Response of Faba Bean Subjected to Drought Stress Under Free Air CO_2 Enrichment Facility (FACE) in a Mediterranean Dry Environment

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1 Background

N_2 fixation of legumes is extremely sensitive to water stress. Legumes grown under elevated CO_2 (e[CO_2]) might have less impact of drought on N_2 fixation due to greater water use efficiency (WUE) and water soluble carbohydrate availability to root nodules [1].

Most previous studies on nitrogen fixation of legumes in Free Air CO_2 Enrichment (FACE) facilities were done in high rainfall systems [2], yet drought can impose additional constraints on N_2 fixation and not investigated yet using the approach of FACE facility. This study aimed to evaluate whether faba bean (*Vicia Faba* L.) can maintain N_2 fixation and overcome N limitation under e[CO_2] in a drought prone Mediterranean climate regions.

2 Research question

Can e[CO_2] stimulate N_2 fixation and maintain grain N concentration ([N]) of faba bean when exposed to drought?

3 Material and Methods

Faba bean (cv. PBA Fiesta) were grown in e[CO_2] (~550 μmol mol^{-1}) or ambient CO_2 concentrations (a[CO_2], ~ 400 μmol mol^{-1}) using SoilFACE facility in Horsham, Australia. Drought was imposed at vegetative stage and continued until maturity by withholding 40% of irrigation and 100% of rainwater (covering the columns).

Photosynthesis, nodule water soluble carbohydrate concentration (WSC), carbon isotopic composition ($\delta^{13}C$) and N_2 fixation of faba bean was analysed by ^{15}N natural abundance using wheat as reference at flowering and grain [N] at maturity.

