Agrivoltaics: Chance to tackle climate change in agriculture?

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German government wants more agrivoltaics (AV) on fields used for agricultural production.
Background

Agriculture: What are the benefits of AV?

- Simultaneous production of food/feed and electricity
  → Increases land use efficiency
  → Eases conflicts between food and energy production
- Diversifies renewable energies provided by agriculture
- Reduced radiation is most likely negative for certain crops, however, there might also be some positive effects on harvestable yields
- Can provide shadow for grazing animals as well

Objectives of the project:

- Test the suitability of field crops for the cultivation under AV
- Measure the impact of solar panels on development, harvestable yield and yield quality of crops
- Analyse the effects of AV on micro-climatic conditions, soil and biodiversity
- Develop recommendations for the practical implementation of AV*.

Field experiment

Site:
Hofgemeinschaft Heggelbach, Herdwangen-Schönach (Germany)
Organic farm („Demeter“)

Crops:
- Winter wheat
- Potato
- Clovergrass
- Celeriac

→ Part of an organic crop rotation
Field plan: 1\textsuperscript{st} year

- Plot with micro-climate station (32 in total)

Picture: Edgar Gimbel (modified)
Measurements

Agriculture
- Crop development
- Crop yield
- Crop quality
- Soil

Micro-climate
- Photosynthetically active radiation (PAR)
- Air temperature ($T_{\text{air}}$)
- Air temperature ($T_{\text{air}}$) & Humidity ($\text{RH}_{\text{air}}$)
- Soil temperature ($T_{\text{soil}}$)
- Soil temperature ($T_{\text{soil}}$) & Humidity ($\text{RH}_{\text{soil}}$)

Environment
- Rain distribution
- Erosion risk
- Water logging
- Potential nitrate leaching

Biodiversity
- Monitoring
- Accompanying vegetation (weeds)
- Accompanying fauna (ground beetles, spiders, etc.)

Background | Materials & Methods | Results & Discussion | Outlook
Micro-climate: Solar radiation

Winter wheat
Micro-climate: Solar radiation

- Reduced solar radiation under AV
- Significant differences in terms of solar radiation from spring to late autumn.
Micro-climate: Temperature, humidity and precipitation

- Reduced soil temperature under AV
- Significant difference with regards to soil temperature from late spring until autumn
- No significant differences in terms of air temperature, air humidity and soil humidity.
Crop development: Winter wheat

**Canopy height**

- REF
- AV

**Chlorophyll content**

- REF
- AV

**Background | Materials & Methods | Results & Discussion | Outlook**
Crop development: Clovergrass

Background

Materials & Methods

Results & Discussion

Outlook
Harvestable yield: Winter wheat

- 2017: Decrease in grain yield by -19% under AV
- 2018: Increase in grain yield by +3% under AV.
2017: Tuber yield was decreased by -18% under AV
Fraction of tubers >50 mm was decreased under AV

2018: +11% under AV
Again, fraction of tubers >50 mm was decreased under AV.

Harvestable yield: Potato

<table>
<thead>
<tr>
<th>Year</th>
<th>REF</th>
<th>AV</th>
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<tr>
<td>Yield [dt FM ha⁻¹]</td>
<td>Yield [dt FM ha⁻¹]</td>
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<tr>
<td>&gt; 50 mm</td>
<td>35 - 50 mm</td>
<td>&lt; 35 mm</td>
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<tr>
<td>2017</td>
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<tr>
<td>2018</td>
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Harvestable yield: Celeriac

- 2017: Bulb yield was reduced by - 19 % under AV
- 2018: Bulb yield was increased by + 12 % under AV
- In both years, biomass of leaves was increased under AV.
Harvestable yield: Clovergrass

- 2017: Total yield was decreased by - 5 % under AV (4 cuts)
- 2018: Total yield was decreased by - 8 % under AV (4 cuts).
Outlook

- AV provides a promising opportunity
  - **Increased land use efficiency** due to production of crop yield and energy yield at the same area
- Reduced solar radiation is the limiting factor
- Decrease in crop yield was overcompensated by energy yield
- **Additional experimental years** and **test of other species** are needed in order to provide clear conclusion.
Shading and reduced transpiration under AV might be important in the future → climate change

AV is a mitigation option with regard to climate change

AV might be an option for plant production in arid areas with intensive solar radiation and insecure energy supply

AV is a good opportunity to produce healthy food and renewable energy at the same field site

AV is a chance to tackle climate change in agriculture!
Thanks for your attention!

Project website: www.agrophotovoltaik.de

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