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主　論　文　の　要　旨

論文題目　Nutrient Supply and Growth Responses of Potato under Elevated CO_2（高CO_2 環境下における養分供給とジャガイモの成長反応）

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論　文　内　容　の　要　旨

The global atmospheric CO_2 concentration (ambient CO_2, a[CO_2]) has risen from 280 ppm in pre-industrial times to exceed 400 ppm at present, and it is predicted to continue rising in the future. The elevated CO_2 (e[CO_2]) is expected to enhance crop growth and water-use efficiency (WUE), especially in C3 species. Potato (Solanum tuberosum L.) is the most important non-grain crop in the world and may have great response to e[CO_2] because of its large sink capacity. However, enhancement of crop growth and water economy under e[CO_2] may be dependent on soil nutrient availability. Therefore, it is important to investigate how nutrient supply affect CO_2 effects on plant growth and water use in potato plants under e[CO_2].

Firstly, I quantified potato growth in response to phosphorus (P), nitrogen (N), as well as potassium (K) supply under a[CO_2] and e[CO_2] in growth chambers (GC) to investigate the minimum nutrient and water demands for the maximum plant growth at early growth stage. The e[CO_2] enhanced maximum growth and WUE by 1.5-fold without additional P and water supply. N and water required by potato plants under e[CO_2] was dependent on P supply. Although under P-sufficiency conditions, e[CO_2] increased N but not water demand to obtain maximum growth during the early growth stage, N demand was unchanged and water demand was decreased by e[CO_2] under P-deficiency conditions, probably owing to growth limited by P availability. K supply could remarkably enhance the accumulation of plant biomass under e[CO_2] by promoting tuber formation. Though the maximum plant biomass in response to K supply was not obtained due to narrow range of K supply, CO_2-fertilization effect and WUE were dependent on both P and K supply. Less biomass accumulation in response to K supply in plants with P deficiency, indicates that a balanced nutrient status is crucial for crop production under e[CO_2].

Secondly, to further investigate CO_2 effects on potato plants at different developmental stages and at large scale, I conducted experiments in GC covering the whole growth period of potato plants and in open-top chambers (OTC) at different developmental stages. Total plant and tuber biomass at maturity were increased by 1.4- and 1.6-fold under e[CO_2] in GC when nutrient was sufficient. Enhancement of plant growth under e[CO_2] was smaller in OTC than in GC, though the reason is still unknown. Plant biomass was decreased by e[CO_2] at entire maturity in OTC, which could be due to accelerated senescence under e[CO_2]. Furthermore, the e[CO_2]-mediated senescence could not be prevented, however can be delayed by nutrient supply due to extended growth period, indicating plants with longer lifespan may benefit more from e[CO_2].

Finally, I compared responses of six varieties belonging to various maturing groups to e[CO_2] in order to examine effects of variety earliness on CO2 effects. It was expected that the variety with longer lifespan can profit more from e[CO2] during the same growth period. Eventually, the late maturity variety such as Red Moon was found to have greater effect size of e[CO_2], suggesting an importance to maintain vegetative growth under e[CO_2]. Additionally, the varieties (Inkanomezame, Dejima and Red Moon) with higher leaf but lower tuber proportion was found having greater effect sizes of e[CO_2] in total plant biomass comparing to the others. That indicates leaf expansion rather than tuber formation at early growth stage may be more important to fully utilize CO_2 from whole growth period. Lower net assimilation rate (NAR) under e[CO_2] in very early varieties, but higher NAR under e[CO_2] in late varieties indicates the possibility of e[CO_2]-mediated senescence is dependent on earliness of potato plants.

This study suggested that e[CO_2] could remarkably increase maximum plant growth in potatoes without additional P and water demands but with additional N demand at early developmental stage. The enhancement by e[CO_2] could be achieved even until the end of life cycle unless nutrient is deficient. However, e[CO_2]-induced senescence may cause yield reduction, especially under nutrient deficiency. To against e[CO_2]-induced senescence and fully benefit from e[CO_2], rational fertilization supply and variety breeding are supposed to be deeply considered.