Accelerated senescence by elevated CO$_2$ in Solanum tuberosum: Effects of nutrients and chamber types

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Introduction
Atmospheric carbon dioxide concentration ([CO$_2$]) has increased to over 400 ppm at present and is predicted to keep rising in the future (IPCC, 2014). Regardless of global warming due to elevated [CO$_2$] (e[CO$_2$]), e[CO$_2$] can efficiently promote crop growth, known as CO$_2$-fertilization effect, especially in C3 plants (Kimball, 1983; Kimball, 2016). The degree of CO$_2$-fertilization effect was dependent on nutrient status (Campbell and Sage, 2006) and CO$_2$ enrichment facilities (van der Kooi et al., 2016). However, the cause for the difference occurred between varied facilities is unclear. In this study, trials in both growth chambers (GC) and open-top chambers (OTC) were conducted to investigate possible cause for this difference.

Materials and Methods
A single potato cultivar (Irish Cobbler) was used in this study. Firstly, three pot experiments (Trial 1, Trial 2, and Trial 3) were carried out in GC during a relative short-term growth period with different levels of nitrogen (N), phosphorus (P), and potassium (K). Then, an additional pot experiment (Trial 4) in GC covering the whole growth stage was conducted to investigate if the CO$_2$-fertilization effect could be maintained or not till maturity. Finally, two pot experiments (Trial 5 and Trial 6) were carried out in OTC to investigate if the CO$_2$-fertilization effect could be maintained in OTC.

Results
e[CO$_2$] enhanced total plant biomass at all nutrient status in Trials 1, 2, and 3, however, increment by e[CO$_2$] was dependent on nutrient status. Maximum plant biomass was increased at e[CO$_2$] by approximately 1.4-fold in Trial 1, but 1.5-fold in Trial 2. That could be due to plants were harvested at different developmental stages, since tuber proportion was about 23% in Trial 1 but 36% in Trial 2. In Trial 4, both total biomass and tuber biomass were increased by e[CO$_2$] under sufficient nutrient status, however not changed under N- or P-deficiency, though accelerated senescence was observed at [CO$_2$] under all nutrient status. CO$_2$-fertilization effect was decreased in Trial 5 in OTC, even disappeared when P was deficient. In Trial 6, not only under P-deficiency, but also under P-sufficiency, total plant biomass and tuber biomass were decreased by e[CO$_2$]. Apparently accelerated senescence at e[CO$_2$] was observed under both P-deficiency and P-sufficiency, which could be likely to explain the disappeared CO$_2$-fertilization effect in OTC.

Conclusions
CO$_2$-fertilization effect was dependent on developmental stage, nutrient status, as well as chamber type. CO$_2$-fertilization effect was decreased or disappeared under OTC, which is likely to be caused by accelerated senescence under e[CO$_2$]. Thus, the next subject will be how alleviate e[CO$_2$]-induced senescence.

Acknowledgements
This work was supported by Japan Society for The Promotion Science [Grant number 16H05055]. We are grateful to Yasuko Kato for her technical assistance.