

The effects of foliar applied $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Ca}(\text{OH})_2$ and K_2CO_3 combined with the surfactants Glucopon and Plantacare on gas exchange of 1 year old apple (*Malus domestica* BORKH.) and broad bean (*Vicia faba* L.) leaves

R.Q. Bai^{a,*}, T.K. Schlegel^b, J. Schönherr^{b,1}, P.W. Masinde^c

^a Agronomy College, Inner Mongolia Agricultural University, Xinjiandongjie 275, Huhhot 010019, China

^b Institute of Biological Production Sciences, Hannover University, Herrenhäuser Straße 2, Hannover D 30419, Germany

^c Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000, Nairobi 00200, Kenya

Received 9 January 2007; received in revised form 15 October 2007; accepted 23 October 2007

Abstract

Calcium chloride, calcium hydroxide, potassium carbonate and the alkylpolyglycoside surfactants Glucopon 215 CSUP and Plantacare 12 UP are salts applied to leaves as foliar nutrients and fungicides. These chemicals were sprayed on apple (*Malus domestica* BORKH.) and broad bean (*Vicia faba* L.) leaves. Stomatal conductance and rates of net photosynthesis were measured continuously in the light and in the dark using a Portable Photosynthesis System CIRAS-1. All compounds with the exception of $\text{Ca}(\text{OH})_2$ affected stomatal conductance and net photosynthesis, albeit to different degrees. In light, Plantacare either alone (0.2 g l^{-1}) or in combination with $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (5 g l^{-1}) or K_2CO_3 (5 g l^{-1}) caused a rapid initial increase in stomatal conductance during the first 1–3 h after spraying on the leaves, maximum conductances were observed about 6 h after application. A rather high stomatal conductance was observed during the dark period when Glucopon (0.2 g l^{-1}) was applied either alone or in combination with $\text{Ca}(\text{OH})_2$. The combination $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ + Glucopon did not cause this elevated stomatal conductance during the dark. $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ reduced stomatal conductance in combination with both Glucopon and Plantacare. The surfactant Plantacare reduced net photosynthesis during the first light period (12 h), if applied alone or in combination with $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$. Treatment of broad bean leaves with K_2CO_3 + Plantacare resulted in a rapid decrease in net photosynthesis during the first hour, and then the rates of net photosynthesis increased rapidly and approached to those of the water control. The effects of surfactants and salts on net photosynthesis had nearly disappeared by the beginning of the second light period. Non-specific glycosidases presumably cleaved the glycosidic bond between the alkyl and the sugar moieties during the preceding night. Our data showed that foliar applications of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ and K_2CO_3 together with alkyl polyglycoside surfactants can affect gas exchange. However, the effects of the chemicals at the concentrations used in our study were not very large and were transient. They practically vanished within 24 h and a detrimental effect on growth and development of crops was not likely.

© 2007 Elsevier B.V. All rights reserved.

Keywords: Foliar nutrients; Fungicides; Glucopon; Photosynthesis; Plantacare; Stomatal conductance; Surfactants; Transpiration

1. Introduction

Foliar nutrition is an option when nutrient deficiencies cannot be corrected by applications of nutrients to the soil. Application of nutrients during grain filling is an example of usefulness of foliar nutrition (Hanway, 1988). Calcium hydroxide and potassium carbonate have potentials as fungicides against apple scab (Schulze and Schönherr,

2003). Calcium salts are routinely and repeatedly applied to apples and other fruits that suffer from calcium deficiency (Schlegel and Schönherr, 2002; Grimm-Wetzel and Schönherr, 2005a).

Stomatal movement is accomplished by changes in the ionic content within guard cells as well as in the cell wall of the surrounding stomatal pore. Potassium, calcium and chloride ions are involved in regulation of stomatal opening (Felle et al., 2000). Salts applied to the foliage can be phytotoxic by virtue of their high osmotic potential (Weinbaum, 1988) or by interfering with metabolic processes such as photosynthesis or stomatal opening (Swietlik et al., 1984). Stomata are particularly vulnerable, because the cuticle over guard cells is the main site

* Corresponding author. Tel.: +86 471 4308973; fax: +86 471 4301175.

E-mail address: bairuiqin2003@yahoo.com.cn (R.Q. Bai).

¹ Present address: Rueland 6, Winsen 29308, Germany.

of entry into leaves after foliar applications (Schlegel et al., 2005). Foliar potassium applications may prevent stomatal closing in wilting leaves (Hartley et al., 1982).

Wetting agents improve retention of sprays and greatly increase rates of cuticular penetration of salts (Schönherr, 2000, 2001, 2002a). Many surfactants penetrate the cuticle (Anderson and Girling, 1983) and can damage cells (Kristen, 1997; Uhlig and Wissemeier, 2000) and cell membranes (Müller et al., 1999). Commercial adjuvants are mixtures of surfactants and other ingredients and some have been shown to decrease photosynthesis and affect stomatal conductance (Wood, 1997). Ethoxylated alcohols are non-ionic surfactants, which are often used, in agricultural sprays. With Ca^{2+} ions they form positively charged complexes of high molecular weights, which do not penetrate cuticles. Hence, surfactants toxicity is eliminated but the fraction of calcium ions complexed remains on the cuticle and does not penetrate (Uhlig and Wissemeier, 2000). For this reason, ethoxylated surfactants should not be used in foliar nutrition.

