



Modified Field Environments for High Latitude Crop Production

Meriam Karlsson* and Jeffrey Werner
University of Alaska
Fairbanks, AK 99775

Introduction

High tunnels have been shown to allow season extension, higher yields, improved quality as well as more consistent and predictably timed harvest. A clear polyethylene film is commonly used to cover greenhouses and high tunnels although plastic covering materials with variable absorption and transmission characteristics are now commercially available. Examples of attributes are plastics with selective transmission of infra-red wavelengths to conserve energy during cold nights or to cool the environment during hot days. Absorption of far-red wave-lengths and altered red to far-red ratio may also be a potential feature. Under northern conditions with naturally extreme day lengths, non-traditional plastics may more efficiently support crop productivity in high tunnels. Specialty plastics were therefore, evaluated in relation to field conditions and traditionally recommended high tunnel cover materials.



Figure 1. The high tunnels (12 feet wide by 24 feet long) used in the study.

Materials and Methods

High tunnel structures 7.3 m (24 feet) long by 3.7 m (12 feet) wide were used to test the impact of plastic covering materials on northern field crop production. The selected covering materials (Figure 1) included K50 Clear (6 mil ethylvinylacetate), K50 IR/AC, KooLite380® (Klerks Plastic Product Manufacturing, Inc., Richburg, South Carolina) and Solatrol (Visqueen GCF 925C9, British Polythene Industries PLC, Greenock, United Kingdom).

The daily temperature and irradiance profiles were identified for the various plastics and the adjacent field conditions. The quality of light was determined in the high tunnel environment during the time period 11:00 to 14:00 for several days throughout the summer using a SPEC-PAR/UV 300-850 nm (Apogee Instruments, Logan, Utah). Light transmission was calculated based on photon numbers between 400 and 700 nm as a percentage of the open field conditions. Temperatures were recorded at 15 min intervals 1 m above ground inside and outside the high tunnels using Watchdog Data Logger temperature sensors 400/200 Series (Spectrum Technologies, Inc, Plainfield, Ill.).

To evaluate crop response in the various environments, raspberries were grown in a container system (Figure 2). Long canes of 'Tulameen', a well adapted raspberry cultivar for containers, were planted using 11.3 liter (3 gallon) large containers filled with Premier Pro-Mix BX (Premier Horticulture, Premier Brands, Inc., Red Hill, Pennsylvania) on June 14 for same season berry production. Two rows of 7 raspberry containers were placed along each tunnel and under unobstructed field conditions. As the raspberries ripened, they were picked every other day, counted and weighed after removing the center core. The yield was recorded individually for each of the center 5 plants in each row. Harvest was terminated as fall frost was experienced on September 21. Data were analyzed using analysis of variance and LSD tests.

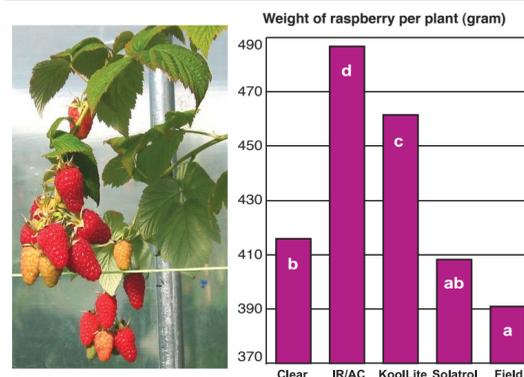


Figure 5. Yield of raspberry 'Tulameen' grown in high tunnels covered with K50 Clear (Clear), K50 IR/AC (IR/AC), KooLite380 (KooLite), Solatrol and unobstructed field conditions. Bars indicated with different letters show significantly different yields at LSD $P < 0.05$ ($n = 10$).

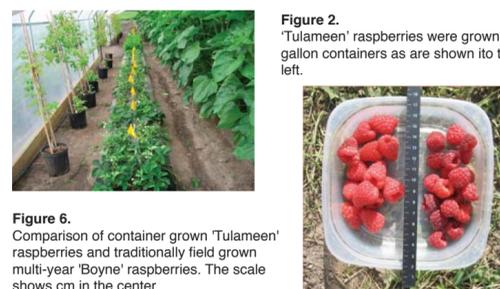


Figure 6. Comparison of container grown 'Tulameen' raspberries and traditionally field grown multi-year 'Boyne' raspberries. The scale shows cm in the center.

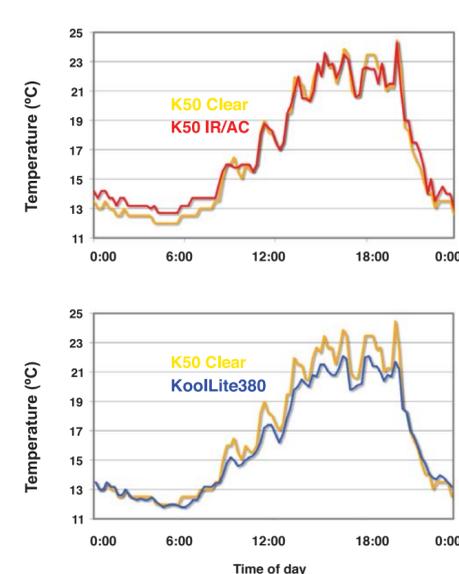


Figure 4. Air temperature (1 m above ground) during August 15, 2007, in high tunnels covered with K50 Clear (yellow), K50 IR/AC (red) and KooLite380 (blue).