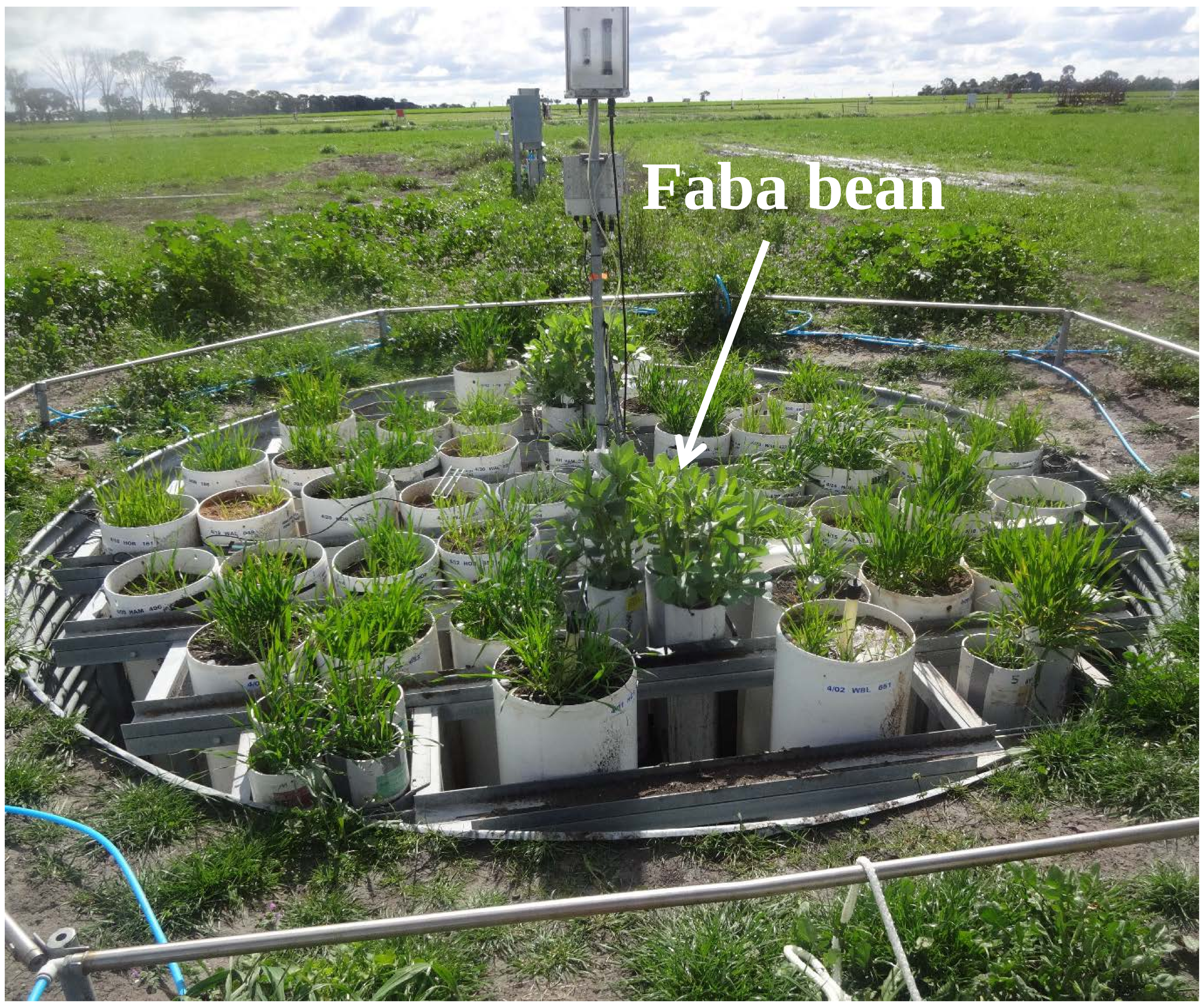

Figure 1: Experimental set-up in the Soil Free CO_2 Enrichment Facility (SoilFACE), part of Australian Grains Free Air CO_2 Enrichment (AGFACE) facility project in an e[CO_2] ring with CO_2 injection system. Arrow: faba bean columns used in this study in 2016.

4 Results

Elevated [CO_2] increased photosynthesis and greater WSC supply to nodules under drought (Fig. 2 A, B). Less negative ^{13}C isotopic composition ($\delta^{13}C$, ‰) of e[CO_2] grown faba bean represented enhanced water use efficiency during drought condition (significant CO_2 × W interaction) (Fig. 2 C)[3].

N_2 fixation was stimulated by e[CO_2] even under drought. Soil N uptake was lower ~~under~~ e[CO_2] compared to a[CO_2] grown faba bean and such trend maintained during the period of drought (Fig. 3 A). Partitioning of the sources of N in above and below ground organs (Figure 3 A) indicated that the amount of N derived from the atmosphere (Ndfa) was significantly greater under e[CO_2] compared to a[CO_2], irrespective of water treatment.

