A Distributed Solar Photothermal System for Scalable, Chemical-Free Weed Control

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Synthetic herbicides dominate agriculture due to their effectiveness and low cost; however, they cause water contamination, biodiversity loss, and the development of resistant weeds, threatening the long-term sustainability of modern agricultural systems. Thermal weed control methods such as laser and solar optical treatments, offer an alternative but are limited by point-focus designs requiring precise alignment, high energy requirements, and safety constraints. Literature and patent analysis show that practical, field-ready solar thermal systems remain an unsolved engineering challenge. SunRays introduces a distributed heliostat photothermal system delivering sustained heat (>60°C) over broad zones using motorised mirrors coordinated by GNSS-RTK positioning and real-time control algorithms. The system consists of a 10-mirror heliostat array (0.09m² each), a mobile rover with GNSS-RTK and a 1.0m × 0.1m thermal receiver, and a control algorithm that continuously optimises mirror angles for maximum solar flux output. Unlike point-focus systems, SunRays redirects non-concentrated optical flux to a receiver on the rover, maintaining center-weighted heating despite terrain or weed variation. Its key innovation integrates distributed mirror control, GNSS-RTK guidance, and receiver-defined thermal field to produce diffuse, controllable heating suitable for dynamic farm conditions. Field trials achieved 92% weed mortality and 78% seedbank suppression after 45s at 60-70°C, producing effective heating over 2m long treatment zones with no combustion, chemicals, or tillage. SunRays establishes a scalable, zero-residue framework integrating optics, robotics, and precision agriculture to greatly reduce global herbicide dependence while maintaining crop productivity.

Awards Won:
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