Effect of Red Plastic Mulch on Early Tomato Production

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Light reflected from red mulch has a lower red (R) to far-red (FR) ratio than normal sunlight, while black plastic has little effect on this ratio. The lower ratio has been reported to enhance the carbohydrate movement into the developing tomato fruit resulting in increased early production. Also, many of the colored mulches, including red, are translucent and will increase early spring soil temperature resulting in rapid plant growth, earlier flowering, and fruit maturation.

From 1997 to 1999 we evaluated color mulches at 5 site-year locations using a staked, mulched bed, and trickle irrigated tomato culture system. The sites were eastern Iowa, a coarse sand soil at Fruitland (along the Mississippi river); central Iowa, a loam soil at the Horticulture Station at Gilbert; and western Iowa, a silt loam soil at Castana (loess hills). The red mulch significantly increased early production at 3 of the 5 site-year locations. However, when IRT100 mulch (selective wavelength for weed control) was included in the trials it performed as well as the red. We continued the study in 2000, examining closer the effect on soil temperature only at the western Iowa location - Castana.

Materials and Methods

Mulch treatments included: black, clear, IRT100, red, and red laid over black polyethylene plastic. Mtn. Spring variety transplants were set May 17, about 7 to 10 days later than normal to avoid cold, harsh weather conditions and to minimize soil temperature differences among the plastic mulch treatments. Plot rows were 25 feet long with a row spacing of 6-feet and in-row plant spacing of 1.5 feet. Orientation of the rows were in an East-West direction. Plants were pruned to the first flower cluster and staked using the Florida stake and weave system. All plots were trickle irrigated and standard fertilization and pest management practices were followed. Irrigation was applied to maintain the 8-inch soil tensiometer at 25-35 kPa.

Reflective light measurements were taken over the plastic strips at a 14-inch height between plants using a Li-Cor 1800-11 remote cosine receptor head mounted in a horizontal orientation. All readings were taken between 12 pm and 1:30 pm, central time on June 1, a cloudy-bright day. Each measurement consisted of the average of three spectral scans from 400-800 nm at 5 nm intervals. To determine the R:FR ratio, energy values for R (red) = 650-670 nm and for FR (far red) = 720-740 nm were calculated. Photosynthetic photon flux density (PPFD), a measure of photosynthesis activity, was also determined.

Fruit were harvested weekly for 5 harvest from July 18 to August 15. Fruit were sorted into marketable and unmarketable (cracks, blotchy ripening, and small), and the fruit size determined. The first two harvests, July 18 and July 25th, were considered as early harvest. Results were analyzed by appropriate statistical procedures, and mean separation determined by the Duncan's multiple range test, 5% level of significance.

Results and Discussion

Reflected Light

Light reflectance from the mulches was measured June 1 or two weeks after transplanting. At his time, the plants were not large enough to influence or shade each other. The R:FR ratio was similar for all plastic mulches, but significantly lower than the sky value (Table 1). All values were close to 1.000. Also, the PPFD (photosynthetic photon flux density) from the mulches were similar; but 85% lower than sky radiation, as expected. Thus, like 1999, there were no significant differences among the mulches for reflected radiation. In 1997 and 1998, the red mulch R:FR values were 9% and 11% lower than the black plastic.

Soil Temperatures

The May-June average air temperature was 66.1 F which was 2 F > normal. The last spring frost of 32 F occurred April 17. The minimum 4-inch soil temperature generally occurred between 6-7 am; and although there were significant differences among the mulches (Table 2) the difference was < 2 F, clear producing the highest daily minimum temperature. A two degree rise in minimum temperature, from 56 F to 58 F can result in a doubling of tomato seedling shoot growth. At the time of transplanting all mulches produced a minimum soil temperature > 60 F. Often, growth is highly correlated to maximum and minimum temperature differences or the concept known as heat units or growing degree days. Using a lower threshold value of 55 F (below which root growth is minimal) we calculated the mulches effect on accumulating heat units. Table 2 shows that clear produced the greatest heat units with no differences among the IRT100, red, and red/black films; but all significantly greater than the black mulch.

Daily maximum soil temperature occurred between 4-5 pm and there were significant large differences among the mulches. As expected, clear mulch resulted in +13 F compared with black mulch, 91 F vs 78 F, respectively (Fig. 2). In July, the clear plastic could produce soil temperatures > 90 F which research has shown to be detrimental to continued tomato growth and fruit development. The recorded July soil temperatures at the 4-inch depth approached this threshold value only from July 12 to July 15, a high solar radiation and air temperature period. The clear plastic soil temperature averaged 91 F for the 4 days.