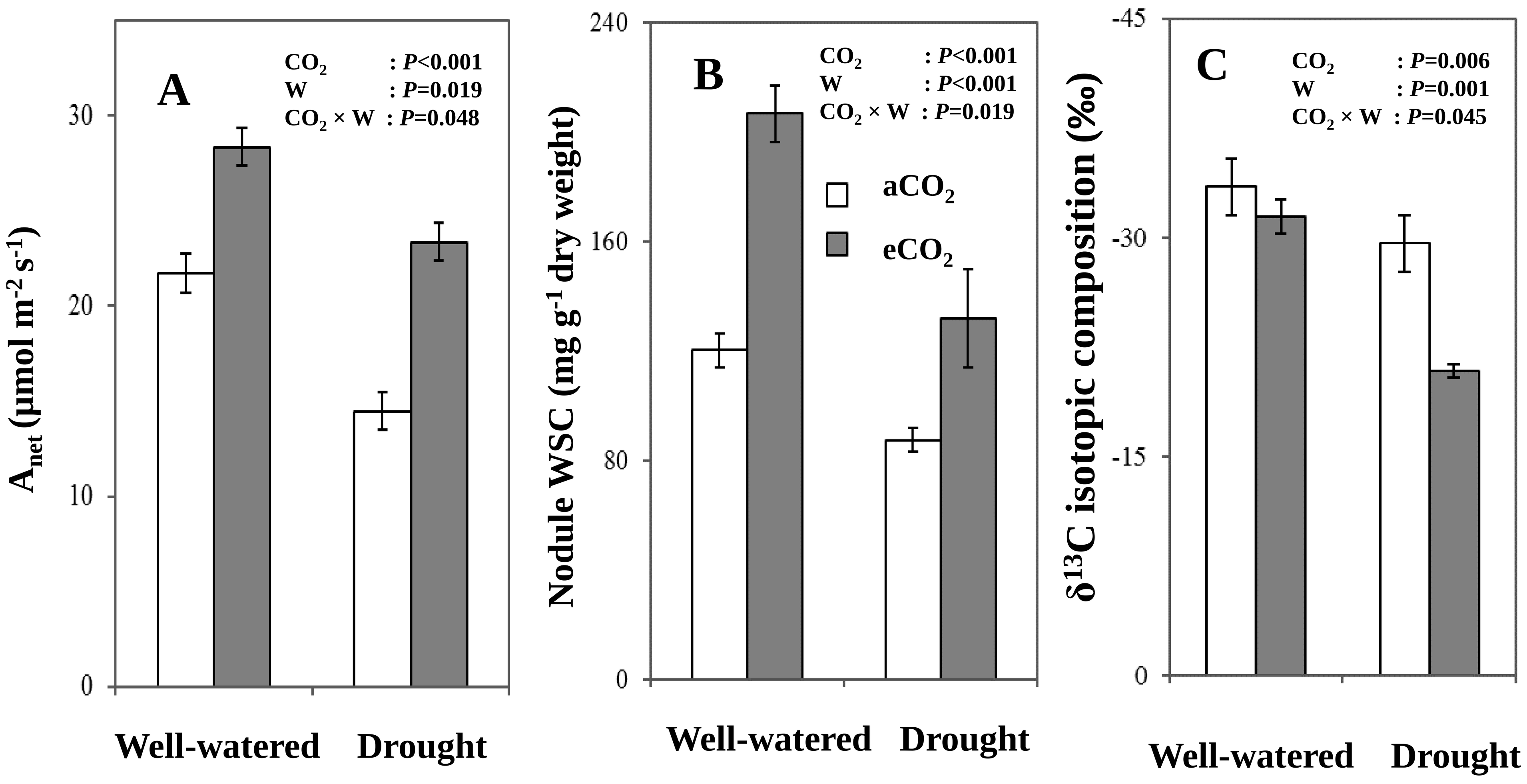

Figure 2: A. Net CO_2 assimilation rate (A_{net}), B. Nodule water soluble carbohydrate concentrations (WSC), and C. ^{13}C isotopic composition of faba bean grown under a[CO_2] (~400 μmol mol^{-1}, white bars) or e[CO_2] (~550 μmol mol^{-1}, grey bars) and two water (W) regimes (Well-watered and drought) in SoilFACE. Means and ±SE (n=4) in each bar.

Drought reduced Ndfa in both above and below ground organs compared to well-watered plants but the extent of decreased was prominent under a[CO_2] compared to e[CO_2]. Grain [N] concentration decreased by e[CO_2] under well watered condition but increased in drought treated faba bean (significant CO_2 × W interaction, Fig. 3 B).

