Large-scale applications of phosphine in commercial facilities

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The use of wireless phosphine sensors opens the barriers for extensive and continuous monitoring. In this regard, we evaluated wireless sensors in order to illustrate gas concentration, but also to depict spatio-temporal distribution of the gas within a given facility and commodity. Moreover, this novel technique is able to evaluate the commodity penetration speed in "real world" fumigations, its distribution attributes, the effects of temperature and relative humidity and the effectiveness of the dosages used in commercial applications. Based on our results, distribution in large warehouses is not usually adequate for a satisfactory level of insect control and any application will not lead automatically to uniform concentrations unless means of aeration are used. In fact, in light of our findings, it is likely that, in some of the cases tested, gas penetration in the tested commodities is minimal, suggesting that phosphine may not be effective. This is particularly important for traditional monitoring techniques, as any measurements correspond to the specific time of monitor and is not transferable to additional intervals, which makes fumigators to either overestimate or underestimate the outcomes of a given fumigation. One of the critical factors is that, despite the fact that temperature may not be that critical for the concentration of phosphine, humidity is the key factor that determines concentration and the concomitant gas distribution. Finally we found that the recommended label concentrations cannot be used in some cases due to limitations of the free air and free humidity in a closed space. Overall, the tests, that were carried out for the first time globally, with phosphine sensors clearly suggested that the sensors were effective in measuring phosphine and are generally expected to

play an important role in the near future in programs related with integrated pests management at the post-harvest stages of agricultural commodities.

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