Novel way of managing barley powdery mildew in the presence of fungicide resistance - additional tools for integrated powdery mildew management

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Key messages

- 3 mMol. Sodium saccharin (Sugarine®) effectively controlled powdery mildew but not barley leaf rust.
- Potassium nitrate @ 1.6 kg/ha was used as foliar spray for effective control of powdery mildew but not leaf rust.
- Either one of the products listed above can be incorporated into powdery mildew management to reduce the number of fungicide applications and the development of fungicide resistance in the pathogen.

Background

Powdery mildew (PM) is an issue for growing malting barley varieties in the high rainfall long season environment of southern Western Australia (WA). Most of the current popular varieties are susceptible to the disease. The disease is caused by fungus *Blumeria graminis* f. sp*. hordei* which survives in the previous seasons infected stubble and regrowth barley to infect unprotected susceptible barley crops.

Currently PM is managed by extensive use of *triazole* fungicides. These fungicides were effective in managing PM until recently. The pathogen has developed resistance to *tebuconazole,* a *triazole* fungicide (Tucker *et al.* 2013). This resistance is now widely spread in WA. For fungicide resistance management it is essential to reduce the use of currently registered *triazole* based products and to introduce new classes of fungicides with different modes of action. Another option is to use resistant varieties but a recent survey indicates some current varieties which carry major resistance genes are threatened with breaking down sooner or later due to diversity in pathogen populations on the south coast (Jayasena *et al*. 2013). It is therefore important to identify other means of PM control as part of an integrated disease management strategy.

Alternative strategies to limit PM infection could include the use of potassium (K) fertiliser. During 2002-2006, K fertiliser was found to control PM (Brennan and Jayasena, 2007). No foliar sprays were used in those experiments. However, other literature suggests foliar application of K can control a range of diseases.

The concept of inducing resistance to certain diseases in plants using chemicals (not fungicides) is not new but is currently not used in Australian broad acre cropping. One such chemical is “Saccharin” which is a metabolite of “Probenzole,” a synthetic compound which stimulates the accumulation of salicylic acid in the systemic acquired resistance (SAR) signalling pathway (Boyle and Walters 2006).

Aims

The present study aimed to evaluate the performance of sodium saccharin along with the potassium nitrate (KNO_3) as foliar spray against barley PM.

Method

Glasshouse experiment

Baudin barley seeds were sown on commercial grade garden potting mix soil in 10 cm pots with one seed per pot on 22 July. Five week old seedlings were sprayed with either KNO_3 solutions containing 1.6 kg/ha and 0.8 kg/ha, 3 mMol sodium saccharin (Na saccharin) or Amistar® Xtra^{AZ} 400 mL/ha a day before the plants were taken into the field at South Stirling (28 Aug). Plant were sprayed with distilled water as untreated controls. The pots were placed in a PM infected crop for 2 wks and then returned to glasshouse for PM disease assessment.

Field experiment

Untreated susceptible Baudin barley was sown @ 60 kg/ha, on sandy over clay duplex soil on 31 May 2013 at Gnowellen (Wellstead). Prior to seeding Boxer Gold® @ 1.8L/ha with Trifluralin 480 EC @ 1.5 L/ha was applied for weed control. No other chemicals were used except for PM control treatments (Table 1). Plot size was 10 m X 5 m in a randomized block design. Before seeding soil samples were randomly taken across the site, from 0-10 and 10- 20 cm depth. At tillering 50 leaves were collected to determine plant tissue K level. Flexi-N liquid fertiliser was applied as nitrogen source to basal? out the nitrogen effect due to use of KNO_3 in the trial. KNO_3, Na saccharin and fungicide were applied at the first sign of the disease at early tillering growth stage (Z22). Powdery mildew symptoms were assessed 2 wks and 3 wks after the initial foliar treatment (11 July) and final assessment was on 19 Sept (11 weeks after).

Table 1 The treatments and the time of foliar spray

1.	Nil (0 K) + Flexi-N 1.3L/ha (Untreated)
2.	*K as KNO_3 (1.6 kg/ha) + No Flexi-N at ****Z22 & Z32
3.	1/2 K rate (0.8 kg/ha) + Flexi-N 0.65 L/ha at Z22 & Z32
4.	1/4 K rate (0.4 kg/ha) + Flexi-N 1.0 L/ha at Z22 & Z32
5.	**Fungicide only (0 K) + Flexi-N 1.3 L/ha at Z22 & Z32
6.	3 mMol *** Na saccharin + 1% v/v Hasten at Z22 & Z32

*K (KNO_3) @ 1.6 kg in 60L water/ha; Flexi-N liquid fertiliser as nitrogen source to basal out nitrogen effect;
Fungicide = Prosaro® 420 SC @ 150 mL with 1% v/v Hasten in 80 L of water/ha; * Na saccharin (Sugarine®); ****Foliar chemical spray on at Z22 (11 July) & Z32 (14 Aug)

For both the glasshouse and field work the data was analysed using GenStat v? 16 statistical package.

Results

Glasshouse PM experiment

The disease assessment was done 19 days after plants were exposed to natural powdery mildew infection under field conditions. The PM severity ranged from 0 (Amistar Xtra) to 18% (Untreated) as the average of the top four leaves. Foliar application of two

rates of KNO_3 and Na saccharin significantly reduced PM on Baudin barley compared to nil treatment (Table 2). Amistar Xtra treated plants were completely PM free. Foliar application of KNO_3 @ 1.6 kg/ha and 0.8 kg/ha reduced the PM by 50% and 20% respectively where as 3 mMol Na saccharin reduced the disease by 77 per cent. The higher rate of KNO_3 was significantly better than low rate of KNO_3 but application of Na saccharin significantly reduced the PM compared to KNO_3.

