Black soil zone in western Canada. For CWRS cultivars, Garnet tended to have lower incidences in black point, smudge and FDK and resulted in the least downgrading compared with other CWRS cultivars. For CWAD cultivars, Kyle tended to have lower incidence of black point, Plenty had less smudge-caused downgrading effects, DT 369 had lower penetrated smudge incidence, but higher red smudge incidence, and Plenty tended to have severer FDK-caused downgrading effects compared with other CWAD cultivars. CWAD class had higher frequency of downgrading than CWRS class and it usually had higher incidences of all kernel discolorations (black point, smudge, penetrated smudge, red smudge and FDK) and greater downgrading effects than CWRS class.

### Introduction

Kernel discoloration of wheat, such as black point, red smudge and Fusarium Head Blight damaged kernel (FDK), are important downgrading factors in western Canada (Table 1). Although genotype differences in susceptibility to kernel discoloration among wheat species, quality classes and cultivars were found by some studies, to our knowledge, no study has been done to concurrently compare varietal susceptibilities to all above-mentioned kernel discolorations and their downgrading effects in western Canada. This information is important for producers to choose suitable wheat class and cultivars under their environments and for breeders to select lines resistant to kernel discoloration. The objective of this study was to determine cultivar differences in the incidence of these kernel discolorations and in their downgrading effects for CWAD and CWRS wheat in western Canada.

### Materials and Methods

Grain samples were taken from a four-year (1997-2000) field study conducted at six sites with different soil types (Beaverlodge and Lethbridge, AB, Swift Current, Melfort and Indian Head, SK, and Glenlea, MB). Three CWAD cultivars (AC Avonlea, Kyle and Plenty), an unregistered durum wheat genotype, DT 369, and six CWRS cultivars (AC Cadillac, AC Domain, Garnet, Katepwa, Roblin and Saunders) were tested in the study. For simplicity, DT 369 will hereafter be referred to as a CWAD cultivar. The experimental design was a two-replicate RCB in a split-plot arrangement, with harvest time as the main plot and genotype as the subplot. Each subplot consisted of a 3m long row. Starting from 3 to 4 weeks after anthesis, all heads from each subplot were harvested at 8-12 weekly intervals and air-dried until the moisture content was 11-14%.

Incidences of black point, smudge, penetrated smudge, red smudge and FDK and kernel weight were determined in a sample of 300 kernels randomly taken from the harvested grain from each subplot. Grades were determined according to the Official Grain Grading Guide of Canadian Grain Commission 2002 (Table 1). In order to eliminate the weathering effect on kernel discoloration caused by delayed harvest, only data from harvests when the crop just reached physiological maturity were used for analysis. Physiological maturity was determined by comparing kernel weights among harvests, assuming that wheat physiologically matures when kernels reach the maximum weight.

### **Statistical Analysis**

All dependent variables were analyzed with the Mixed model (SAS Institute, Inc. 1996) using the REML option for each environment (location/year), and combined with cultivars fixed and replications and environments random. Environments without any incidence of a discoloration were not included in the combined analysis of that variable. Bartlett's test for homogeneity of errors was performed over environments on each trait. If the errors were heterogeneous, a REPEATED statement was used for combined analysis to specify a GROUP effect of environments. Single df contrasts were used to compare traits between CWAD and CWRS classes. Means comparisons were done by Fisher's protected least significant differences (LSD) based on Student's t distribution.

## **Results and Discussion**

### **Black point**

There were six environments (Lethbridge, Swift Current and Indian Head in 1997; Beaverlodge and Swift Current in 1998; and Swift Current in 1999) without black point incidence for any cultivar. Kyle tended to have lower incidence of black point than other CWAD cultivars and had the least occurrence of downgrading effect. Plenty averaged highest black point incidence and had more downgrading effects than other CWAD cultivars. In CWRS class, Garnet tended to have lower black point incidence than other CWRS cultivars and downgrading effects caused by black point incidence were only found for AC Domain and Roblin at Glenlea in 1997.

