BENEFITS FOR AGRICULTURAL CROPS COMBINED WITH SOLAR PANELS

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Bulgarian context

- Bulgarian legislation on agrivoltaics is currently in a legal vacuum, as attempts to regulate it were overturned by the Constitutional Court in the spring of 2025.
- As of today (September 2026), there is no legal definition or clear rules in force in Bulgaria governing the construction of agrivoltaic systems.

Bulgarian context

- Bulgarian farmers cannot install solar panels on their crops. Their agricultural plots will be classified as ineligible for subsidies
- There is no published data on experiments in Bulgaria to combine agricultural production with photovoltaic
- There are only statements by farmers who graze their sheep in solar farms. They say that during July and August on the plains, the only fresh grass is found under the solar panels

Bulgarian context

Benefits for the crops -

- Lower crop and soil temperatures
- Higher soil-moisture retention
- Improved water-use efficiency
- Reduced irrigation demand and drought stress
- Maintained or increased yields for shade-tolerant crops
- Protection against hail, heavy rain, and frost

Lower crop and soil temperatures

- Agrophotovoltaic systems reduce plant temperature primarily through **partial shading**, which limits overheating of the leaves and reduces water loss. The effect depends on the crop, the density and height of the panels, their orientation, and the local climate.
- reduce direct solar radiation
- reduce transpiration and evaporation
- retain more moisture in the soil
- reduce wind speed
- improve the microclimate
- The average data show decreases in air and soil temperatures of approximately 1–4 °C and an improvement in water use efficiency of 20–47%.

Protection against hail, heavy rain, and frost

- The panels absorb or deflect some of the hail impacts. For effective protection, the following are important: sufficiently sturdy panels and a load-bearing structure; small gaps between the panels; proper overlap between rows;
- In areas with intense and frequent hailstorms, the panels cannot prevent hail damage on their own and should be combined with anti-hail nets
- The panels can reduce: mechanical damage to the fruit/vegetables caused by large raindrops; cracking caused by sudden rainfall after a long dry period; soil erosion; soil compaction and the formation of a soil crust; excessive wetting of the leaves and fruit.
- If the panels are combined with gutters and a system of pipes for draining and storing rainwater, this will have a dual effect: a reduction in crop diseases caused by excessive moisture on the leaves and fruits during the rainy seasons, and an additional supply of water for irrigation during the dry months.

Protection against hail, heavy rain, and frost

- The panels can reduce the risk of scab on apples and pears, but they do not prevent it entirely. Their main effect is to limit rain contact with the leaves and fruit, thereby shortening the period of leaf wetness—a key factor in infection by *Venturia inaequalis / Venturia pirina*
- The panels above the rows act as a partial rain shelter. They reduce direct water contact with: young leaves; flowers; young fruit; and the interior of the canopy. This can limit both the release and spread of spores, as well as their germination on the moist leaf surface. If the leaves are not completely wet, they dry out more quickly. This reduces the likelihood that the wet period will last long enough for infection to occur. This is the most important mechanism by which overhead structures can reduce the pressure from scab.
- A large majority of fruits and vegetables grown outdoors suffer damage from direct sunlight — known as sunscald. In an apple trial in France, movable panels reduced the proportion of fruits with sunscald from 13% to 2%.

Protection against hail, heavy rain, and frost

- Late spring frosts are causing increasingly severe damage to fruit trees. Can solar panels help? The panels work best under the following conditions: a clear night; light wind; radiative frost; dry air; sufficiently warm soil after a sunny day; the ability to incline or close the panels before the critical period.In the case of advective frost—an influx of cold air accompanied by strong winds and low temperatures—the effect is much weaker. The panels cannot warm the air throughout the entire orchard and do not completely block the cold airflow.
- Solar panels can protect the fruit from some of the late-spring frosts by slowing radiative cooling during clear, calm nights. The best results are achieved with dynamic systems that close only when there is a risk of frost. They should be viewed as a supplementary measure, not a complete replacement for anti-frost spraying, fans, or heating.

Optimal shading percentage for good photosynthesis

Crop Group	Suitable Shade	Comments
Leafy vegetables, spinach, lettuce	30–50%	They often tolerate shade well and can benefit from the lower temperature.
Berries and some fruit crops	20–40%	Reduces heat stress, but light and humidity must be monitored.
Potatoes, legumes, carrots, onions	15–30%	Moderate shading is usually safer.
Sugar beets	about 15–25%	Higher shading may reduce biomass and sugar accumulation.
Wheat and other C3 cereals	about 15–25%	They are more sensitive during the grain formation and filling stages
Corn and sunflowers	about 10–20%.	These are light-loving C4 crops; heavier shading often reduces yield.

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Thank you for your attention!

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