

Balanced plant nutrition may help reduce pesticide use by improving tea plants' resistance to fungal diseases

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Abstract

Increasing efforts are being made to minimize pesticide use as a basic approach to controlling pest and disease incidence in tea and other plants. In China, where the soil is frequently deficient in potash, applying adequate amounts of this nutrient could help reduce the need for pesticides. Lower rates of infestation of tea plants by fungal disease in response to potassium added to the soil has been demonstrated.

Résumé

Pour lutter contre les parasites et les maladies qui ravagent le thé et d'autres plantes, on s'efforce de plus en plus de réduire l'utilisation de pesticides. En Chine, où le sol présente souvent une carence en potasse, un apport suffisant de cet élément nutritif pourrait permettre une utilisation moins importante de pesticides. En effet, il a été prouvé que l'apport de potasse dans le sol permet une diminution du taux d'infestation du thé par les maladies fongiques.

Resumen

Cada vez prosperan más los esfuerzos para evitar el uso de pesticidas como solución generalizada para el control de plagas y enfermedades en el té y otras plantas. Aplicando al suelo la cantidad adecuada de potasa en China, que suele ser pobre en este nutriente, se puede paliar la necesidad de emplear pesticidas. También ha quedado demostrado que, al añadir potasio al suelo, se reduce el índice de plagas fúngicas en la planta del té.

Fertilization affects not only the growth and metabolism of plants, but also their susceptibility to pathogens. In a study, pot experiments were conducted to evaluate the relationship between potassium (K) application and tea plants' resistance to three widespread fungal diseases (Figures 1-3). Young tea seedlings were grown in soil supplemented with K applied at different rates. They were inoculated with spores of *Gloeosporium theae* (anthracnose), *Guignardia camelliae* (brown blight) and *Pestalotiopsis theae* (grey blight).

Results show that increased K reduced the occurrence of all three fungi. At 36 days after inoculation (DAI), the number of leaves infested by *G. theae* in the treatment with K was 2.8 times lower than in the control group. Using a soil/quartz sand mixture as substrate, the *P. theae* infestation rate was reduced by 33.3% and 53.8% when K was applied at rates of 106 and 212 mg kg⁻¹, respectively. Under the same conditions, *G. camelliae* infestation rates decreased by 39.4% and 42.6% (K₁ and K₂ application rates). Reduced tea plant infestation by fungal disease in response to K may be attributed to increased polyphenol content in plants receiving sufficient amounts.

Tea is cultivated under a variety of climatic

conditions in tropical, subtropical and temperate areas. The high humidity and warm temperatures required for tea production also provide favourable conditions for the spread of disease. Anthracnose, grey blight, brown blight and other widespread diseases are responsible for considerable productivity loss every year. To control pests and diseases, which cause 10-20% of annual yield losses in China (Chen and Chen 1999), a number of pesticides are usually applied. However, depending on their toxicity, pesticides may present risks to both human health and the environment. In addition, a recent announcement that the EU is likely to recommend a further reduction of permissible critical levels of certain pesticides found in Chinese tea has alarmed growers. China exports 200,000-240,000 tonnes of tea annually.

During the past 50 years, plant protection has gone through a number of changes that might be described as occurring in three stages: total chemical control of the pest population and of disease infestation; integrated pest control based on threshold levels of attack; and, more recently, integrated pest management (IPM). IPM is considered the most sustainable, as it emphasizes plants' natural disease resistance. Adopting suitable cultivation practices is considered the basic

IPM approach, with proper fertilization a crucial component. Fertilization, which has an important impact on plants' growth and metabolism, affects their susceptibility to attacks of pathogens.

Quantitatively, nitrogen is the nutrient required by tea in the greatest amounts. However, there are an increasing number of reports concerning over-application of nitrogen fertilizers that directly link this problem to increased occurrence of some diseases. For example, the widespread occurrence of anthracnose in Japanese tea plants in the last 20 years has to a large extent been attributed to excessive nitrogen input (Chen and Chen 1999).

