Field assessment of pre-harvest sprouting of wheat varieties in Western Australia

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Abstract
Falling Number (FN) was recorded in field grown and weathered agronomy trials located across the WA Agricultural zone that combined a range of wheat varieties and sowing times in each season from 2007 to 2011. Wet harvest conditions at 29 out of 128 environments gave a good range of FN. In nurseries in South Perth from 2008-2010, all varieties were essentially non-dormant (Germination Index>0.40). FN was not well correlated with the variation in this level of dormancy (R^2=0.10). There was consistent varietal performance in falling number after sprouting inducing rainfall and although later maturing lines tended to do better, there were still consistent differences among varieties with similar maturity. The varieties Eagle Rock, Yitpi, Estoc, Sapphire and Scout performed well (FN>300s), while Westonia, Carnamah, Emu Rock and Katana consistently performed poorly (FN<200s). Dormancy information needs to be complemented with FN data from field trials to give better agronomic advice to growers about pre-harvest sprouting (PHS) susceptibility. For more robust predictions across seasons field grown samples should be weathered using a rainfall simulator.

Key Words
Wheat, variety, falling number, pre-harvest sprouting, seed dormancy.

Introduction
Pre-harvest sprouting (PHS) is caused by rain late in grain filling and/or after maturity prior to harvest. Sprouted grain causes end users a number of problems, including sticky dough, and bread with a poor loaf volume, crumb structure and sliceability (Derera 1982). As such, grain can be heavily discounted depending on the degree of sprouting, which is measured by the Falling Number (FN) test. The FN is the international standard test of sprouting and indicates the amount of alpha amylase enzyme present in grain (Hagberg 1960). The grain delivery FN standard in Australia is currently set at Milling >300 s, General Purpose 200-300 s, Feed < 200 s (Australian Wheat Board 2003-2004).
Varietal differences in PHS tolerance are controlled by a number of factors including the amount, timing and duration of the rain events (Mares 1993), seed dormancy(Mares 1996), the environmental conditions influencing dormancy (Biddulph*et al*. 2007), the physical structure of the wheat ear (awnlessness, chaff tightness, head nodding angle) (King 1984; King and Richards 1984) or grain waxiness (King and Wettstein-Knowles 2000). Falling number in the absence of sprouting is also influenced by a range of grain quality traits and other potential sources of alpha-amylase (Mares and Mrva 2008). Despite this, grower deliveries are only subject to FN tests when visually sprouted grains are detected at delivery. From an agronomic perspective, grain from field trials that experience rain at harvest is a potentially useful indicator of PHS tolerance. This FN data can be difficult to interpret due to maturity differences among varieties and the interaction with timing of sprouting inducing rainfall. However in commercial farming businesses variety choice is made the previous season and the ability to harvest a wheat variety upon reaching harvest maturity is compromised in wet harvest years as the sprouting inducing rainfall also delays harvest of earlier maturing canola and barley crops (SEPWA growers Sprouting workshop February 2009). The aim of this study was to evaluate the level of pre-harvest sprouting tolerance of new and established wheat varieties, including potential maturity interactions, as this is part of the risk growers businesses are exposed to from PHS.

Methods
Grain for this study came from DAFWA agronomy trials managed with standard practice; ~ 24 varieties, three sowing times and up to 11 sites in each season from 2007 to 2011 across the WA wheat belt. These trials were replicated, randomised complete block designs with time of sowing (TOS) the main plot factor and variety the subplot factor. FNwas measured when field trialswere exposed to late season/ pre-harvest rainfall. FN was determined on 7g wholemealflour in 25 mL DI water according to Hagberg (1960) using a Perten 1700 falling number machine (Huddinge, Sweden). At Esperance Downs Research Station (EDRS) in 2011 physiological maturity (PM) was assessed by recording the loss of green from the peduncle on at least 90% of stems (~Z91). Grain GI was measured at PM according to Walker-Simmons (1987) in purpose sown nurseries at South Perth with translucent covers to minimise maturity by rainfall interactions on dormancy, and supplementary ground irrigation to minimise moisture stress along the lines of Biddulph *et al.* (2008).

