Effect of elevated CO_2 and harvest schedule on *Allium* biomass and sensory quality of *A. fistulosum*

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ABSTRACT

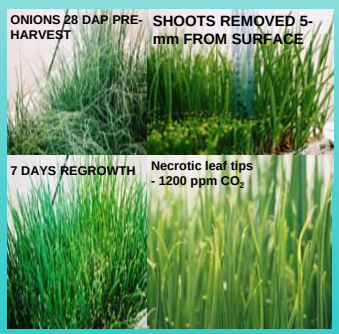
Plants of three *Allium*s were grown at 400 and 1200 ppm CO_2 in Environmental Growth Chambers. Shoots of these plants were harvested weekly, bi-monthly, or at 70 days after planting (DAP). Shoots were harvested by severing at 50-mm and weight was (g) recorded. Japanese bunching onion (JBO) and bulbing onion had the greatest shoot biomass. Plants harvested one-time at 70 DAP weighed more than those harvested weekly and bi-monthly. Shoot weight depended upon harvest schedule and CO_2. Shoots from plants grown under 400 ppm weighed more than those grown under 1200 ppm CO_2 when left undisturbed and harvested once at 70 DAP. JBO grown at 400 ppm were greener; consumer panelists (n=25) ranked sensory quality of JBO grown under 1200 and 2000 ppm CO_2 as more visually appealing at 28 DAP. JBO grown under 400 ppm CO_2 were ranked more visually appealing at 70 DAP.

INTRODUCTION

The goal of this research was to select *Allium* species and a harvest strategy that produced maximum edible biomass and appealing sensory quality while minimizing crew-time handling of plant material. Green shoots of plants harvested multiple times provide edible biomass for extended periods. This unique accumulation of edible biomass in leaves and bulb make onion a versatile candidate for fresh consumption. It has been observed that plants grown under elevated CO_2 have an initial increase in growth, but as plants age growth. In addition, plants grown under high CO_2 also show damaged chloroplasts and reduced chlorophyll (Arp, 1991). Slow saturation of carbohydrate sinks exposed to elevated CO_2 over time resulted in decreased growth (Del Pozo et al., 2005; Mitchell et al., 1999).

MATERIALS AND METHODS

Plants of *A. fistulosum*, Japanese bunching onion (JBO), *A.cepa*, bulbing onion, and *A. schoenoprasum*, chive were grown hydroponically in growth chambers at 400 and 1200 ppm CO_2 and irrigated with recirculating Hydro-sol® nutrient solution. Experimental design was a completely randomized block with repeated measures; data was analyzed using SAS 9.1. Shoots were removed 50-mm from media surface at 28 DAP repeated weekly, bi-monthly, or 70 DAP. JBO was grown separately under 400, 1200 and 2000 ppm CO_2, harvested bi-monthly for visual sensory. Ranking of sensory quality for visual appeal was 1 to 6 (dislike very much to like very much).



RESULTS

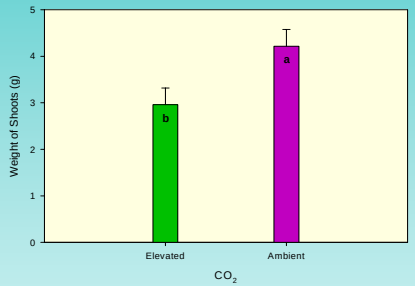


Figure 1. Weight of shoots of *Allium* species grown under ambient (400 ppm) and elevated (1200 ppm) CO_2 harvested once a 70 DAP, (p>0.05, protected LSD).

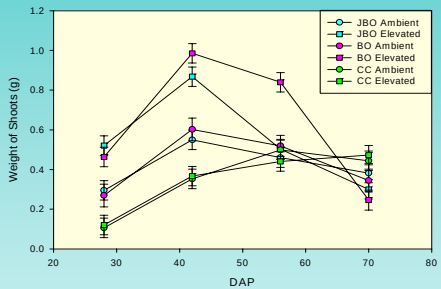


Figure 2. Weight of shoots of *Allium* species, JBO, BO (bunching onion), and CC (chive), grown under two CO_2 levels harvested bi-monthly, (p>0.05, protected LSD).

