Potassium and plant health

Ping He¹, Jiyun Jin¹, Wenjuan Li², Xiaoyan Liu²

¹ PPIC Beijing Office
² Soil & Fertilizer Institute, Chinese Academy of Agricultural Sciences, Beijing 100081
Outline

- Review on role of K nutrition in resistance to diseases
- Current results of our group
K enhances plant resistance to many diseases

- Maize stalk rot (Li et al., 2004; Heckman, 1998)
- Wheat powdery mildew (Bhaakar, 2001; Kettlewell, 2000)
- Rice stalk rot (Williams, 2001)
- Wheat leaf blight, Cotton leaf spot (Sharma et al., 1994, 2005)
- Rapeseed black spot (Sharma et al., 1994)
Given that controlling HLB through fungicide application is costly and frequently unaffordable to resource-poor farmers, disease reduction through adequate K₂O fertilization could be a viable alternative to using fungicide.

Since there is a lack of information on the effect of potassium fertilization and HLB interactions on wheat performance in rice–wheat cropping systems and non-traditional warmer growing regions, this study was conducted to determine their combined effect on grain yield and thousand-kernel weight (TKW) of three wheat varieties under severe natural disease pressure. This information is essential for developing an integrated crop management strategy that will reduce wheat yield losses due to HLB on resource-poor farms.

Effect of potash fertilization on Helminthosporium leaf blight severity in wheat, and associated increases in grain yield and kernel weight

Sarala Sharma, Etienne Duveiller, Roshan Basnet, Chandra B. Karki, Ram C. Sharma

Received 8 July 2004, received in revised form 17 September 2004, accepted 17 September 2004
K and wheat leaf blotch


Effect of foliar-applied potassium chloride on septoria leaf blotch of winter wheat

R. L. Mann†‡, P. S. Kettlewell and P. Jenkinson

Crop and Environment Research Centre, Harper Adams University College, Newport, Shropshire TF10 8NB, UK

Discussion

benefits. If potassium chloride was applied instead of a fungicide, or was tank-mixed with a reduced dose of fungicide, there would be no extra cost for this application.
K and maize stalk rot

应用足量钾肥和高效种衣剂防治玉米茎腐病的试验研究

李红①，沙洪林①，宋淑云①，张伟①，晋齐鸣①，李羽②，王秀波②
(1. 吉林省农业科学院植物保护研究所，公主岭 136100；2. 公主岭市植检植保站，公主岭 136100)

摘 要：试验研究了不同钾肥施用量与玉米茎腐病发生的关系及种衣剂结合施用钾肥对茎腐病的防治效果。结果表明：增施钾肥可增强植株的抗性，降低玉米茎腐病的发病率。随着钾肥施用量的增加，玉米茎腐病的发病率逐渐降低，而对玉米茎腐病的防治效果逐渐提高。以钾肥施用总量150 kg/ha²防治效果最好，质量分数为2.5%适乐时悬浮种衣剂与钾肥150 kg/ha²结合施用对玉米茎腐病防效达87.40%。

关键词：玉米茎腐病；钾肥；种衣剂

Lodging

Yield loss

Spike rot
Stalk lodging in Liaoning (2006)
K role in stalk rot resistance in Shandong(2005)

2005年山东省海阳市赵疃乡杜格庄

土壤速效钾？？？
INORGANIC AMENDMENTS (NPK)

by stimulating antagonistic micro-organisms in the rhizosphere and in turn inhibiting the pathogen

by changing the host metabolism and creating an unfavorable environment within the plant and in the root region

Control by combined effect,

i.e. by changing the host metabolisms, inhibiting the pathogen directly and by stimulating antagonistic microflora in the rhizosphere

Dutta B K, Isaac I. Plant and soil. 1979, 52(4): 561-569
Sucrose content and maize stalk rot

Relationships between sucrose content and resistance of corn to stalk rot

LONG Shu-sheng¹, LI Ya-ling¹, SHI Chun-xi¹,
LI En-cai², ZHANG Yu-hong¹, LI Ming-lei¹

(¹ Key Laboratory of Plant Protection Resources and Pests Management, Chinese Ministry of Education, College of Plant Protection, Northwest Sci-Tech University of Agriculture and Forestry, Yangling, Shaanxi 712100, China;
² 2 Station of Plant Protection and Quarantine of Baoji, Baoji, Shaanxi 721001, China)

[Abstract] The relationship between sucrose content and corn resistance to corn stalk rot caused by *Fusarium graminearum* was investigated. The incidence of corn stalk rot was closely related to sucrose content in the pith tissues of the second internode above the ground at the physiological maturity stage. Corn hybrids resistant to stalk rot had higher sucrose contents in the pith tissues of the second internode above the ground than hybrids susceptible to the disease. In addition, disease incidence was negatively correlated with sucrose content in the pith tissues of the second internode above the ground at the physiological maturity stage. The results suggested that sucrose content could be used as an indicator of corn stalk rot resistance and for selecting corn hybrids for resistance to corn stalk rot.