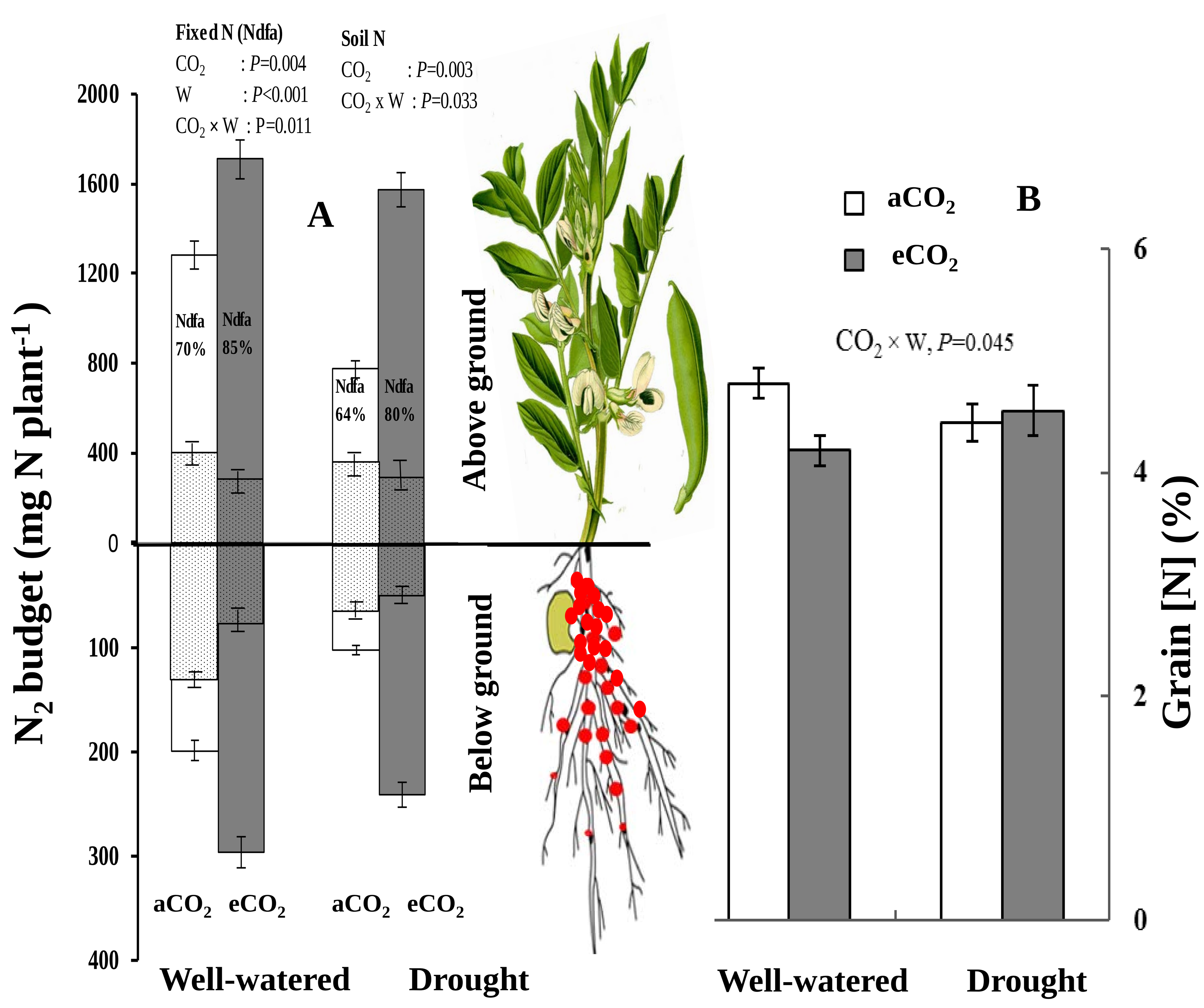

Figure 3: A. Total N budget at flowering and B. Grain [N] at harvest of faba bean grown under a[CO_2] (~400 μmol mol^{-1}, white bars) or e[CO_2] (~550 μmol mol^{-1}, grey bars) and two water (W) regimes (Well-watered and Drought) in SoilFACE. Ndfa refers to the percentages of total N derived from the atmosphere in both above and below ground parts together. Soil N uptake is indicated as dotted bars for both a[CO_2] and e[CO_2] treatments. Means and ±SE (n=4) in each bar. Only significant effects are shown (P<0.05).

5 Conclusions

Elevated [CO_2] stimulated N_2 fixation and increased grain [N] concentration of faba bean by improving water use efficiency and greater WSC supply to nodules under drought which will provide advantage of growing faba bean in dry land semi- arid environment in a unforeseen climate change.

6 References

[1]Serraj et al 2008 Plant Cell Environ 21; [2]Roger et al 2006 Plant Cell Environ 29; [3]Farquhar and Richards, 1984 Aust. J. Plant Physiology 11.

7 Acknowledgement

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