### **Smudge**

Smudge-damaged kernels were found in 15 environments (Table 2). Cultivar difference was significant in most of these environments. Plenty in CWAD and Garnet in CWRS had less downgrading effects than other within-class cultivars. Similar to black point incidence, in most cases, CWAD class had more smudge damaged kernels than CWRS class although not always significant. On average, CWAD class also had more downgrading effects than CWRS.

### **Penetrated smudge**

The penetrated smudge was only found for CWAD cultivars at some Black soil sites. Downgrading effects occurred and in some cases they were very severe, such as at Glenlea in 1997 and at Indian Head in 2000. DT 369 had less downgrading effects than other cultivars.

### **Red smudge**

Similar to penetrated smudge, the incidence of red smudge was only found for CWAD cultivars at some Black soil sites and cultivar differences in the percentage of red smudge were not significant. In opposite to penetrated smudge, DT 369 had more red smudge-caused downgrading effects than other CWAD cultivars.

### **Fusarium-damaged kernels**

The incidence of FDD was found at some Black soil sites. In the CWAD class, all cultivars were susceptible to Fusarium infection, but Plenty tended to have higher incidence and greater FDK-caused downgrading effects than other cultivars. In the CWRS class, the incidence of FDK was very low for Katepwa, Garnet and AC Domain and no downgrading effects were found. AC Cadillac had relatively higher incidence and more downgrading effects compared with other CWRS cultivars.

### **Grades determined by all thresholds of kernel discolorations**

In total, there were 92 downgrading cases in this study (Table 3). The downgrading frequency was 48% for CWAD and 32% for CWRS. Only a small portion of downgrading cases was associated with the incidence of black point and black point incidence was seldom a major downgrading factor. Almost all downgrading cases were associated with smudge damage and smudge damage was the major downgrading factor in most of the downgrading cases for both CWAD (74%) and CWRS (98%) wheats. For CWAD cultivars, DT 369 had the most downgrading cases (14), followed by AC Avonlea (12), Kyle (11) and Plenty (9). Plenty tended to have less downgrading effects caused by smudge, but have more and severer downgrading effects caused by FDK compared with other CWAD cultivars. For CWRS cultivars, Katepwa had the most downgrading cases (10), followed by AC Domain (9), AC Cadillac (8), Roblin (8) and Garnet (5). In general, CWAD cultivars had more and severer downgrading cases than CWRS cultivars.

In summary, smudge was the major downgrading factor. FDK was the second, but often resulted in severe downgrading for CWAD class. Penetrated smudge and red smudge were only found for CWAD cultivars at Black soil sites. In CWAD, Kyle tended to have lower incidence of black point, Plenty had less downgrading effects caused by smudge incidence, DT 369 had lower penetrated smudge incidence, but higher red smudge incidence, and Plenty tended to have severer FDK-caused downgrading effects compared with other CWAD cultivars. In CWRS cultivars, Garnet tended to have lower incidences in black point, smudge and FDK and resulted in the least downgrading compared with other CWRS cultivars. CWAD class had higher incidences of all kernel discolorations (black point, smudge, penetrated smudge, red smudge and FDK) and greater downgrading effects than CWRS class.

### References

Canadian Grain Commission. 2002. Official Grain Grading Guide. 4. Wheat. pp. 1-65. Winnipeg, Manitoba, Canadian Grain Commission.

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**Table 1. Grade thresholds determined by penetrated smudge (%), red smudge (%), total smudge (%), total smudge and black point (%), and FDK (%) according to Canadian Grain Commission (2002).**

Grade name	Penetrated smudge (P)	Red smudge (R)	Total smudge (smudge, penetrated smudge and red smudge, S)	Total smudge and black point (B)	FDK (F)
<b>CWAD</b>					
No. 1	3K <sup>1</sup>	30K	30K	5.0	0.5
No. 2	0.25	1.0	1.0	10.0	0.5
No. 3	0.5	1.0	3.0	20.0	2.0
No. 4	----- Consider overall appearance -----				2.0
No. 5	--				5.0
<b>CWRS</b>					
No. 1	-	-	30K	10.0	0.25
No. 2	-	-	1.0	20.0	1.0
No. 3	-	-	5.0	35.0	2.0
Feed	-	-	-	-	5.0

<sup>1</sup>K: Number of kernel-sized pieces in a 500 g grain sample.