Flower Production , Fruit Set, and Yield

Early vegetative development and flower cluster production was not affected by mulch treatment (Fig. 2). Growth, as measured by shoot dry weight accumulation, increased 6-fold from June 6 to July 6. But this rate was not affected by mulch type. Flower cluster development was measured June 20 and July 6. On either date there were no effects of mulch treatment on flowers or fruit produced, averaging 7.3 flower clusters per plant. The yield and fruit size from July 18 to August 15 harvests were lower this year from Septoria disease infection. No yield parameter measured - early, marketable, cull, total or fruit size -

were affected (Table 3). We continue to believe the main controlling factor of early tomato production by plastic mulch selection is soil temperature. Thus, our recommendation would be to:

1. Use an early, adaptive high quality variety.
2. Apply clear plastic mulch (assumes herbicide for acceptable weed control) 7 to 10 days ahead of transplanting.
3. Use rye strips for wind breaks. Consider using hooped, silted, row covers.
4. Plant close to the spring frost free date in early May for central Iowa.
5. Stake and prune using the Florida weave system.

Following the above steps may give the highest economical early yields. Weed control with clear plastic can be a major problem. Therefore, choose a wavelength selective film (such as IRT or SRM films) which block light necessary for weed growth but transmit some radiation to warm the soil. Although more expensive than clear plastic, wavelength selective films may be economically feasible.

Table 1. Red:Far red ratios of reflective light measured 14 inches from the mulch surface on the south side of the row. The sensor was placed between two plants and 10 inches form the plant center line. The sky values are incoming radiation. [1]

Plastic Treatment	R:FR Ratio	PPFD[2]
Sky	1.296 A[3]	863 A
Black	1.019 B	104 B
Clear	1.087 B	158 B
IRT100	1.002 B	91 B
Red	1.011 B	168 B
Red/Black	1.055 B	126 B

[1] Measures taken June 1 at 12 noon. Sky conditions were cloudy, bright.
[2] PPFD = photosynthetic photon flux density, a measure of radiation necessary for the plant's photosynthesis process.
[3] Mean values in a column followed by the same letter do not significantly differ at the 5% level.

Table 2. Minimum soil temperature in degrees F, occurring generally from 6 to 7 am, for the first four weeks after transplanting (plants set May 17) as affected by plastic mulch treatment.

Treatment	May 24 to May 30	May 31 to June 6	June 7 to June13	Accumulated Heat units [1]
Bare ground	58.9	59.0	68.3	—
Black	61.5	64.2	70.0	162 C [2]
Clear	63.1	66.2	73.4	254 A
IRT100	62.1	64.8	71.2	193 B
Red	62.1	64.9	71.4	195 B
Red/black	60.3	59.4	67.5	190 B

1 Heat units = calculated daily using the formula (Tmax + Tmin)/2 - 55F, where 55 F is the minimum threshold soil temperature at which tomato root growth is minimal.
2 Mean values in a column followed by the same letter do not significantly differ at the 5% level.

Table 3. Effect of plastic mulch type on early and total yield and fruit size of Mtn. Spring tomato, Castana, Iowa. [1]

Mulch Treatment	Early Yield, cwt/acre Marketable	Cull	Total	Mkt. Fruit Size, oz.	Total Season Yield, cwt/a
Black	7.3	1.2	8.5	5.4	216
Clear	11.3	4.2	15.7	5.8	233
IRT100	11.5	1.2	12.7	5.3	196
Red	7.0	1.2	8.2	4.9	224
Red/Black	13.0	1.2	14.2	7.0	241
Sign., P>F [2]	ns	ns	ns	ns	ns

[1] Early yield = July 18 to 25. Transplants set May 17, 2000.
Total yield = July 18 to August 15.
[2] Significant difference among treatments, 5% levels. ns. = not statistically significant.

