Potassium Deficiency and Defence Signalling

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Background

Potassium (K) is an essential element in plants and is required in large quantities to maintain normal growth, development and metabolism (1). In a microarray study investigating transcriptome changes of *Arabidopsis thaliana* during K starvation and after resupply Armengaud *et al* 2004 (2) identified genes related to jasmonic acid signalling as one of the largest functional categories within K-responsive genes. A rise in JA as well as other oxylipins was subsequently confirmed in K-deficient plants.

Jasmonic acid (JA) is a phytohormone involved in a number of processes in growth and development as well as response to abiotic and biotic stress (3). JA is part of a complex signal network involved in the response to pathogen attack acting in conjunction with ethylene (ET) and salicylic acid (SA). While ET is involved in K-sensing in the roots (1), SA is not affected by K-deficiency.

Questions:

- Does the JA-response to K-deficiency occur in plants other than *A. thaliana*?
- Do increased JA levels in K-deficient plants interfere with defence, and how?

Aims of the project

1. Test the effect of K nutrition on JA reporter genes in barley
2. Establish the effects of K-deficiency on wound/defence responsive genes.
3. Establish whether and how K-deficiency affects sensitivity of barley to pathogens, such as powdery mildew and *Rhynchosporum*?

Figure 1. Establishing K starvation conditions.

In order to establish how long the barley plants need to be grown in K free media before K starvation occurs, the total fresh weight (a), the shoot weight (b) and the root weight (c) of 6 plants were measured over a period of time, for plants growing in full nutrient (▪) and K-free (▫) media. No significant difference between plants was detected up to day 10, but on days 13 and 15 a significant reduction in weight is seen in the K-starved plants.

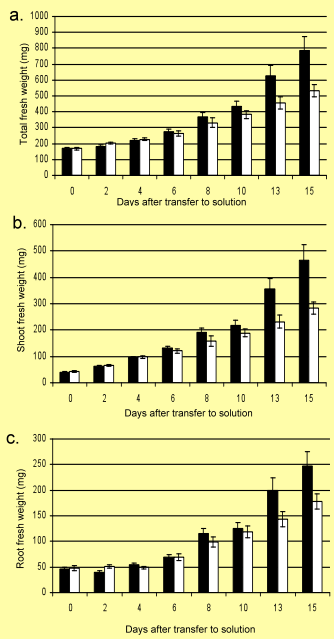
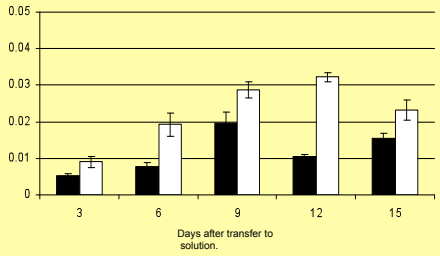


Figure 2. Is there an increase in JA related gene transcription in K starved plants?

The level of transcription of the JA biosynthesis enzyme Lipoxygenase 2 (LOX2) was determined using qPCR for plants grown in full nutrient (▪) and -K (▫) media. 5 plants were pooled every 3 days, the mean (± SE) of 3 replicate experiments is shown. As early as Day 3 an increase in LOX2 can be seen in the K -starved plants.



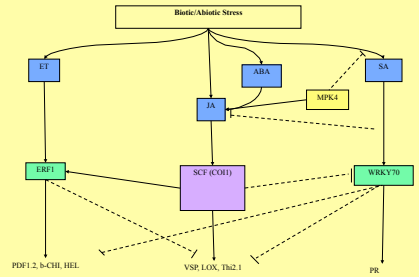


Figure 3. Stress-responsive network involving the JA, ET, SA and ABA signalling pathways. Different types of biotic or abiotic stress, such as pathogen infection or wounding, induce the synthesis and subsequent activation of several hormonal pathways (i.e. JA, ET, SA and ABA). (Modified from Lorenzo and Solano, 2005(4)).

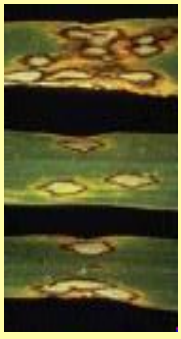
Figure 4. Does this increase in JA effect pathogen infection?

Two pathogens will be used to investigate if the JA increase induced by low K has any effect on pathogen infection. The level of infection and the expression levels of various pathogen related marker genes will be investigated.

Blumeria graminis

- Common name Powdery mildew.
- Obligate Biotroph – requires living host
- Plants are most susceptible during early growth.
- Produces white fluffy fungal growth on leaf surface.
- Reduces yield by draining plant of nutrients

Rhynchosporum secalis



- Commonly know as scald or leaf blotch
- Hemi-biotroph -Grows symptomlessly under cuticle in early infection, before producing conidia and visual symptoms.
- Important disease in barley, particularly in wet /humid conditions.
- Polycyclic disease

Conclusions

Up-regulation of a JA biosynthesis gene LOX2 is seen in K starved barley plants. An increase in transcript levels has also been observed for Jasmonate-Induced Proteins (JIPs) JIP23, JIP37 both of unknown function and JIP60 a ribosome inactivating protein (data not shown). The results provide strong indication for and increase in JA levels in the K starved barley plants.

References

1. Schachtmann and Shin (2007) Annu. Rev. Plant Biol. 58, 47-69.
2. Armengaud *et al.* (2004) Plant Physiol. 136, 2556-2576
3. Wasternack *et al* (2007) Ann. Bot. 100, 681-697
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