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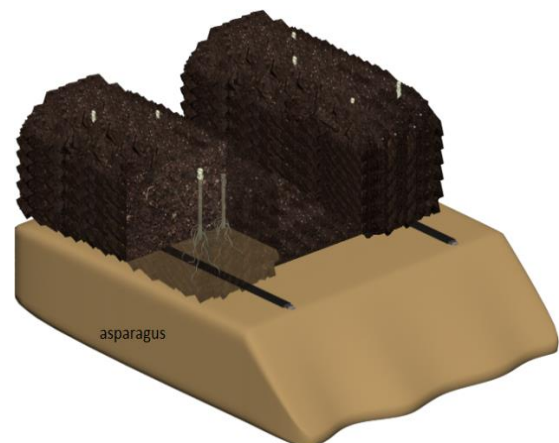
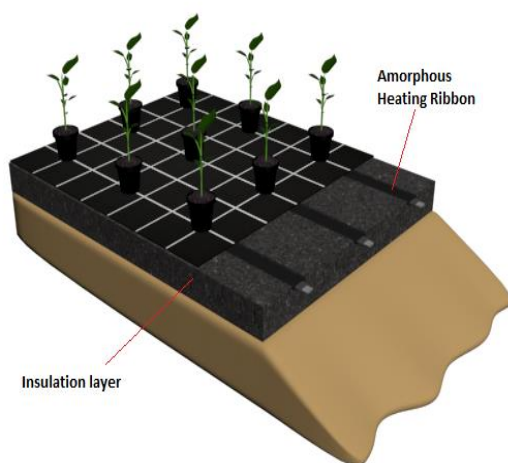
Radiant heating systems for agricultural applications

**Advanced growth and
year-round harvesting of
crops, fruits and flower bulbs**

Introduction

Heating Solutions International has created a new world of growth acceleration by enhancing the efficiency of their heating solutions.

HSI's heating systems distinguish themselves by only delivering heat in specific locations when required. As the heating systems do not heat the air but only the soil, huge energy savings are created. In addition, HSI's control systems are able to provide various zones with different soil temperatures based on their own environmental circumstances. All heating systems are fully automatically (sensor based) controlled. Furthermore the heating systems are dismountable and therefore transferable to another location.



For a short video impression about agricultural Heating solutions see:

<https://www.youtube.com/user/HSIBV2010/videos>



Our heating solutions

Studies and pilots conducted by one of the world's leading agricultural Universities (Wageningen University NL) and applications in practice have proved that infrared radiation stimulates the growth of asparagus, rhubarb, strawberries, sweet potatoes, raspberries, tulips, etc. Resulting in an advanced growth/harvest against competitors and enabling year-round cultivation. HSI's heating systems are the most efficient one's Worldwide.

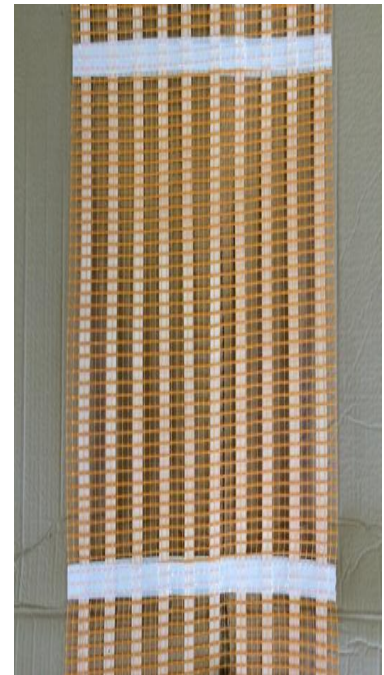
The heating applications can be easily installed in greenhouses as well as in open fields. The systems are automatically engaged/disengaged based on the required and preset values for the soil and environmental temperature. When required also the moisture value can be used as parameter for controlling. This leads to heat only when and where needed. It is also possible to adjust the required radiation to the specific type of plant, e.g. for cultivation tables. Another big advantage of HSI's agricultural heating systems is the flexibility in use: the complete heating system is dismountable and therefore transferable to another location. This means the heating system can be used for another lot, e.g. after one year of cultivation.

1. HSI's standard solutions for greenhouses

a. Growth acceleration on cultivation tables with fixed surface

The cultivation table will be provided with a radiant heating ribbon directly beneath the top layer in order to transfer heat in the most efficient way.

In general the heating ribbons will be applied as mats. The ribbons can be controlled by a control unit per table or one control system for several tables. For example all tables in one greenhouse.





b. Growth acceleration on cultivation tables with soft surface

The cultivation table will be provided with a radiant heating ribbon directly beneath the top layer (in general root cloth with a thin PE layer beneath for water protection). The heating ribbons will be applied as mats. The ribbons can be controlled by a control unit per table or one control system for several tables. For example all tables in one greenhouse.



c. Growth acceleration on open ground cultivation tables

For open ground heating applications the more robust variant (outdoor) heating ribbons will be used.