Field experiment

The K level in the soil at the trial site at 10 cm and 20 cm depth was 65 ppm and 41 ppm, respectively, and rated as marginal at 10 cm and deficient at 20 cm depth. Leaf tissue sample testing suggested that the K level of 3.15% was deficient according to Reuter and Robinson (Plant Analysis and Interpretation Manual 2nd Edition).

Table 2 Effect of potassium nitrate and saccharin foliar spray on powdery mildew control in glasshouse grown Baudin barley.

Treatment	%leaf* area diseased Z22 *(Leaf 1 to Leaf 4)
Untreated (Nil)	17.9**a
***KNO_3 @ 0.8 kg/ha	14.5b
KNO_3 @ 1.6 kg/ha	9.3c
3 mMol Na saccharin + 1% v/v Hasten	4.2d
Amistar 430 SC @ 400 mL/ha + 1% v/v Hasten	0e

*% leaf area data was angular transformed for statistical analysis; **Each number in this column with a different letter was significant at $p \leq 0.05$.; ***Chemicals were sprayed on 27 Aug the one day before the plants taken to filed on 28 August; Plants brought back on 11 Sept. and disease assessment was done on 16 September.

Initially at the trial site PM was evident at early stem elongation growth stage (Z31). However, at later growth stages the dominant disease was barley leaf rust (BLR). Therefore, PM assessments were done up to 3 wks from initial foliar spraying. The results are shown in Table 3. The PM severity varied from 3% to 16% at mid tillering growth stage (Z25/Z26). Application of KNO_3 @ 1.6 kg/ha and 0.8 kg/ha, Na Saccharin and Prosaro reduced the PM severity by 37%, 28%, 61% and 82% respectively compared to untreated.

A second spraying was done 33 days after the first spraying at early stem elongation (Z32). The leaf rust was assessed on Z34 and mid ear emergence stage (Z55). Application of Prosaro fungicide as foliar spray significantly reduced the leaf rust compared to all other treatments at Z34 (Table 3). The KNO_3 or Na saccharin treatments did not reduce BLR. At Z55 the BLR severity varied from 41 to 44% but none of the treatments were significantly different.

Table 3 Effects of Potassium nitrate and Saccharin on control of foliar diseases and yield of Baudin barley at Gnowellen, WA 2013

Treatment	% leaf area diseased *ang				Yield
	PM (Powdery Mildew)		BLR (Barley Leaf Rust)		
	Z23/24 (25 Jul) (Leaf 1 to Leaf 4)	Z25/26 (1Aug)	Z34 (29 Aug) (Leaf 1 to Leaf 4)	Z55 (19 Sept) Flag to Flag-2	t/ha
Nil (Untreated)	6.1a	16.2a	31.4a	43.5a	1.8a
KNO_3 @ 0.8 kg/ha	3.3bc	11.7b	29.8a	42.4a	2.5b

KNO_3 @ 1.6 kg/ha	2.7cd	10.1c	29.9a	42.0a	2.5b
3 mMol Na saccharin	2.1d	6.3d	31.7a	42.1a	2.6bc
Prosaro @ 150 mL/ha	0.5e	3.0e	23.4b	40.8a	2.8c

*ang = angular transformed data; values followed by different letters are significant at $p \leq 0.05$.

The yield varied from 1.8 t/ha to 2.8 t/ha (Table 3). All the foliar treatments significantly increased the yield compared untreated. However, Prosaro significantly increased the yield compared KNO_3 treatments. There was no significant yield difference between Na saccharin and Prosaro fungicide treatment.

The decision to control a disease is mainly determined by cost of the product and the yield potential. At present 1kg KNO_3 is around $AU10.00 (from e-bay) and application cost around $AU6.00. A single application of KNO_3 @ 1.6 kg/ha will cost $AU22.00/ha. Similarly application of 3 mMol Sugarine (28 mg Sodium saccharin from Woolworths costs $3.80/200 tablets) is around $AU36/ha. Bulk purchase of sodium saccharin is likely to be much cheaper.

Applying the products listed in Table 4 increased the profit between from $AU123/ha and $AU219/ha. The most profitable treatment was foliar Prosaro controlling both PM and BLR. Of two rates of KNO_3 used the most profitable was 0.8 kg/ha rather than 1.6 kg/ha however, the higher rate gave better PM control. Na saccharin marginally increased the profit over higher rate of KNO_3.

Table 4 Economic return in application of KNO_3, Na saccharin and Prosaro on Baudin barley at Gnowellen, WA 2013.

Treatment	Yield	Yield increase over Nil	Gross return	Net return	Profit
	t/ha	kg/ha	$/ha	$/ha	$/ha
Nil (Untreated)	1.8a	-	452	-	-
KNO_3 @ 0.8 kg/ha *****X 2	2.5b	713	630	178	156
KNO_3 @ 1.6 kg/ha X 2	2.5b	668	619	167	123
3 mMol Na saccharin X 2	2.6bc	785	648	196	124
Prosaro @ 150 mL/ha X 2	2.8c	1010	704	253	219

Assuming barley grain price $250/t; Prosaro 2 applications $34/ha (single application of Prosaro 150mL is around $10/ha + 1% Hasten $1/ha + application cost $6/ha); *****X 2 = 2 applications

Conclusion

The glasshouse and field trials clearly demonstrate that KNO_3 and 3 mMol Na saccharin reduced PM severity compared to unprotected barley. Neither of these products was effective against BLR. The performance of Prosaro fungicide was outstanding in control of PM. Incorporation of either KNO_3 or Na saccharin in the foliar application programme and limiting the use of fungicides can provide an effective PM control and will delay the development of fungicide resistance.

References

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Key words

Potassium nitrate, Sodium saccharin, fungicides, powdery mildew, barley, disease management

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