Table 2. Smudge (%) and its downgrading effect <sup>1</sup>																
Cultivar	1997		1998				1999				2000			Mean		
	MF	GL	LB	MF	IH	GL	LB	MF	IH	GL	BL	SC	MF		IH	GL
<b>CWAD</b>																
AC Avonlea	1.0(2)	1.2(3)	0.3(2)	0.2	0.3(2)	1.3(3)	0.5(2)	0.0	3.5(4)	4.2(4)	0.3(2)	0.2	1.7(3)	1.2(3)	4.0(4)	1.3
DT 369	1.8(3)	0.8(2)	0.7(2)	0.2	0.0	1.0(2)	0.5(2)	1.5(3)	1.3(3)	3.2(4)	0.8(2)	0.8(2)	5.7(4)	0.5(2)	4.3(4)	1.5
Kyle	0.3(2)	2.7(3)	0.0	0.0	0.0	1.3(3)	0.3(2)	0.3(2)	3.5(4)	3.7(4)	0.8(2)	0.2	2.2(3)	1.0(2)	2.8(3)	1.3
Plenty	0.8(2)	7.7(4)	0.8(2)	0.2	0.0	1.8(3)	0.0	0.5(2)	0.0	4.3(4)	0.0	0.2	1.0(2)	4.8(4)	4.3(4)	1.8
Mean	1.0	3.1	0.5	0.2	0.1	1.4	0.3	0.6	2.1	3.9	0.5	0.4	2.7	1.9	3.9	1.5
<b>CWRS</b>																
AC Cadillac	1.2(3)	0.5(2)	0.0	0.0	0.2	0.0	0.0	0.5(2)	0.0	1.5(3)	0.5(2)	0.0	0.7(2)	1.8(3)	0.8(2)	0.5
AC Domain	0.7(2)	1.2(3)	0.2	0.0	0.2	0.2(2)	0.7(2)	0.7(2)	0.2	0.7(2)	0.2	0.0	1.0(2)	1.3(3)	0.3(2)	0.5
Garnet	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7(2)	0.0	0.2(2)	0.2	0.0	2.2(3)	2.3(3)	0.2(2)	0.4
Katepwa	2.5(3)	1.3(3)	0.2	0.0	0.3(2)	0.2(2)	0.2	0.5(2)	0.2	0.0	1.3(3)	0.3(2)	1.0(2)	1.2(3)	0.3(2)	0.6
Roblin	0.8(2)	7.0(F)	0.2	0.3(2)	0.0	0.2(2)	0.0	0.7(2)	0.0	0.3(2)	0.0	0.2	0.0	4.3(3)	1.2(3)	1.0
Saunders	0.0	0.8(2)	0.0	0.0	0.0	0.0	0.0	0.3(2)	0.0	0.0	0.7(2)	0.0	0.3(2)	1.5(3)	1.3(3)	0.3
Mean	0.7	1.7	0.1	0.1	0.1	0.1	0.2	0.5	0.1	0.2	0.4	0.1	0.8	1.8	0.6	0.6
Overall mean	0.9	2.3	0.2	0.1	0.1	0.6	0.2	0.6	0.9	1.8	0.5	0.2	1.6	2.0	2.0	0.9
LSD (0.05)	0.8	4.6	NS	NS	NS	0.9	NS	NS	0.8	2.1	0.8	0.4	2.2	1.6	1.2	0.8
CWAD vs CWRS	0.3NS	1.4NS	0.4*	0.1NS	0.0NS	1.3***	0.1NS	0.1NS	2.0***	3.7***	0.1NS	0.3**	1.9**	0.1NS	3.3***	0.9***

<sup>1</sup>Environments in where no downgrading effects caused by kernel discolorations were found for any cultivar are not shown.

<sup>2</sup>Letter(s) in the parentheses following the grade are incidence(s) resulted in the final grades. S: smudge; B: Black point; P: penetrated smudge; R: red smudge; F: FDK.

BL: Beaverlodge; LB: Lethbridge; SC: Swift Current; MF: Melfort; IH: Indian Head; GL: Glenlea.