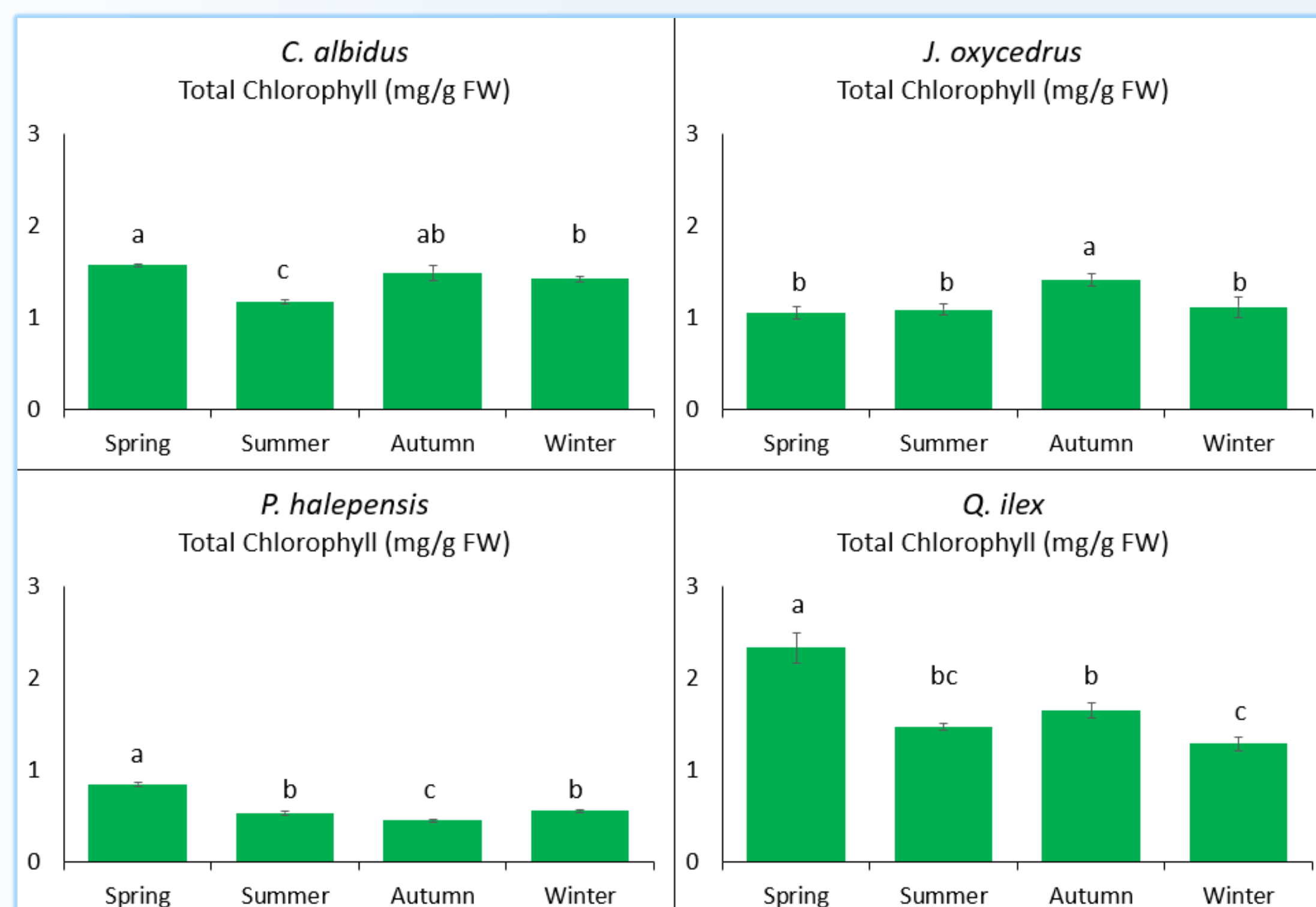


Indicators of environmental stress in *Cistus albidus*, *Juniperus oxycedrus*, *Quercus ilex*, and *Pinus halepensis*: seasonal changes

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Objective

The aim of this study was to evaluate the physiological and biochemical responses of *C. albidus*, *J. oxycedrus*, *Q. ilex*, and *P. halepensis* at an intensive monitoring station of the Global Change Observatory of the Subbética Mountains (southern Sierra of Jaén).

Sampling	<i>P. halepensis</i>		
	Na	K (%)	Ca
Spring	0.0047 ab	0.4170 a	1.2152 a
Summer	0.0054 a	0.3472 b	0.8036 b
Autumn	0.0032 bc	0.3452 b	0.4424 c
Winter	0.0026 c	0.3167 b	0.4672 c
	*	***	***

*, *** indicate significant differences at Ps0.05 and 0.001, respectively



P. halepensis reached maximum MDA levels in summer, while hydrogen peroxide levels peaked in spring and winter. In the case of proline content, no seasonal differences were observed (LSD test, $P \leq 0.05$).