[Key words] sucrose content; resistance; corn stalk rot; *Fusarium graminearum*
Sucrose content in the pith tissues of the second internode above the ground at physiological maturity stage could be used as an indicator of corn stalk rot resistance.

Fig. 2 Sucrose content in the second internode above the ground at different growth stages.

Each value represents the average of three replicates.

Long et al., 2003
Biosynthesis of lignin (Boudet, 2003)
PAL activity and maize stalk rot

A. Changes of PAL activity for healthy plant
B. Changes of PAL activity under inoculation condition
C. Changes of PAL activity for susceptible variety Xinong 11
D. Changes of PAL activity for resistant variety Shaandan 931

Fig. 1  PAL activity of resistant and susceptible hybrids

Li et al., 2003
### Changes of lignin in different varieties after infection

<table>
<thead>
<tr>
<th>品种</th>
<th>处理</th>
<th>木质素含量 (g/kg)</th>
<th>1d</th>
<th>2d</th>
<th>3d</th>
<th>4d</th>
<th>5d</th>
</tr>
</thead>
<tbody>
<tr>
<td>陕单931</td>
<td>接种</td>
<td>6.44</td>
<td>7.97</td>
<td>9.30</td>
<td>10.89</td>
<td>11.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>健康</td>
<td>4.92</td>
<td>5.01</td>
<td>5.05</td>
<td>5.06</td>
<td>5.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>净增加值</td>
<td>1.52</td>
<td>2.96</td>
<td>4.25</td>
<td>5.83</td>
<td>5.98</td>
<td></td>
</tr>
<tr>
<td>西农11号</td>
<td>接种</td>
<td>9.25</td>
<td>11.44</td>
<td>11.78</td>
<td>11.10</td>
<td>10.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>健康</td>
<td>7.75</td>
<td>7.78</td>
<td>7.81</td>
<td>7.80</td>
<td>7.79</td>
<td></td>
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<tr>
<td></td>
<td>净增加值</td>
<td>1.54</td>
<td>3.66</td>
<td>3.97</td>
<td>3.30</td>
<td>2.46</td>
<td></td>
</tr>
</tbody>
</table>

注：净增加值 = 接种植株 - 健康植株
玉米苯丙烷类次生代谢物与玉米对茎腐病抗性关系

龙书生1, 李亚玲1, 段双科1, 张宇宏1, 李强1, 王炜1, 李武高2
(1 西北农林科技大学 植物保护学院 教育部植保资源与害虫管理重点实验室, 陕西 杨凌 712100;
2 郑州市蔬菜研究所, 河南 郑州 450015)

【摘要】 对抗病玉米品种陕单931 和感病玉米品种西农11 号在抽雄初期接种禾谷镰刀菌孢子悬浮液, 于接种后测定茎秆髓部组织内苯丙烷类次生代谢物木质素和绿原酸的变化。结果表明, 玉米植株原生木质素与玉米对茎腐病的抗性无关, 仅诱导产生的木质素在玉米的抗病性中起作用。并证实玉米植株受到镰刀菌侵染后可产生对镰刀菌有抑制作用的物质。

【关键词】 玉米茎腐病; 抗性; 木质素; 绿原酸
【中图分类号】 S432 2*3; S435 131 4*9 【文献标识码】 A 【文章编号】 1671-9387(2004)09-0093-04
Our results

Stalk rot incidence in Jilin (2004)

K0  K113  K225
56.6  33.3  29.6

Yield (kg/ha)

K0  K113  K225
10176  9184  10100

K0  K113  K225
9800  9400  9600

K0  K113  K225
10200  10400  10000
K effect on incidence and yield (Jilin, 2005)

![Graph showing the effect of K on stalk rot incidence and yield.](image)
KCl could not inhibit pathogen growth directly

K promoted growth of pathogen, but soil extract from K treatment inhibited growth of pathogen.
K deficiency induced sugar secretion

<table>
<thead>
<tr>
<th>Treatment</th>
<th>吉单327</th>
<th>Jidan327</th>
<th>吉单180</th>
<th>Jidan180</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total sugar</td>
<td>Reducing sugar</td>
<td>Sucrose</td>
<td>Total sugar</td>
</tr>
<tr>
<td>CK</td>
<td>18.60 ± 1.29</td>
<td>10.08 ± 0.26</td>
<td>8.09 ± 1.04</td>
<td>15.41 ± 0.95</td>
</tr>
<tr>
<td>KCl</td>
<td>10.85 ± 1.34</td>
<td>2.44 ± 0.34</td>
<td>7.98 ± 0.65</td>
<td>9.00 ± 1.06</td>
</tr>
</tbody>
</table>
Addition of sugar promoted growth of Fg.