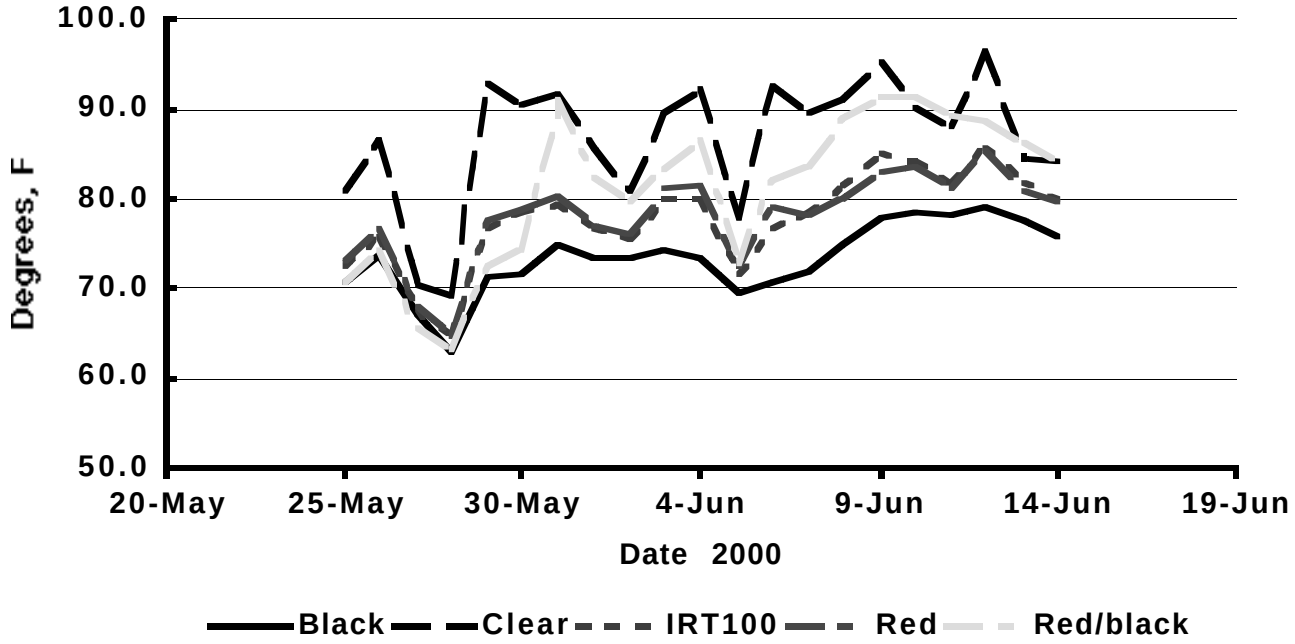

Figure 1. Effect of plastic mulch treatments on maximum soil temperature, 4-inch depth, for three weeks after transplanting.

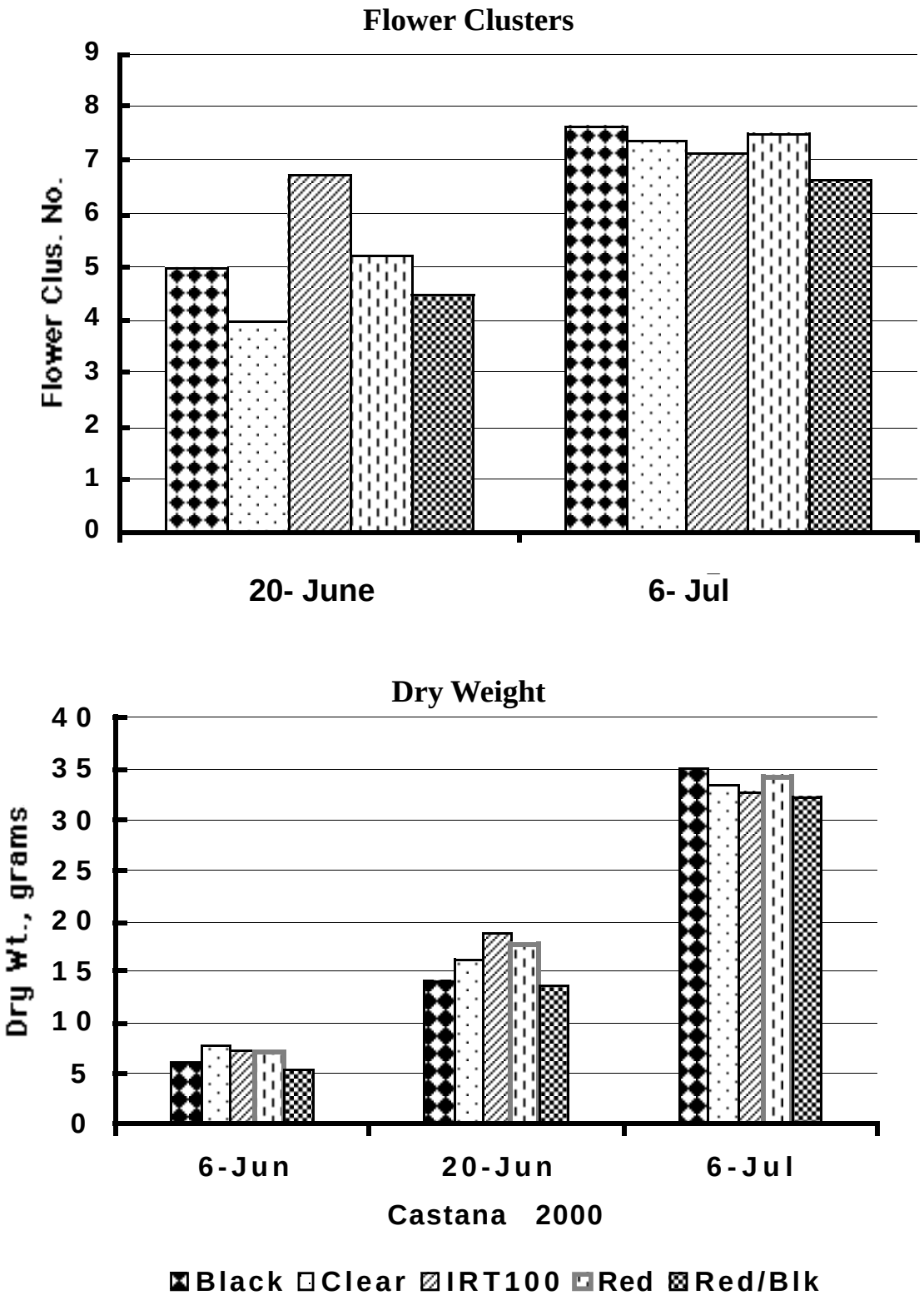

Figure 2. Flower cluster number and dry weight of Mtn. Spring tomato seedlings as affected by plastic mulch treatment up to 1st flower cluster stage of growth.