Conclusion

Seasonal variation in leaf hydrogen peroxide, proline, and MDA contents showed distinct patterns among the species studied.

Sampling	<i>C. albidus</i>		
	Na	K (%)	Ca
Spring	0.0140 a	1.3970 a	2.4381 a
Summer	0.0074 b	1.1144 b	1.5079 b
Autumn	0.0046 c	0.8863 c	1.0408 d
Winter	0.0047 bc	0.9271 c	1.2841 c
	***	***	***

*** indicates significant differences at Ps0.001



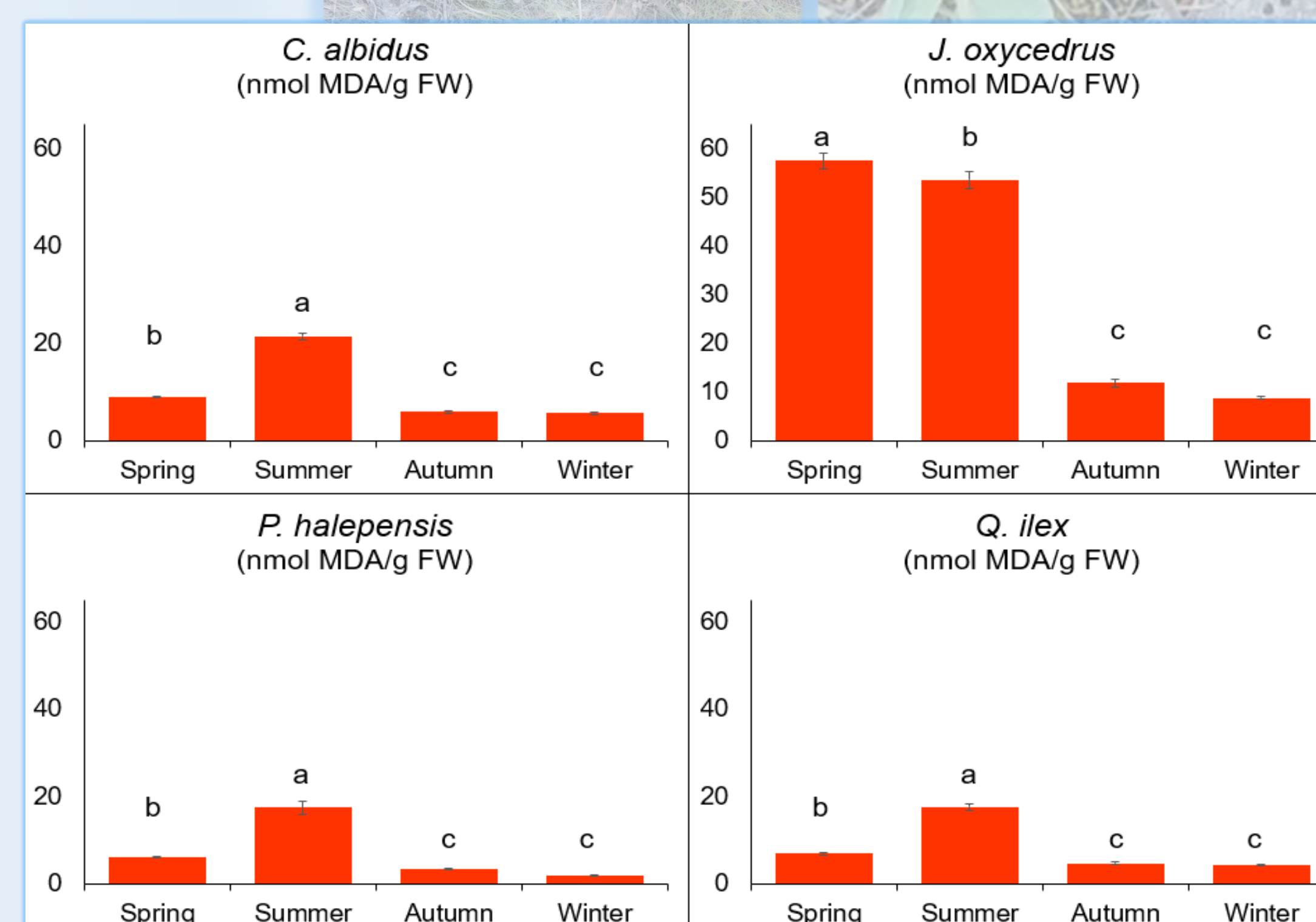
Results

P. halepensis and *Q. ilex* showed the highest chlorophyll levels in spring (LSD test, $P \leq 0.05$), whereas in *J. oxycedrus* this occurred in autumn. *C. albidus* exhibited maximum values in both spring and autumn.