In contrast to nitrogen, potassium generally tends to decrease plants' susceptibility to disease (Perrenoud 1990). It can be demonstrated that potassium deficiency has become a production limiting factor in China, and that K application improves both the yield and quality of different types of tea (Wu and Ruan 1994, Ruan et al. 1999). However, there is little information on K with respect to disease resistance of tea plants.

The pot experiments reported here were conducted to evaluate the relationship of K nutrition and tea plants' resistance to three fungal diseases that differ significantly in their pathway of infestation and the damage caused by the pathogen. *G. theae* (anthracnose) invades the plant by the leaf hairs located on the lower surface of younger leaves. *G. camelliae* (brown blight) invades mature and old leaves directly through the epidermis. The pathogen primarily reduces production of new shoots. *P. theae* (grey blight) is a weak parasite that invades leaves mainly via wounds and may cause serious damage, especially in areas where the tea is mechanically harvested.

In the three experiments, year-old tea seedlings of the Lonjing 43 variety were transplanted to pots containing soil whose K content was adjusted using K₂SO₄, with the amounts of other nutrients (nitrogen, phosphorous, magnesium) kept at the same level in the each treatment. The treatments consisted of 18 pots per K level (a total of 54 test plants in the anthracnose experiment and 12 pots per treatment in the brown blight and grey blight experiments, equivalent to a total of 36 seedlings respectively). The tea plants were then subjected to spores of the pathogens *Gloeosporium*, *Pestalotiopsis* and *Guignardia*. Infestation by these diseases was recorded according to time intervals, as shown in the figures.

Other topics

Effects of potassium on anthracnose infestation

Twenty-one days after inoculation (DAI), nine leaves or four seedlings showed signs of anthracnose in the CK treatment (without K application). In the +K treatment, where the plants received 250 mg kg⁻¹, no plants were affected (Figure 1). The number of leaves/seedlings infested increased rapidly with the length of the experiment. At 36 DAI, the number of leaves and seedlings showing signs of anthracnose in the CK treatment was 2.8 and three times higher, respectively, than in the +K treatment.

The strong suppression of anthracnose outbreak in the K-treated plants may be due to the low potassium level in the soil in the control treatment. This is in agreement with Perrenoud (1990), who concluded that disease suppression through adding potassium is usually confined to the K deficiency range. One reason for disease suppression could be a morphological change in the leaves, increasing their hardness and thickness, but alteration of the leaf's chemical composition could also play an important role. With low-molecular potassium substances, soluble nitrogen fractions, amides and amino acids, for example, which are usually preferred as "food" by the pathogens, were synthesized to polymeric substances such as proteins, which did not correspond to the pathogens' dietary requirements.

