

The solar corridor: a new paradigm for sustainable crop production

Opinion

Current industrial-scale crop production is managed as monocultures of commodity crops on thousands of hectares with indiscriminant inputs of synthetic fertilizers and pesticides that inherently reduces biological and ecological interactions that are critical in ecosystem-level mediation of nutrient cycling and suppression of pest populations. The environmental impacts associated with such inputs have raised concerns about the sustainability of industrial agricultural practices and has triggered efforts to develop alternative management practices designed to maintain yields while minimizing the need for external inputs to ensure economic and environmental sustainability.¹ Innovative management systems for improving crop production and yield can be developed by integrating cultural practices for effective utilization of abundant, readily available environmental inputs of sunlight and carbon dioxide. One such management approach is based on wide-row spacing of single or twin narrow rows of tall-stature crops (i.e., maize [*Zea mays* L.]) forming a corridor to provide more uniform vertical distribution of incident sunlight available to all chloroplasts within fully exposed leaves. This solar corridor planting system (SCPS) increases availability of sunlight to plants in all rows in the field.

The SCPS is a novel planting arrangement and method that rearranges the spatial positioning of plants in an alternative crop architecture designed to maximize the capture of solar radiation and carbon dioxide to improve crop growth and yield.² In practice, the SCPS uses wide rows of a main crop, combined with inter-row planting of either a compatible cash crop or non-cash crop such as a cover crop or forage species, to maximize use of light and other resources by the main crop. The SCPS is an advancement of the strip intercropping design, which is based on cultivating two or more crops simultaneously in different strips across the field for greater use of resources including solar radiation, water, and nutrients compared with either of the component crops grown in monoculture.³ The field design of the SCPS is flexible as presented in one proposed model⁴ whereby 152-cm corridors between twin-rows of maize enables incidental sunlight to reach each leaf from the early vegetative through reproductive growth stages. The solar corridor floor, in this example, was planted to winter wheat with red clover, which sustained growth after maize harvest and into the next season. Because light energy initiates the photochemical processes required for photosynthesis, incident solar radiation provides a most productive low cost and abundant form of light as well as atmospheric carbon dioxide needed for essential carbon compounds, which comprises 90-95% of the total plant dry matter.⁵ Determination of optimum plant densities for the most efficient capture of solar radiation has been challenging since the early days of crop production research.⁶ Current high-yield production systems based on planting dense, mono-cropped fields use a fraction of the available supply of incident sunlight and atmospheric carbon dioxide. In most production systems, maize leaf canopies intercept between 59 and 79% of the incident photo synthetically active radiation (PAR), which suggests inadequate leaf area is available for efficiently capturing radiation.⁷ However, maximum grain yield

Volume 4 Issue 3 - 2016

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Received: July 25, 2016 | **Published:** August 01, 2016

could be achieved when leaf canopies intercepted 95% PAR due in part to using hybrids selected for large leaf area regardless of row spacing or plant population size.⁷ Early research also suggested that maize hybrids respond differently to plant population density due to differences in photosynthetic effectiveness under low light conditions.⁸ Some modern maize hybrids selected for high radiation-use efficiency (RUE) show increased dry matter accumulation at all growth stages through the grain-filling period,⁹ and thus provide a basis for selection of hybrids for efficient use of solar radiation in the SCPS. The SCPS may be adaptable to other crops including sorghum (*Sorghum bicolor* [L.] Moench), which exhibited 25% improved RUE when intercropped with various legumes compared with mono-cropped sorghum.¹⁰

Early research reviewed by Kremer et al.,¹¹ document the potential for yield increases from greater exposure to radiation, but few, if any, practical methods were offered for harvesting maximal radiation at the field scale. Several intercropping methods similar to the SCPS including skip-row systems are based on manipulation of row widths to improve sunlight capture, soil moisture conservation, and to reduce crop-protection chemical use. Moderate row-spacing (i.e., 52-cm widths) of maize at high plant densities (>75,000 plants ha⁻¹) may enhance RUE through deep light penetration within the leaf canopy.¹² Narrow strips of crops (double or twin rows of maize in the SCPS) compatible with contemporary farm machinery may improve crop yield and biological efficiency. Kanwar et al.,¹³ reported that yields of maize, soybean (*Glycine max* [L.] Merr.) and oats (*Avena sativa* L.) planted in narrow strips increased by 5% compared with mono-cropped maize in a maize-soybean rotation system. They further concluded that the inter-cropping system is an environmentally sustainable farming practice in the Midwestern U.S. due to decreases in nitrate leached via subsurface drainage compared with the maize-soybean rotation. However, selection of maize hybrids for improved growth performance in the intercropping study was not considered.

Although the primary focus of the SCPS is to improve grain yield of the main crop (i.e., maize), the inter-cropped species have important implications for soil conservation, fertility management, soil organic matter maintenance, pest suppression, and soil health.¹⁴ Cover crop mixtures including legumes in intercrop combinations may serve

as nitrogen fertilizer resources for the main crop and minimize chemical fertilizer inputs and their potential environmental impacts.¹ Cover crops integrated into the SCPS may further promote soil microbial biomass and biodiversity including soil mycorrhizal fungi that associate with numerous crops to enhance nutrient acquisition, disease resistance, and drought tolerance. The inter-cropped species may reduce damage to main crops by insect pests and simultaneously suppress weeds through potential allelopathy. Such interactions may provide yield stability for the main crop because the crop mixture in the SCPS maximizes light capture and water and nutrient use, and thus a more efficient resource utilization strategy by limiting competition by weeds. Proper management of the complexity of an intercropping system such as the SCPS will accommodate the physical, biological, and ecological interactions between the crop components to maximize biomass and grain yields while contributing to essential ecological services including nutrient cycling, biological pest control, water and soil conservation, and soil health.¹⁴ The keys to effective management in the SCPS is

- i. selection of maize hybrids responsive to the solar corridor planting arrangement to fully utilize radiation; and
- ii. compatible inter-crop species that do not interfere with maize yet provide the benefits of a secondary crop in grain or forage yields or for soil improvement and conservation.

The solar corridor is a paradigm shift for crop production that allows direct access of more leaf chloroplasts to incident sunlight over a longer period of time. Limited field trials have shown the potential for increased maize yields of specific hybrids, however, more studies must be conducted to overcome some of the challenges of the solar corridor for it to be a fully successful sustainable crop production system.^{4,15} Early work with the SCPS demonstrated that specific maize hybrids could be selected for high yield performance,^{2,4} however, seed sources of these classical hybrids are limited or have disappeared as alternative germplasm has been developed for current industrial maize production. Screening of modern hybrids for high yields is critical for the SCPS to be operational in conventional crop production settings. Replicated studies on the solar corridor crop system paired with conventional production systems across various crop production regions and major soil groups is needed to validate the SCPS protocol. We believe the SCPS readily offers a solution for improving diversification of crop production systems, which provides more efficient utilization of soil nutrients, improves soil organic matter and soil structure, suppresses weeds and insect pests, reduces chemical inputs, and improves environmental health relative to current mono-cropping systems. Although a perceived risk is often associated with adopting diversified systems, farmers who decide to implement this approach for crop production and deliberately follow management practices required to fully exploit the benefits of the system reduce their risk considerably.¹⁶ Knowledgeable producers can adapt the solar corridor to fit their crop production system for consistent and economic yields while maintaining environmental sustainability.

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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