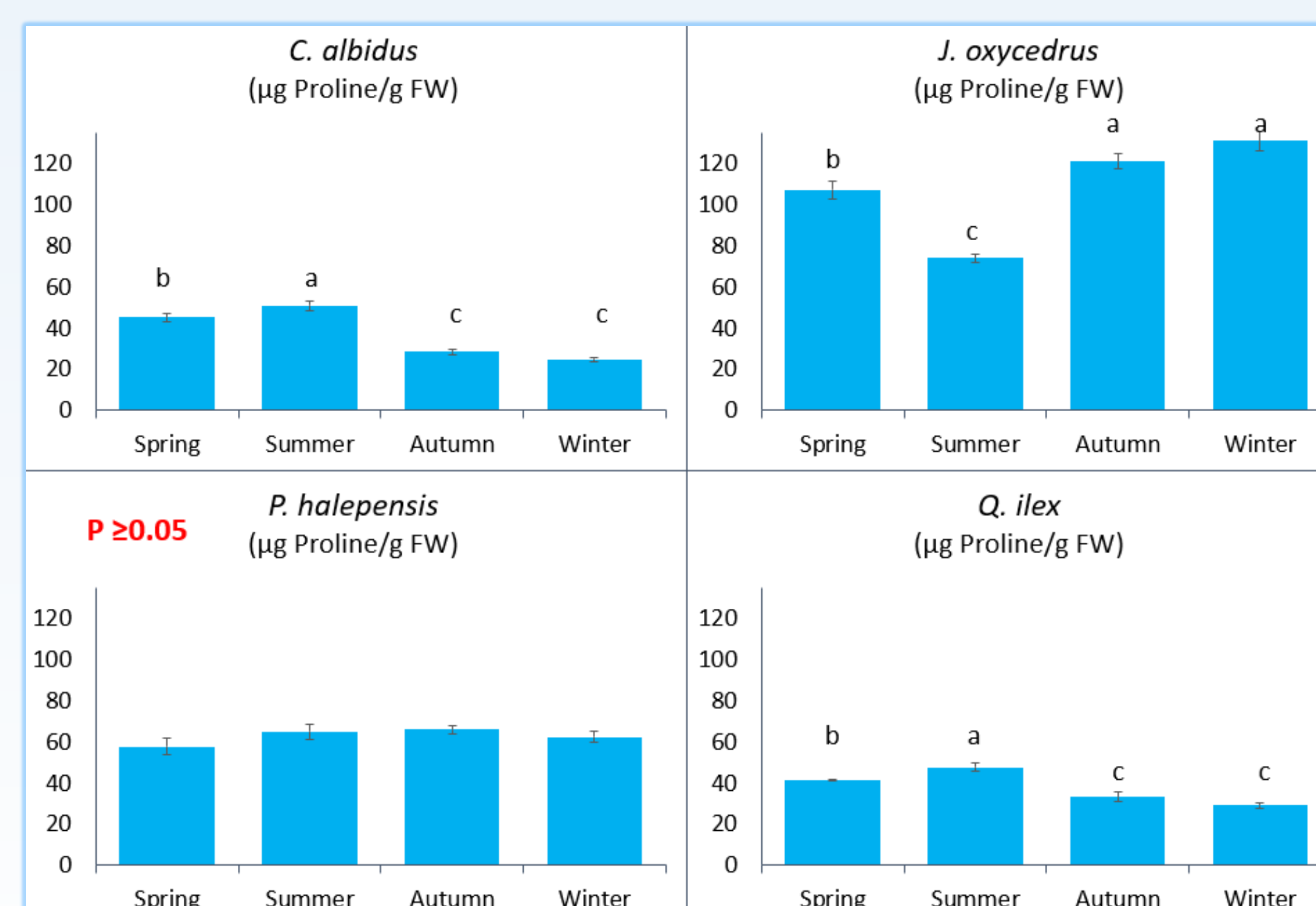
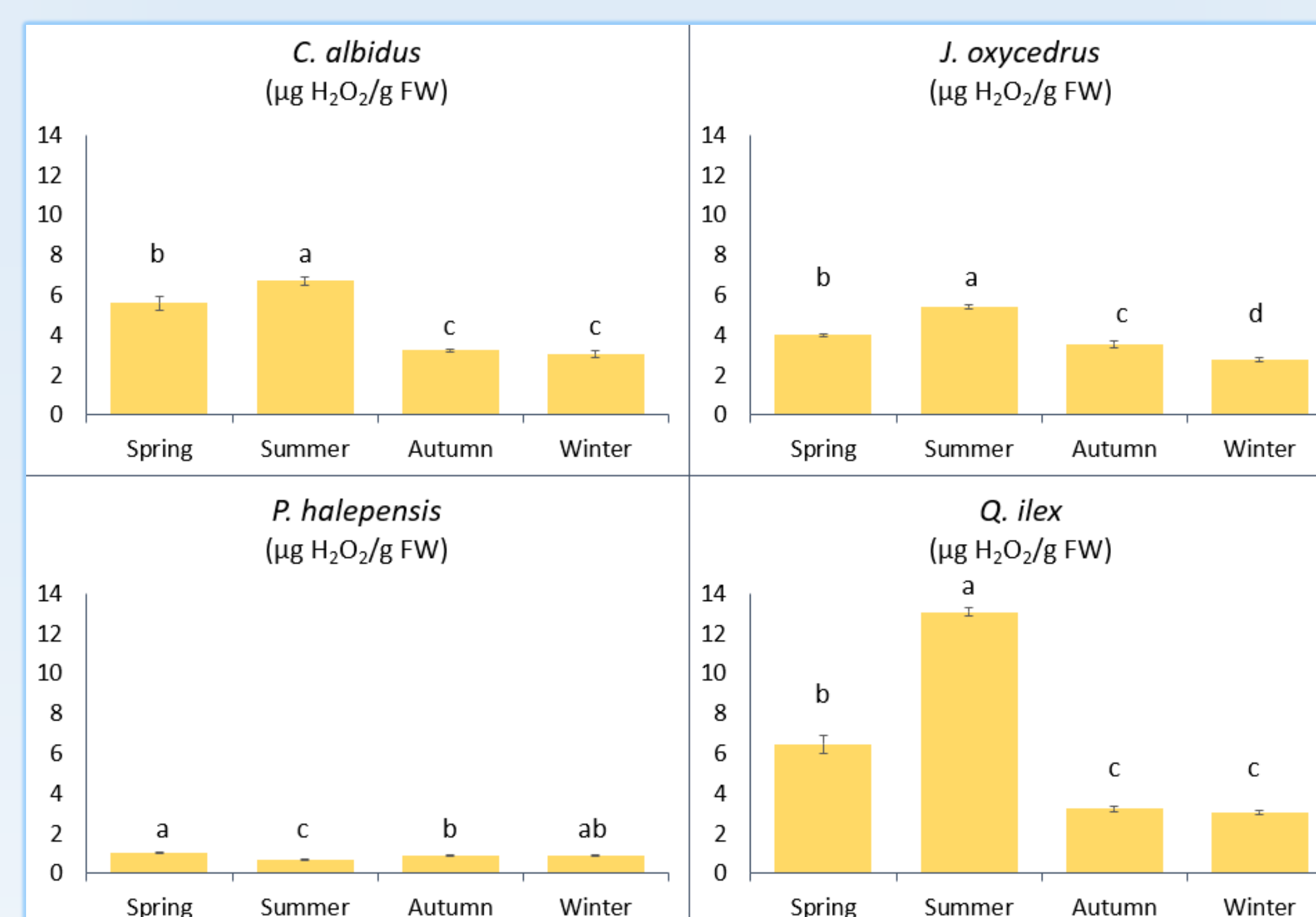
C. albidus and *Q. ilex* exhibited the highest levels of hydrogen peroxide, proline, and MDA in summer.