Results and Discussion

Although widely used as a PHS screening method for breeding purposes, there is not a strong relationship (R^2 0.10) between the GI (Germination Index) values and FN of field grown commercial wheat varieties (Figure 1). Given the poor relationship between GI and FN in the field it seems inappropriate to use GI aloneas a basis for evaluating variety PHS risk. Further development of an appropriate rating method is warranted. Most commercial varieties are non-dormant (GI>0.40) and variation at this low level of dormancy is not robust enough to withstand normal, seasonal weathering events (data presented here and in Biddulph *et al.* 2008).

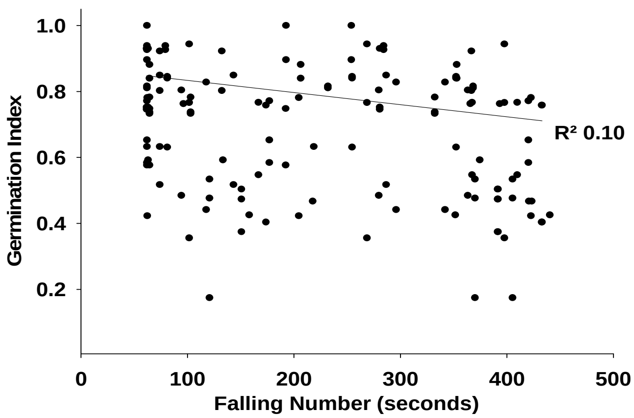

Figure 1. Relationship between GI determined at South Perth 2008-2010 and FN of 2011 EDRS field grown samples.

Over the 5 year study period pre-harvest rainfall and sprouting occurred at 29 out of the possible 128 environments, approximately 20% of the total. Sites ranged from Esperance on the South Coast to Mingenew in the Northern Agricultural Region. Over this wide range of environments there have been consistent varietal reactions to FN following pre-harvest rainfall. Four varieties with a similar seed dormancy GI (0.50-0.80) but contrasting FN performance after sprouting in the field are illustrated in Figure 2 with their FN compared to the control (Wyalkatchem).

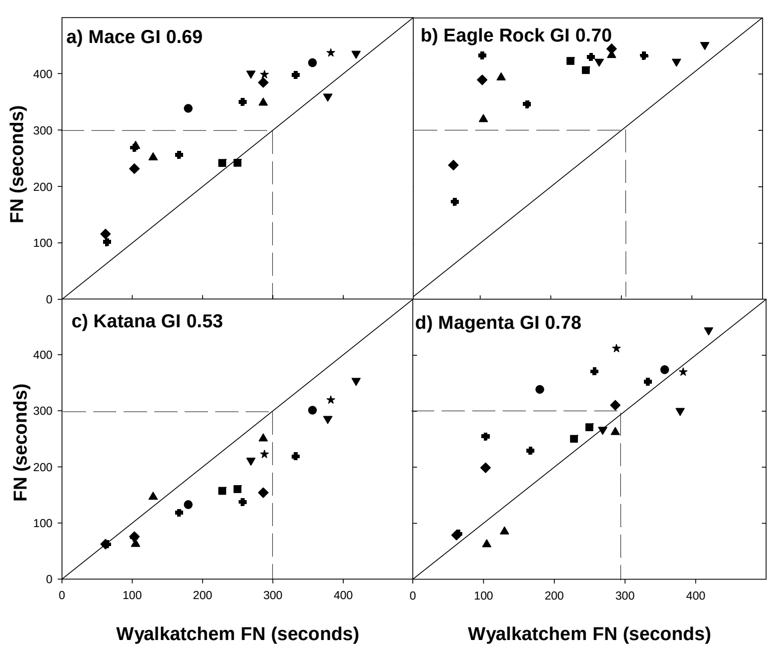

Figure 2. FN of (a) Mace, (b) Eagle Rock, (c)Katana and (d)Magenta wheat varieties, relative to Wyalkatchem, across a range of environments and seasonal conditions in which PHS occurred in WA (▲ EDRS 08, ▼Grass Patch 08, ●GSARI 08 (Katanning), ◆ Mt Barker 08, ■ Mingenew 09, ★ Newdegate 08, ✚ EDRS 11). Average

GI of Wyalkatchem 0.77.