Fig. 3 Effect of glucose and sucrose on the growth of *F. graminearum*
KCl promoted ferulic acid secretion

<table>
<thead>
<tr>
<th>品种</th>
<th>处理</th>
<th>阿魏酸（μg/plant/h）</th>
<th>绿原酸（μg/plant/h）</th>
</tr>
</thead>
<tbody>
<tr>
<td>吉单180</td>
<td>CK</td>
<td>0.68</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>KCl</td>
<td>7.93</td>
<td>0.75</td>
</tr>
<tr>
<td>吉单327</td>
<td>CK</td>
<td>0.35</td>
<td>3.27</td>
</tr>
<tr>
<td></td>
<td>KCl</td>
<td>5.63</td>
<td>2.46</td>
</tr>
</tbody>
</table>
Furulic acid had a negative correlation to incidence

\[ y = -2.56x + 30.24 \]
\[ R^2 = 0.86 \]
Phenol effect on Fg

阿魏酸对Fg生长繁殖的抑制作用。氯原酸，氯原酸抑菌浓度>>阿魏酸。氯原酸刺激Fg孢子萌发（徐茂，1992）
Potassium promoted secretion of organic acid in root exudates

<table>
<thead>
<tr>
<th>品种</th>
<th>处理</th>
<th>草酸 (μg/plant/h)</th>
<th>酒石酸 (μg/plant/h)</th>
<th>苹果酸 (μg/plant/h)</th>
<th>乳酸 (μg/plant/h)</th>
<th>柠檬酸 (μg/plant/h)</th>
<th>∑ (μg/plant/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>吉单 180</td>
<td>CK</td>
<td>6.24</td>
<td>0.88</td>
<td>2.39</td>
<td>0.86</td>
<td>0.07</td>
<td>10.77</td>
</tr>
<tr>
<td></td>
<td>KCl</td>
<td>3.56 (¢)</td>
<td>1.85 (¢)</td>
<td>2.07</td>
<td>2.86 (¢)</td>
<td>0.31 (¢)</td>
<td>12.32</td>
</tr>
<tr>
<td>吉单 327</td>
<td>CK</td>
<td>4.95</td>
<td>0.37</td>
<td>6.21</td>
<td>0.22</td>
<td>0.16</td>
<td>11.92</td>
</tr>
<tr>
<td></td>
<td>KCl</td>
<td>9.17 (¢)</td>
<td>0.90 (¢)</td>
<td>4.36</td>
<td>0.73 (¢)</td>
<td>0.86 (¢)</td>
<td>16.02</td>
</tr>
</tbody>
</table>
K increased K content in ear leaf

![Graph showing the change in K content in leaves over days after sowing for resistant and susceptible plants with different K treatments (K0, K1, K2).]
K increased K content in the pith tissues of the second internode above the ground.
K enhanced sugar content at maturity
K increased sugar content in the pith tissues of the second internode above the ground.
K enhanced phenol content in ear leaf

![Graph showing the phenol content in leaves (%)](image)

**Uninfected**
- K0
- K1
- K2

**Infected**
- K0
- K1
- K2

Days after sowing (d)

Phenol content in leaves (%)
Phenol increased after infection at maturity, K decreased phenol content in the pith tissue.
PAL gene expression

<table>
<thead>
<tr>
<th></th>
<th>不接菌 K0</th>
<th>K1</th>
<th>K2</th>
<th>接菌 K0</th>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actin</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Conclusion I

- K decreased incidence of maize stalk rot, and therefore increased yield;

- Mechanism:
  - K could not inhibit growth of Fg directly;
  - Root exudates: K reduced sugar, but enhanced phenol and organic acid;
  - Metabolism regulation:
    - Primary metabolism: K enhanced sugar content in ear leaf and 2nd pith tissue;
    - Secondary metabolism: K increased phenol content in ear leaf, but decreased phenol content in pith tissue. There is no correlation between phenol content in 2nd pith tissue and incidence to stalk rot? (Ruiz, 1999; Petkovšek, 2003)

- Related mechanism need to be furthered
Conclusion II

- Relationship between plant nutrition and plant pathology is a crossing and hot research area, more attention need to be paid to;

- The main point of this study is to control disease with balanced fertilization with K instead of fungicide to protect environment.
Thank you!