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Letter to the Editor

Balancing Delay and Demise: Peptides and Leaf Senescence

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Leaf senescence refers to the final stage of leaf development whereby a leaf undergoes biochemical, physiological and structural changes. During the process of leaf development, a leaf gradually undergoes a regulated form of aging, which is characterized by the yellowing of leaves, the translocation of valuable resources to developing seeds and/or young leaves, as well as, deterioration of metabolic activity. Leaf senescence is programmed and controlled not only by genes, but also influenced by environmental factors and hormones, such as ethylene, abscisic acid, and cytokinins [1]. Recently, Li *et al.* [2] reported that small peptide signals regulate the beginning and end of leaf senescence. In their study, Li *et al.* [2] demonstrated that secreted peptides, and not just hormones and/or transcriptional factors, are indeed mobile messengers that control leaf lifespan. CLEs, IDLs, Peps, PDKs, and SCOOPs, were used as examples to show how peptide signalling creates a homeostatic balance between inhibiting or facilitating senescence.

Zhang *et al.* [3] stated that the CLE14 peptide delays age-dependent and stress-induced senescence by aiding in JUB1-mediated reactive oxygen species (ROS) scavenging, however, Zhang *et al*. [4] reported that the CLE42 peptide induces an antagonistic effect on ethylene signally processes, causing the postponement of aging. In addition, it has been found that leaves exposed to natural light, such as sunlight and darkness, undergo accelerated senescence induced by the IDLE peptide [5]. The above examples highlight how different peptide signals balance the delay and facilitation of senescence, and Li *et al.* [2] thus highlights that peptides are targets for crop improvement strategies. Another recent example where peptides aid in senescence is found in rose plants [6]. In rose plants, petal abscission, a process related to senescence due to organ detachment and nutrient mobilization, occurs through RbIDL peptide signalling [6].

According to Butenko *et al.* [7] and Czyzewicz *et al*. [8], the use of IDL and CLE peptides display a mixture of divergent and convergent roles on the different parameters associated with ROS activity, as well as, the hormonal regulation of senescence. This indicates that those peptides intersect the functionality of gene sets, proteins, as well as, the pathways that produce, sense, and detoxify ROS [9]. Additionally, Kim *et al.* [10] reported a network of hormone biosynthesis, transport, perception, and signally genes - such as jasmonic acid and salicylic acid (senescence-promoting) - and auxin and gibberellins (senescence-delaying), which may possibly intersect the functionality of IDL and CLE peptides. However, as leaf senescence regulation cannot be compartmentalized because it is a complex process, Matsubayashi and Sakagami [11] highlight the conserved function of the PDK peptide in delaying stress-induced senescence by promoting cellular survival, while IDLs and CLEs still implement regulatory control. This emphasizes the balancing act that small peptides play in performing regulatory control over leaf senescence mechanisms. This result shows the intersection of communication networks that have a promising effect on the agricultural sector, specifically because strategic manipulation of peptide signaling could probably improve crop productivity, nutrient mobilization, and stress resilience [12]. There are, nevertheless, still

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substantial gaps in how senescence is regulated in leaves by peptides, particularly, because peptide-receptor pairs are poorly characterized, i.e., the receptor-ligand interactions involved in activating downstream biological processes are not well understood [13]. Although progress has been slow, a more collaborative effort has been made to grasp the mechanistic links between peptide perception and downstream transcriptional reprogramming in senescence [14]. Further investigation is required to understand the crosstalk between peptide-mediated pathways and classical hormones [15]. Olsson *et al.* [16] recommend the need for comparative studies across plant species under environmental stress conditions, e.g., in field experiments, to examine the intersection between conserved and lineage-specific peptide tasks.

Physiological and ecological understanding of leaf senescence points to a developmental programme, or a plants' response to environmental conditions, however, Li *et al.* [2] showed that senescence needs to be reframed as a process governed by intracellular cues. According to Li *et al.* [2], these cues are dialogues that may either prolong leaf longevity, or expedite its death. By being able to respect the duality afforded by intracellular messengers, the core agricultural challenge of understanding crops aging and their translational potential becomes clearer [17, 18]. This enables us to gather a varied view on plant productivity and resilience, particularly because senescence is more generally known from a hormonal perspective, implying that peptide signals may add to the dimensions of views pertaining to leaf senescence.

Some natural stressors that can be used to envisage the delay or demise of leaf senescence with signaling peptides include fluctuating temperatures, variable water availability, and diverse microbial communities. Additionally, comparative studies can offer evolutionary insights, particularly since individual plants must adapt to their growth environment in order to grow and thrive properly [16]. Furthermore, understanding the diversity and specificity of peptide functions tie in with their acclimatization resilience to tolerate stressors, and the possibility to thrive with better growth characteristics [16]. Examples of comparative peptide studies that could be investigated are: (1) cross-species transcriptomics analysis amongst different field crops, e.g., barley, rice, etc. (2) comparative analysis of small secreted peptide signaling in vascular and non-vascular plants, and (3) comparative transcriptomics of multi-stressor responses [19], e.g., using cold-, salt-, and UV-B radiation-induced stress conditions to analyze both overlapping and divergent gene expression patterns. I decided to write and present this letter because I believe that Li *et al.* [2] provided a synthesis of a premise that's important in scientific research, particularly their stance, and evidence, that peptides are pivotal regulators of plant aging. By doing this, they have placed peptide signaling at the forefront of senescence research, which I support. From the above, it can be gathered that the fundamental theory about leaf senescence sets the stage for practical measures to optimize plant lifespan and performance through intracellular communication. However, charting the spatiotemporal maps of peptide signaling with transcriptional and hormonal networks still requires resolution.

