Influence of potassium on leaf disease of cereals

Summary
Twenty one field experiments were carried out on potassium (K) deficient sandy soils to assess the effect of fertiliser K, as either potassium chloride (KCl - 50% K) or potassium sulphate (K₂SO₄ - 41% K), on the leaf diseases and grain production of barley crops. The leaf diseases identified were powdery mildew (Blumeria graminis f.sp. hordei), spot-type net blotch (Pyrenophora teres f. maculata) and barley leaf rust (Puccinia hordei). The percentage leaf area diseased (%LAD) and grain yield of barley in response to increasing amounts of applied K were measured.

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Conclusions
1. Cereals deficient in potassium (K) are more prone to foliar leaf diseases, reducing grain yields.
2. The percentage of barley leaf area diseased (%LAD) due to spot-type net blotch and powdery mildew decreased as K inputs increased up to 40 kg/ha.
3. The percentage of barley %LAD by powdery mildew was affected by the source of K fertiliser. KCl reduced the %LAD due to powdery mildew at rates of 10 and 20 kg/ha of K, less than required for control with K₂SO₄.
4. The two sources of K gave different yield response curves where powdery mildew was present.
5. Amounts of KCl required to achieve 90% of the maximum grain yield in the presence of foliar disease tended to be 10% more than the amount of K₂SO₄.
6. K fertiliser applied at higher rates (80, 120 kg/ha of K) than required for maximum grain yield produced no additional benefit.
7. K fertiliser had no effect on the %LAD by rust in either wheat or barley.
8. Grain protein was not affected by rate or type of K fertiliser. The protein percentage decreased with fungicide application and the control of powdery mildew and spot-type net blotch. This decrease in percentage protein may be a result of dilution of protein due to the increased grain yield resulting from disease control.
9. The percentage of screenings was reduced with the addition of K and application of fungicide that controlled powdery mildew and spot-type net blotch.
10. Grain hectolitre weight was not significantly affected by rate or type of K fertiliser. However, grain hectolitre weight increased with fungicide application.
11. Application of K fertiliser and control of foliar diseases using fungicide sprays had no effect on the concentration of K in the grain. Grain K concentration (% K) was about 0.44 (± 0.05) (n = 504) irrespective of the amount or source of K applied or the level or type of foliar disease present.

Recommendations
1. In regions prone to leaf diseases, we suggest farmers take soil samples before seeding to determine soil potassium (K) levels. We recommend soil testing be routinely carried out to assess the current K status of the soil on paddocks to be sown to cereal in the next growing season. If a test indicates likely K deficiency, apply 50 kg/ha of K (100 kg/ha potassium chloride [muriate of potash]) to the next crop.
2. For cereals, K fertiliser is required when soil test K levels are <50 mg/kg (ppm).
3. Soil and tissue testing for K are needed to reduce the likelihood of K deficiency reducing barley yields in south-west Australia (SWA). Both tests enable fertiliser requirements to be estimated for the next growing season. Soil samples to measure soil test K are usually collected in the January-March period before the start of the next growing season. Samples for tissue testing are collected and analysed in the previous growing season. However, if barley tissue tests are done early enough in the growing season, it is profitable to apply fertiliser K to crops identified as deficient in K - provided there is sufficient nitrogen (N) for the barley to respond to the added K.

Outcomes
Economic outcomes

Potassium (K) application resulted in significant increases in barley grain yields in all experiments. The grain yield with no K applied and the maximum yield plateaus reached were both significantly lower where foliar diseases were present. The application of K fertiliser at rates up to 40 kg/ha of K significantly decreased percentage leaf area diseased (%LAD) by spot-type net blotch and powdery mildew of barley. The %LAD by powdery mildew was affected by the source of K fertiliser. The chloride source significantly reduced the %LAD at rates of 10 and 20 kg/ha of K. The two K fertilisers – potassium chloride (KCl - 50% K) and potassium sulphate (K$_2$SO$_4$ - 41% K) - gave significantly different yield responses curves where powdery mildew was present. K fertiliser had no effect on the %LAD by leaf rust.

In regions prone to leaf disease, we suggest farmers take soil samples before seeding to determine soil K levels. The Colwell soil K test using the top 10 cm of soil is the standard soil test K procedure used in south-west Australia (SWA). For cereals, K fertiliser is required when Colwell soil test K values are <50 mg/kg. Potassium chloride (muriate of potash) is usually the cheapest K fertiliser and so is widely used in SWA. In the typical April to November growing season of SWA, fertiliser K is usually applied from four to six weeks after barley plants have emerged - by which time they have developed sufficient root systems to take it up. This reduces potential losses of applied K by leaching.