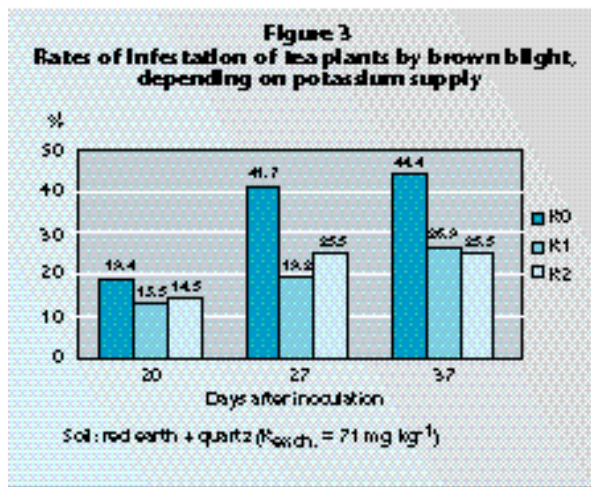
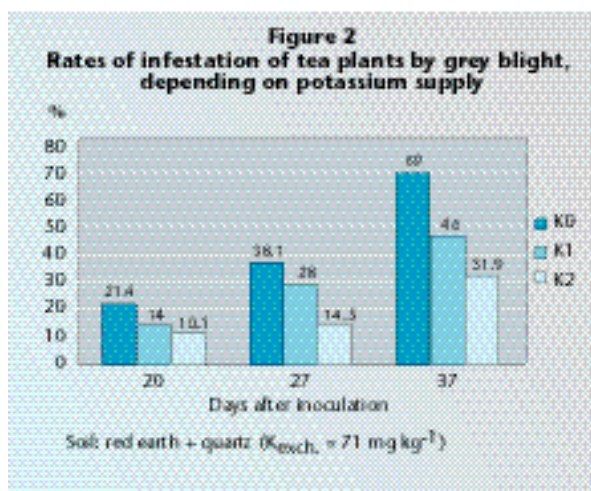
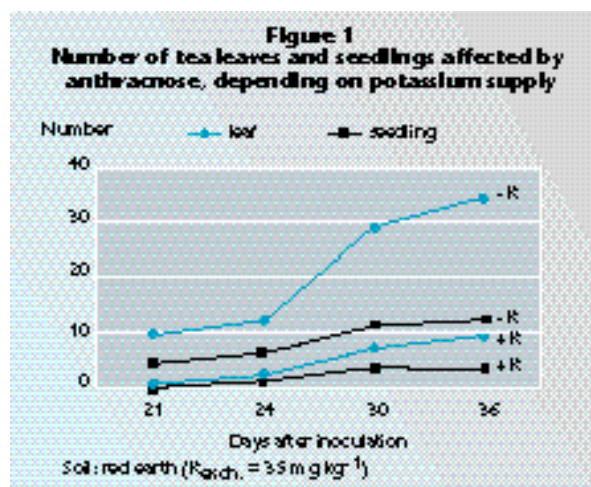
Effects of potassium on grey blight and brown blight infestation

Grey blight and brown blight infestation rates increased gradually over time (Figures 2 and 3).

Grey blight's severity continued to increase until 37 DAI. At each stage recorded, infestation was significantly reduced by adding potassium. Further reduction was achieved through increasing the application rate from K₁ to K₂. The most significant effects of K in reducing grey blight infestation were observed at 37 DAI (33 and 54% reductions with K₁ and K₂ applications, respectively).

Brown blight infestation also peaked at 37 DAI. Increments became smaller after 27 DAI. At every stage, potassium application reduced the occurrence of brown blight in tea seedlings. The difference in infestation if the rate of application was increased to K₁ or K₂ was insignificant, indicating that further reduction cannot be expected once the plants are out of the K deficiency range.

Reduced susceptibility of tea plants to fungal disease through potassium application may also be caused by enhanced synthesis of organic com-



pounds, which could act as phytoalexins that inhibit growth and spread pathogens. Chakraborty et al. (1994) found that higher polyphenols content, in particular, may exert such antifungal effects in plants. Recent results published by Lang'at et al. (1998) confirm the close negative correlation between polyphenol content and incidence of grey blight.

Our own field experiments with green tea (Ruan et al. 1999) have shown that polyphenols in tea leaves increase with K supply. The observed effects on disease suppression in tea may therefore be closely linked to the effect of potassium on the synthesis and accumulation of polyphenols.

In view of the increasing demand for green tea (due to its beneficial effects on human health), together with growing awareness of the risks presented by pesticide residues, the results of this study indicate a significant potential for integrating plant nutrition in the management of pest and diseases. This is especially important with regard to Chinese tea plant fertilization practices, where K inputs are often neglected and the emphasis is on nitrogen. In this case, the benefits for disease resistance of balancing the nutrient supply may primarily be related to potassium deficiency in the soil/plant system. Whether the effects are only confined to the K deficiency range, as stated by Perrenoud (1990), is a matter of further investigation.

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