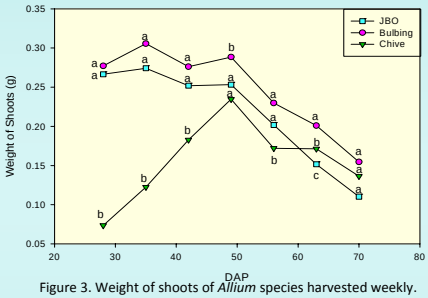


Figure 3. Weight of shoots of *Allium* species harvested weekly. Species means at a harvest followed by the same letter are not different, (p>0.05, protected LSD).

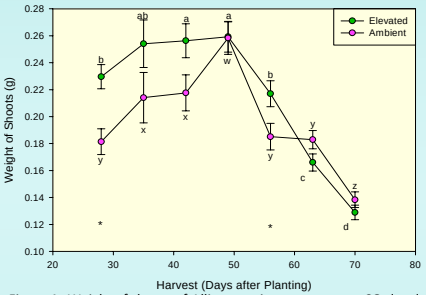


Figure 4. Weight of shoots of *Allium* species grown at two CO_2 levels harvested weekly. CO_2 level means followed by the same letter are not significantly different across harvests, (p>0.05, protected LSD). Harvest 28 DAP and 56 DAP are significantly different (noted by *).

DISCUSSION

Two events led to the observed lower weight of shoots of plants grown at elevated CO_2. As onion matures, a bulb is formed and carbohydrates are shuttled from the shoots to the bulb. In this experiment, the carbohydrates were removed repeatedly when the shoots were severed; carbohydrates were not present to be shuttled to the bulb. Cumulative weight of shoots removed from plants weekly and bi-weekly weighed less than those harvested one time (Table 1). Cumulative biomass was greater when grown under ambient (Table 1). This phenomenon has been observed in other crops (Del Pozo et al., 2005; Mitchell et al., 1999). When shoots were harvested once at 70 days, the carbohydrates were likely shuttled to the sink (bulb) in plants grown under elevated CO_2.

CO_2 (ppm)	Species	Cumulative Shoot Weight by Harvest		
		One-time	Bi-monthly	Weekly
400	JBO	5.826 (0.347) a[1]A[2]	1.687 (0.347) b A	1.468 (0.291) b A
	Bulbing	5.169 (0.347) a A	1.667 (0.375) b A	1.607 (0.284) b A
	Chive	1.654 (0.362) a A	1.386 (0.347) a A	1.056 (0.354) a A
1200	JBO	4.148 (0.347) a B	2.191 (0.347) b A	1.542 (0.291) b A
	Bulbing	3.006 (0.347) a B	2.232 (0.347) a A	1.857 (0.291) b A
	Chive	1.718 (0.362) a A	1.401 (0.347) a A	1.132 (0.284) a A

Table 1. Cumulative shoot weight of JBO, bulbing onion, and chive grown under 400 and 1200 ppm CO_2 harvested one-time, bi-monthly, and weekly over 70 days. [1] Species means within a CO_2 level followed by the same lowercase letter are not significantly different (P>0.05). [2] CO_2 means within a species and harvest followed by the same uppercase letter are not significantly different (P>0.05).

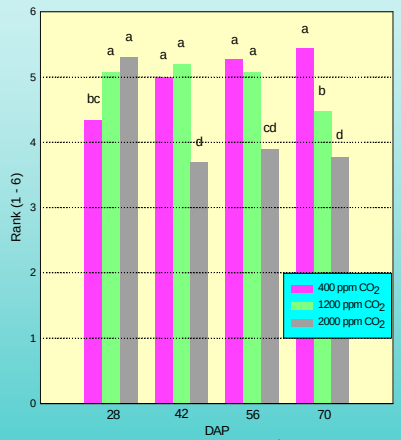


Figure 5. Consumer panelists ranking of sensory quality (n=25) of JBO grown under three CO_2 levels harvested bi-monthly. Rankings were 1 - dislike very much, to 6 - like very much.

CONCLUSION

JBO and bulbing onion weighed more overall than chive for both weekly and bi-monthly harvests (Figure 3). One-time 70 DAP harvest yielded more shoot weight than weekly and bi-monthly. *Allium* plants grown under elevated CO_2 weighed more than those grown under ambient CO_2 when harvested one-time (Figure 1), but did not weigh more when harvested weekly and bi-monthly (Figure 2 and 4). Consumer panelists ranked the sensory quality of JBO grown under 1200 and 2000 ppm as more visually appealing at 28 DAP, but ranked JBO grown under 400 ppm the most visually appealing at 70 DAP (Figure 5).

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