Among the varieties, Eagle Rock, an awnless, tight glumed (and hence difficult to thresh) variety, consistently had a FN above 300 except in severe sprouting situations. Mace and Magenta had higher FN than Wyalkatchem, but Magenta was not as consistent. Katana by contrast consistently had lower FN than Wyalkatchem across all site years where the FN was below the 300s milling grade. This variety information indicates how different varieties perform under field conditions and their ability to consistently meet delivery standards. Based on this information the varieties could be ranked from least to most pre-harvest sprouting susceptible; Eagle Rock, Mace, Magenta, Wyalkatchem to Katana.

One artefact in this approach is that early maturing varieties have longer post-maturity exposure to adverse weather that may result in lower FN compared to late varieties as all are harvested at the same time in each trial. To evaluate the effect of this limitation, trials in 2011 at EDRS were scored for physiological maturity (PM) to compare the FN in each maturity class. Overall there was less PHS damage in the later time of sowing (Figure 3b compared with 3a), due to the timing of the rainfall earlier in the grain fill period. In the earlier TOS (Figure 3a) the later maturing varieties such as Estoc, Endure and Yitpi also had high FN, as they were not damaged by the early November rainfall which induced the sprouting of some earlier maturing varieties. However amongst varieties that matured at the same time (within 2-4 days on the x axis), there was still a range in FN. Scout for example reached PM at a similar time as Cobra, Wyalkatchem and Katana and they ranged in FN by up to 200s (Figure 3). There are a range of varieties with good grain quality, (FN> 300s; Eagle Rock, Yitpi, Estoc, Sapphire and Scout), a range of varieties with poor quality (FN<200s; Westonia, Carnamah, Emu Rock and Katana) and this was consistent across TOS (Figure 3 a, b) and also consistent with previous years (data not shown). Katana and Emu Rock also had low FN at each TOS in another 3 environments in 2011(data not shown).The use of later maturing varieties with phenology that matches the production environment can be a useful agronomic tool for grower to manage their PHS risk. Although such maturity effects exist, there is still variation in FN in material that reaches PM at a similar time, indicating the validity of this approach to evaluate PHS susceptibility of individual varieties.

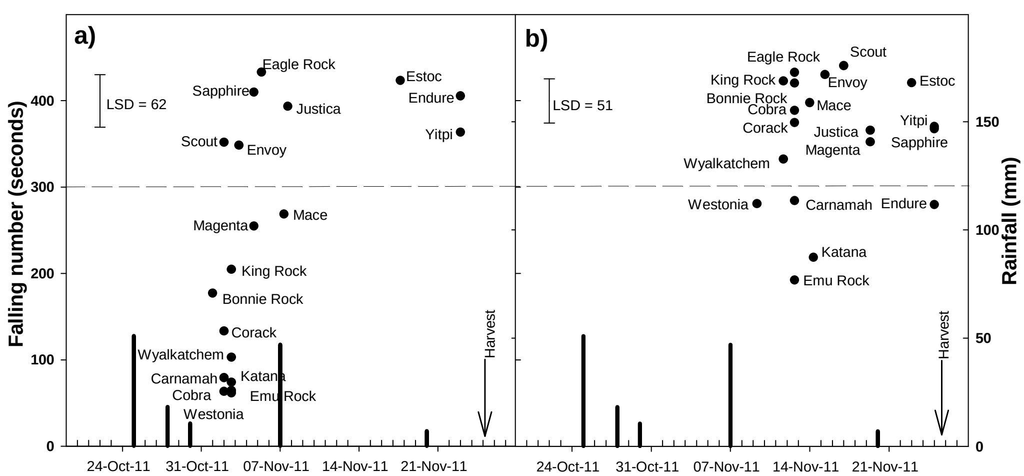

Figure 3. FN of wheat varieties (●) sown on (a) May 20 and (b) June 6 relative to date of PM and rainfall (bars).

Conclusion

For years in which there is significant rain at harvest the measurement of FN on grain samples collected from agronomy experiments with a range of sowing times and maturities can be a useful tool in the assessment of new varieties for susceptibility to pre-harvest sprouting. Development of ratings on PHS for industry should not be based on dormancy alone as in currently available commercial material the variation in dormancy is minimal (GI>0.40) and not well correlated to FN after sprouting inducing rainfall. It is suggested opportunist FN data such as that collected here should be supplemented with FN data on samples subjected to various degrees of weathering in a rain simulator to provide greater consistency between seasons and to provide PHS data in seasons in which pre-harvest rainfall and subsequent sprouting does not occur, though the correlation with field data will still need to be validated.

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