There is very little information on these sub lethal processes of foliar nutrition application as they are not readily visible. There are cases where frequent applications of foliar salts may be necessary for nutritional purposes (Grimm-Wetzel and Schönherr, 2005a). Similarly, frequent applications will be needed if the foliar salts are to be used to control scab (Grimm-Wetzel and Schönherr, 2005b). When numerous applications are needed, even small effects on stomatal conductance or photosynthesis may adversely affect growth and development. Thus, the objective of this study was to investigate whether calcium hydroxide, calcium chloride, potassium carbonate and surfactants influence stomatal conductance and net photosynthesis.

2. Materials and methods

All experiments were conducted using greenhouse-grown plants. Apple leaves were available from May till September 2002. During the remainder of the year, leaves of broad bean were used. For gas exchange measurements, the plants were transferred to a growth chamber at Hannover University, Germany.

2.1. Plant materials

Apple (*M. domestica* BORKH.) 'Elstar' grafts on M9 rootstocks (1 year old) were grown in pots in a mixture of peat, perlite and fertilizer (500 l TKS II + 250 l perlite coarse + 2.5 kg Osmocote per 5–6 M (18-10-11-2 MgO + micro-nutrients)) in a greenhouse from May to September. One year old apple trees were used due to the convenience of handling plants in the growth chamber. Uniform plants with healthy leaves were selected and were allowed to adapt to the climatic conditions in the growth chamber for 1 day before gas exchange measurements were taken.

The broad bean (*V. faba* L.) seeds were sown in pots (12 cm in diameter) with Potgrond P serving as substrate. The seedlings were raised in a greenhouse until they reached a

stage of about 30 cm in height from September 2002 to May 2003. Water was given on demand and fertilizer was supplied weekly with 1 g l⁻¹ Flory-MEGA (N:P:K = 16:6:2). Plants were transferred to the growth chamber 1 day before gas exchange measurements were taken.

The experiments were conducted at 20 °C with 16 h light at about 200 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PAR. Light was provided by fluorescent lamps. Humidity was not controlled.

2.2. Experimental setup

Chemicals tested with apple leaves were $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ and $\text{Ca}(\text{OH})_2$, combined with Glucopon 215 CSUP (an oligomeric alkylpolyglycoside (APG) surfactant having alkyl chain lengths of $\text{C}_{8/10}$), respectively. The plants were treated with aqueous solutions using concentrations which are used in the field. Details are given in the figure legends. Gas exchange was measured for about 4 h (unsprayed control), after which leaves were removed from the cuvette. The lower leaf surfaces were sprayed to run off. Measurement of gas exchange was resumed when the treated leaf appeared dry and was terminated after about 40 h. Each treatment was replicated six times with apple leaves from different plants serving as replicates.

For broad bean leaves, chemicals used for spray were $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Ca}(\text{OH})_2$, and K_2CO_3 (Roth, Germany). Glucopon 215 CSUP, Plantacare 1200 UP (Fluka/Riedel-deHäen, Germany) are oligomeric APG-surfactants having alkyl chain lengths of $\text{C}_{8/10}$ and $\text{C}_{12/16}$, respectively. They are excellent wetting agents and do not complex Ca^{2+} ions. Both surfaces of the selected leaves were sprayed to run off. Concentrations are given in figure legends. The treated leaf was inserted into the cuvette and measurement started as soon as the leaf appeared dry. The start of data acquisition is the zero time point in the figures. Measurements lasted for about 24 h. Ten replications were used, where a replication was represented by the first fully expanded leaf positioned just below the apex of the plant.

2.3. Instrument and data collection

The Portable Photosynthesis System CIRAS-1 was used to measure gas exchange. The temperature (°C), water vapour pressure (mbar) and light intensity (PAR in $\mu\text{mol m}^{-2} \text{s}^{-1}$) inside the leaf cuvette were monitored and stomatal conductance and rates of photosynthesis were calculated from these data.

The main principle of CIRAS-1 is to measure the differences between water vapour and CO_2 partial pressure of air, which flow into and out of the leaf cuvette. For the experiments with apple leaves the source of carbon dioxide was a CO_2 cartridge with adjusted CO_2 concentration (500 ppm). Water vapour was supplied by ambient air of the growth chamber and relative humidity ranged from 75% to 80%. With the CIRAS-1 water vapour pressure can only be decreased but not increased. However, the humidity in the leaf cuvette should be as high as possible during measurement after the spray treatments, since the rate of penetration of the applied salts strongly depends on the humidity of the air above the salt residues on the leaf surface

Download English Version:

<https://daneshyari.com/en/article/4569540>

Download Persian Version:

<https://daneshyari.com/article/4569540>

[Daneshyari.com](https://daneshyari.com)