Sampling	<i>Q. ilex</i>		
	Na	K (%)	Ca
Spring	0.0029	0.4436 b	1.1720 a
Summer	0.0025	1.0188 a	0.7259 b
Autumn	0.0020	0.4322 b	0.5681 b
Winter	0.0026	0.3826 b	0.5260 c
	NS	***	***

NS, *** indicate non-significant differences and significant differences for Ps 0.001, respectively



Calcium content was highest in spring in all four species studied. Potassium levels peaked in spring for *C. albidus* and *P. halepensis*, while in *J. oxycedrus* and *Q. ilex* this occurred in winter.



J. oxycedrus reached maximum MDA levels in spring, whereas hydrogen peroxide levels were significantly higher in summer (LSD test, $P \leq 0.05$). Proline levels, however, peaked in autumn and winter.

Sampling	<i>J. oxycedrus</i>		
	Na	K (%)	Ca
Spring	0.0011 c	0.4529 b	2.2617 a
Summer	0.0015 b	0.5296 a	2.1311 ab
Autumn	0.0021 a	0.3356 c	1.6645 bc
Winter	0.0012 c	0.3587 c	1.6219 c
	***	***	*

*, *** indicate significant differences at Ps0.05 and 0.001, respectively



The species with the highest proline and MDA contents was *J. oxycedrus*, whereas *Q. ilex* exhibited the highest hydrogen peroxide levels.