Results

The spectra under the four plastics during a clear sunny day compared to open field conditions are shown in Figure 3. K50 Clear and K50 IR/AC blocked radiation below 360 nm. As advertised, KooLite380 hindered radiation below 380 nm while Solatrol obstructed wavelengths shorter than 380 nm. Irradiance transmission varied from 82% for K50 Clear to 66% for KooLite380. In addition, Solatrol selectively absorbed radiation between 700 and 800 nm reducing the red to far-red ratio. There was a trend for the KooLite380 material to hinder more radiation in the 400 to 600 nm range compared to other materials.

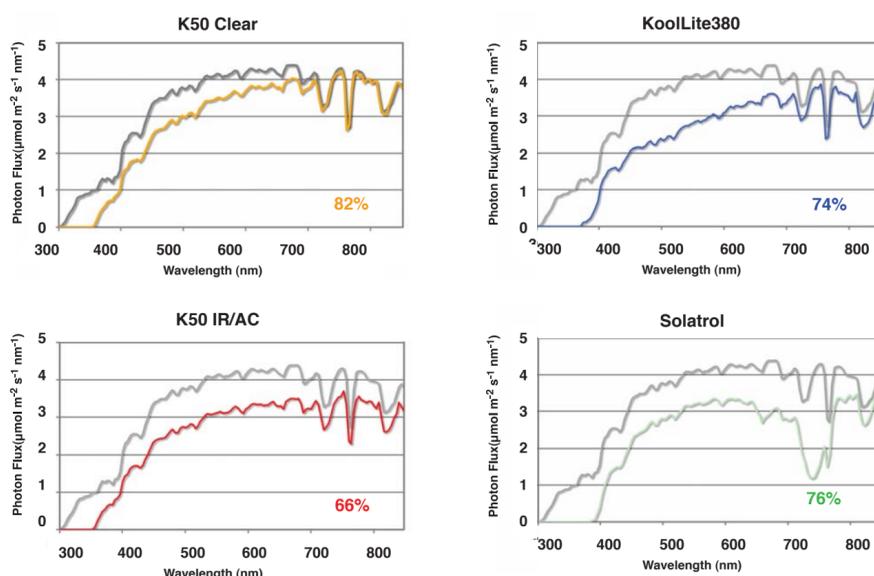
The temperature pattern in the K50 Clear and K50 IR/AC covered tunnels were similar although K50 IR/AC maintained warmer temperatures during cooler periods (Figure 4). The KooLite380 on the other hand, kept a warmer environment compared to K50 Clear during the warmest part of the day.

Excellent growth and pollination resulted in high yields of top quality fresh market raspberries in all environments including the field (Figure 5). More than 100 high quality marketable raspberries were harvested from each single cane plant.

Compared to traditional raspberries established and grown under field conditions in a multi-year system, the container grown 'Tulameen' had larger berries with excellent fresh market taste. The average size of 'Tulameen' raspberries was 4 to 5 grams compared to the 2 to 3 grams of traditional multi-year field grown raspberries (Figure 6).

The lowest harvest (392 grams) was attained in the field while the raspberries in the high tunnel covered with K50 IR/AC produced the significantly highest yield (487 grams, Figure 5). The yield in the Solatrol environment did not differ from the K50 Clear or the field although the K50 Clear environment supported higher yield than the field. More berries and yield (462 grams) were produced under KooLite380 than the K50 Clear, Solatrol or a field environment.

Figure 3. Irradiance in high tunnels covered with the plastic materials K50 Clear (yellow), K50 IR/AC (red), KooLite380 (blue) and Solatrol (green) in comparison to unobstructed field conditions (grey). Relative transmission of photosynthetic active radiation (PAR, 400-700 nm) is indicated as percentage of field PAR for the various high tunnel environments.



Discussion and Conclusions

In this study, the K50 IR/AC plastic kept the growing environment slightly warmer during cool nights (Figure 4). These properties suggest K50 IR/AC to be a potential better choice for extending the growing season as temperatures drop in the fall. Heat sensitive crops such as strawberries may benefit from an environment with cooler conditions during the warmest sections of the day as shown using KooLite380 plastic (Figure 4).

High quality fresh market raspberries were produced in all environments including the field. The exclusion of UV radiation especially under Solatrol and KooLite380 may affect insect pollination and has been reported to reduce problems with insect pests and vector transmitted diseases. In this study, despite relying on natural insect pollinators, problems with pollination, fruit formation and development were not observed.

In addition to modifying light and temperature conditions to create a beneficial production environment, cost needs to be evaluated in selecting a covering material. The cost compared to K50 Clear can be expected 10 to 20 percent higher for K50 IR/AC and 40 to 50 percent higher for KooLite380. Since both the K50 IR/AC and KooLite380 environments resulted in significantly larger yields, more expensive materials may be a better choice with overall higher return.



AGRICULTURAL AND FORESTRY EXPERIMENT STATION
UNIVERSITY OF ALASKA FAIRBANKS