REFERENCES

1. P.O. Lim, H.J. Kim, and H.G. Nam. Leaf senescence. *Annual Review of Plant Biology* 58: 115-136 (2007).
2. X. Li, X. Si, Z. Zhang, Q. Ni, W. Li, Z. Zhang, J. Wang, and Y. Guo. Peptide signals regulating leaf senescence. *Annals of Botany* (2025). https://doi.org/10.1093/aob/mcaf140
3. Z. Zhang, C. Liu, K. Li, X. Li, M. Xu, and Y. Guo. CLE14 functions as a "brake signal" to suppress age-dependent and stress-induced leaf senescence by promoting JUB1-mediated ROS scavenging in Arabidopsis. *Molecular Plant* 15(1): 179-188 (2022).
4. Y. Zhang, S. Tan, Y. Gao, C. Kan, H.L. Wang, Q, Yang, X. Xia, T. Ishida, S. Sawa, H. Guo, and Z. Li. CLE42 delays leaf senescence by antagonizing the ethylene pathway in Arabidopsis. *New Phytologist* 235(2): 550-562 (2022).
5. C. Guo, X. Li, Z. Zhang, Q. Wang, Z. Zhang, L. Wen, C. Liu, Z. Deng, Y. Chu, T. Liu, and Y. Guo. The inflorescence deficient in ABSCISSION-LIKE6 peptide functions as a positive modulator of leaf senescence in *Arabidopsis thaliana*. *Frontiers in Plant Science* 13: 909378 (2022).
6. P. Singh, S.K. Maurya, D. Singh, and A.P. Sane. The rose inflorescence deficient in abscission-like genes, RbIDL1 and RbIDL4, regulate abscission in an ethylene-responsive manner. *Plant Cell Reports* 42(7): 1147-1161 (2023).
7. M.A. Butenko, S.E. Patterson, P.E. Grini, G.E. Stenvik, S.S. Amundsen, A. Mandal, and R.B.

Aalen. Inflorescence deficient in abscission controls floral organ abscission in Arabidopsis and identifies a novel family of putative ligands in plants. *Plant Cell* 15(10): 2296-2307 (2003).

8. N. Czyzewicz, C.L. Shi, L.D. Vu, B. Van De Cotte, C. Hodgman, M.A. Butenko, and I. De Smet. Modulation of Arabidopsis and monocot root architecture by CCLAVATA3/embryo surrounding region 26 peptide. *Journal of Experimental Botany* 66(17): 5229-5243 (2015).
9. I. Jajic, T. Sarna, and K. Strzalka. Senescence, stress, and reactive oxygen species. *Plants* 4(3): 393-411 (2015).
10. J. Kim, H.R. Woo, and H.G. Nam. Toward systems understanding of leaf senescence: An integrated multi-omics perspective on leaf senescence research. *Molecular Plant* 9(6): 813-825 (2016).
11. Y. Matsubayashi and Y. Sakagami. Peptide hormones in plants. *Annual Review of Plant Biology* 57: 649-674 (2006).
12. J.H. Schippers, R. Schmidt, C. Wagstaff, and H.C. Jing. Living to die and dying to live: The survival strategy behind leaf senescence. *Plant Physiology* 169(2): 914-930 (2015).
13. Y. Matsubayashi. Exploring peptide hormones in plants: Identification of four peptide hormone–receptor pairs and two post-translational modification enzymes. *Proceedings of the Japanese Academy Series B Physical and Biological Sciences* 94(2): 59-74 (2015).
14. F. Xiao, H. Zhou, and H. Lin. Decoding small peptides: Regulators of plant growth and stress resilience. *Journal of Integrative Plant Biology* 67(3): 596-631 (2025).
15. H.R. Woo, H.J. Kim, P.O. Lim, and H.G. Nam. Leaf senescence: Systems and dynamic aspects. *Annual Review of Plant Biology* 70: 347-376 (2019).
16. V. Olsson, L. Joos, S. Zhu, K. Gevaert, and M.A. Butenko, I. De Smet. Look closely, the beautiful may be small: Precursor-derived peptides in plants. *Annual Review of Plant Biology* 70: 153-186 (2019).
17. P.L. Gregersen, A. Culetic, L. Boschian, and K. Krupinska. Plant senescence and crop productivity. *Plant Molecular Biology* 82(6): 603-622 (2013).
18. A. Distelfeld, R. Avni, and A.M. Fischer. Senescence, nutrient remobilization, and yield in wheat and barley. *Journal of Experimental Botany* 65(14): 3783-3798 (2014).
19. M.S. Gancheva, Y.V. Malovichko, L.O. Poliushkevich, I.E. Dodueva, and L.A. Lutova. Plant peptide hormones. *Russian Journal of Plant Physiology* 66(2): 171-189 (2019).