Environmental outcomes

Soil and plant tests lead to more efficient use of fertiliser K. Soil and tissue testing for K are needed to reduce the likelihood of K deficiency reducing barley grain yields in south-west Australia (SWA). Both tests enable fertiliser requirements to be estimated for the next growing season. Soil samples to measure soil test K are usually collected in the January-March period before the start of the next growing season. Samples for tissue testing are collected and analysed in the previous growing season. However, if barley tissue tests are done early enough in the growing season, it is profitable to apply fertiliser K to crops identified as deficient in K. This is provided there is sufficient nitrogen (N) for the barley to respond to the added K.

The same amount of fertiliser N was used for all experiments in our study. This amount was sufficient to ensure N deficiency did not reduce barley grain yields. However, there may be a fertiliser K by N interaction affecting both barley grain yields and %LAD of leaf diseases. This requires further research. Application of different rates of fertiliser N may change yield responses of barley and responses to applications of fertiliser K and this effect may have influenced leaf disease severity levels reported in this project. However, the effect of applications of fertiliser N on foliar leaf diseases and on grain production and the interaction of fertiliser N with amounts of applied fertiliser K is not known and was not tested in this study.

Achievements/Benefits

Potassium (K)-deficient barley plants were more prone to powdery mildew and spot-type net blotch leaf diseases and the levels of these diseases on K-deficient plants reduced grain yields. Therefore, K has an important role in determining the resistance of barley plants to the two diseases. These findings are in agreement with Leath and Ratcliffe (1974), Trolldenier (1982) and Perrenoud (1990). The application of K fertiliser at rates up to 40 kg/ha of K decreased the percentage of leaf area diseased (%LAD) for spot-type net blotch and powdery mildew of barley. For barley, the %LAD by powdery mildew was affected by the source of K fertiliser. The chloride source reduced the %LAD at rates of 10 and 20 kg/ha of K. The sulphate source did not reduce the area of infected leaf at these rates. The difference in the effect on %LAD by the two sources of K has been attributed to the chloride ion (Kiraly 1976, Fixen et al. 1986a, b; Perrenoud 1990). We could not find published data on the effect of the chloride ion on spot-type net blotch. However, other researchers found that leaf diseases such as leaf rust (Puccinia recondita) in wheat (Kiraly 1976, Fixen et al. 1986a, b) and leaf rust of barley (Perrenoud 1990; Arafa 1987) were reduced by the chloride source. We were unable to determine why the %LAD affected by barley leaf rust was not reduced by applying increasing amounts of fertiliser K. The improved resistance of K-adequate plants to diseases agrees with findings of Leath and Ratcliffe (1974), Trolldenier (1982) and Perrenoud (1990). We could not find published data that amounts of K fertiliser larger than that required for maximum yield decreased %LAD to lower levels.

In these findings, the amount of K fertiliser required for near-maximum grain yields (90% maximum) was similar to that required for foliar leaf diseases to be reduced to near minimum levels achievable by the addition of K. Our data supports the hypothesis suggested by Marschner (2003) that applying larger amounts of fertiliser K than that required to achieve maximum yield plateaus would give no further decline in the %LAD.
In regions prone to leaf disease, we suggest farmers take soil samples before seeding to determine soil K levels. The Colwell soil K test using the top 10 cm of soil is the standard soil test K procedure used in SWA. For cereals, K fertiliser is required when Colwell soil test K values levels are <50 mg/kg (Edwards 1998; Wong et al. 2000). Potassium chloride (KCl, muriate of potash) is usually the cheapest K fertiliser used in the region and is widely used. In the typical April to November growing season of SWA, fertiliser K is usually applied from four to six weeks after barley plants have emerged, by which time they have developed sufficient root systems to take up much K. This reduces potential losses of applied K by leaching (Barrow 1967; Bolland et al. 2003).

Other research
The same amount of fertiliser nitrogen (N) was used for all experiments in this study. The amount used was sufficient to ensure N deficiency did not reduce barley grain yields. However, there may be a fertiliser K by N interaction affecting both barley grain yields and %LAD of leaf diseases. This requires further research.

Different rates of fertiliser N may change yield responses of barley and responses to applications of fertiliser K and this effect may have influenced leaf disease severity levels reported in this project. However, the effect of applications of fertiliser N on foliar leaf diseases and on grain production and the interaction of fertiliser N with amounts of applied fertiliser K is not known and was not tested in this study.

Additional information


Additional information is provided in the Attachment titled - Cereals deficient in potassium are more susceptible to some leaf diseases.