The cultivation table will be provided with these robust radiant heating ribbons directly in the ground. So, the ribbons will not be used as mats but as separate loose ribbons which have to connect directly to a control unit. The ribbons can be controlled per table or all simultaneously.





d. Growth acceleration in styrofoam trays

In the application below styrofoam trays are heated for the cultivation of sweet potatoes. Each pyramid has six cultivation trays. Each tray contains one heating ribbon. The peak power of each tray is controlled by the control unit. This peak power will only be used when the system is starting up. In automatic mode the total energy consumption will be distributed over the trays. When the ground temperature reaches the desired temperature the power will reduce to zero.



e. Growth acceleration with heated insulated floors

Plants growing from seeds to become commercial products require the best growth circumstances. As the seeds are sown in plastic containers, these containers become the ideal growing environment with a very high growing effect when combined with heating ribbons. With regard to the energy efficiency point of view, the heating ribbons are installed in an insulation layer provided with slots for the heating ribbons.





2. HSI's standard solutions for open ground cultivation

The image below shows the cultivation of Alchemilla by using the robust outdoor heating ribbons. Each row of plants contains one 80 m1 heating ribbon. The ribbon is directly placed in the ground beneath the plants.



a. Strawberry growth acceleration

The use of heating ribbons in the propagation of strawberry plants.

Research Wageningen University, Applied Plant Research (PPO)

Project number 3250088700

Conclusion

The application of heating ribbons below the maternal plants enables the harvesting of earlier and more kg strawberries per hectare. Also the plants obtain a good rhizome diameter what leads to a better quality.



Strawberries can grow in open ground as well as in trays. HSI delivers heating solutions for both kinds of cultivation. Above, an example of heated trays for strawberries.

b. Growth acceleration in open air, for example asparagus

For this application, HSI has conducted extensive research with Wageningen University and associations.

Research Wageningen University, Applied Plant Research (PPO)

Project number 3250088700. The use of heating ribbons in the cultivation of white asparagus.



Conclusion:

The application of heating ribbons in the cultivation of asparagus enables the realization of an advanced harvest of approx. 10 days. Apart from a better harvest spread and more kilograms per hectare, the application of heating ribbons leads to harvesting in periods of huge pricing.

Oil and gas are relatively costly products to heat the asparagus beds. A lot of energy is not used directly for growth stimulation but will be wasted in systems and supply pipes. HSI's heating ribbons will offer the energy 100% on the right place. Besides that the heating ribbons can change and reused after years.

For asparagus, the Infrared heating ribbons are simultaneously applied with planting the asparagus. The heating ribbons are applied on a depth of 28 cm; 7 cm lower than the asparagus plant. The heating ribbons are provided with cold leads, which are connected to the control unit. In the field, a number of sensors are fitted and by means of these sensors the temperature of the field is controlled. It is also possible to control the operation remotely (mobile phone / laptop). The grower determines at which time the heating of the field is switched on. The control unit can be connected to a local power supply or generator.

After a harvesting period of 7 – 10 years for asparagus, the heating system can be used to heat the plot for the next round of vegetables such as rhubarb.



Why HSI's heating solutions: the advantages of HSI's radiant heating systems

With HSI's heating technology it is feasible to achieve acceleration of growth with at least a 30% lower energy consumption compared with traditional heating systems like liquid or electricity.

The main distinctiveness of HSI's radiant heating system is the unique method of heat production which is generated by an amorphous metal glass ribbon. The ribbon enables an optimal (IR wavelength approx. 10 micrometer) heat radiation which stimulates optimal growth as well as



minimal energy consumption. This combined with an intelligent control unit leads to the most efficient heating system worldwide.

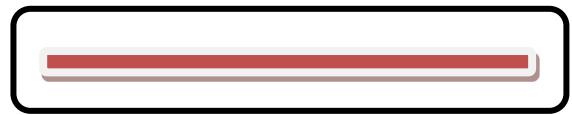
Characteristics of our amorphous metal glass heating ribbons

Due to the shape of the amorphous heating element the structure of the total heating ribbon is different. Some competitors have already copied the unique patented structure of the HSI heating ribbon into their own copper wire ribbon. Although both heating ribbons show a similar exterior design there is a huge difference in efficiency and effectiveness in both ribbons.

Below images show the difference in structure of both heating ribbons and also the difference when using an IR camera. They show the heat output of both systems while powering with the same wattage.

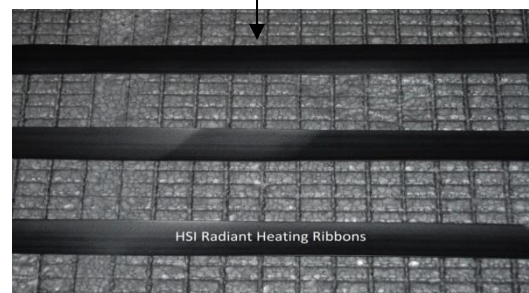
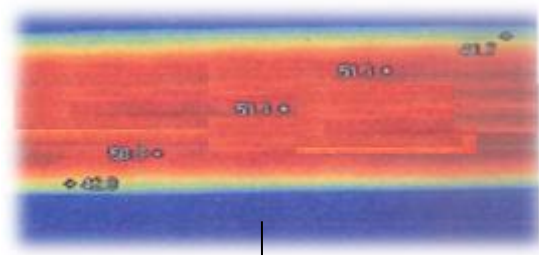
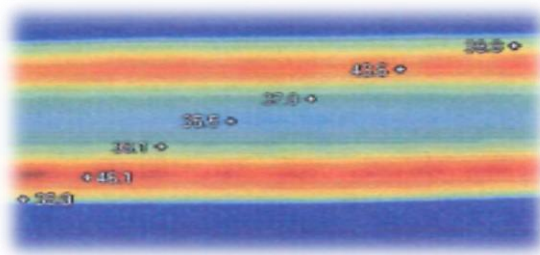


Copper wire heating ribbon



Amorphous metal glass heating ribbon

The images below visualize the difference between both technologies (IR camera).



Design of the amorphous metal glass ribbon

Due to the structure of the amorphous ribbon the energy will be turned into radiant immediately. There is no loss of energy by heating up the material itself. This ensures the difference in performance as shown in the above image.

Combination with a high performance Control Unit

The heating ribbons will be connected to an operating system which will manage the energy consumption in the most efficient way. Modulating and heating cyclically based on the environmental requirements. The system is able to define the optimal way of energy



consumption according to the climatic/weather/soil conditions. This also results in substantial savings on energy costs compared to traditional hydronic/water based systems.

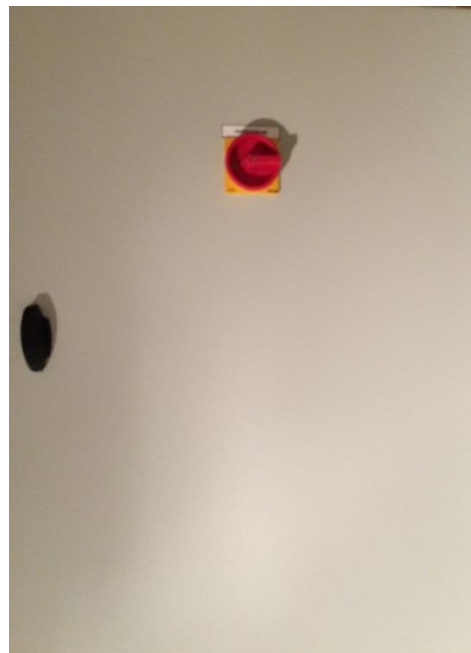
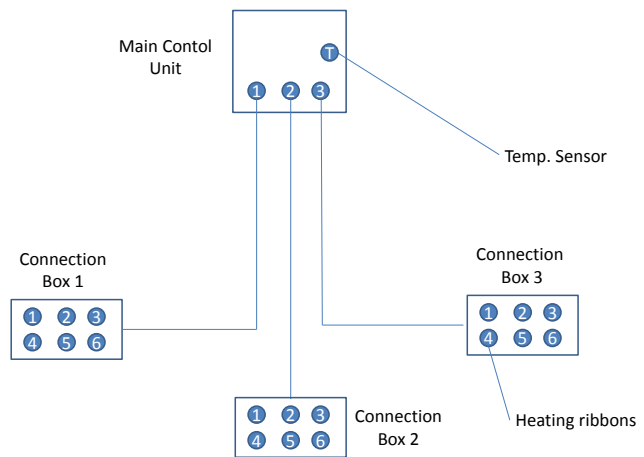
In addition, the control unit can be combined with the power supply of other energy demanding systems, e.g. the lighting installation. This decreases the peak power consumption and can also result in strong additional cost savings.

Required amperage (energy connection) and power consumption

HSI BV will provide the required amperage based on the amount of heating ribbons and the required temperature. Special software enables the use of a heating cycle, thus reducing the total power required.

Application when and where?

One of the biggest advantages of HSI's heating system is flexibility of use. The heating system consists of separate heating ribbons which are joined to connection boxes. The connection boxes are connected to the control unit by central cables. The power can be generated by a generator or the fixed electricity net. This makes the system flexible for usage each year on a different plot.



Example of a main Control Unit for large agricultural applications



External research conclusions

Landstra Engineering

Calculations show that a better temperature distribution in the floor is obtained. At the surface, the temperature variation is 23% smaller than with other systems.



Sintef (Norwegian TNO/ TÜV):

- The chosen thin and relatively broad amorphous ribbons and their internal structure are beneficial compared to the conventional electric wires.
- The chosen DC technologies enable the possibility to supply more power to the ribbons than AC.



Prof. Dr Mark Geller

Hermon Laboratories Israël / Amorphous Competence Center. If the ribbons are situated between 4 cm to 2.5 cm from the surface the warm up time of the ribbons is twice as fast then the wire and when the ribbons are situated less then 2.5 cm from the surface the warm up time could became 4 times faster then traditional copper wires or liquid heating systems.



SGS Intron / Hogeschool Zuyd

The amorphous ribbon generates highly efficient IR radiation. This results in a 35% less energy consumption. In conjunction with renewable energy generation a big step in achieving sustainability objectives can be realized.

