UNIVERSITY OF SASKATCHEWAN

VEGETABLE CULTIVAR AND CULTURAL TRIALS 2009

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Saskatchwan Agriculture and Food

Tunnel Materials for Warm Season Vegetable Crops

Previous trials have demonstrated the benefit of using row covers to enhance early growth of warm season crops like melons and peppers. There are many types of covers available and it is important to select the type of covering material that best suits the needs of the crop. This trial examined the performance of several warm season vegetable crops (peppers, melons and tomato) grown with different types of row cover.

The trial was conducted at the University of Saskatchewan Horticulture field Research Station in 2008 and 2009. This site features a Sutherland Series heavy clay soil which is slow to warm in the spring. The site was prepared by rotovating one week prior to transplanting the test crops. Three days before transplanting a biodegradable wavelength selective plastic mulch was applied to the test plots. Drip irrigation lines were located beneath the mulch. Three week old cantaloupe (cv. 'Strike' in 2008 and 'Athena' in 2009) or 6 week old pepper (cv. 'Red Start') transplants were planted out into the mulched rows once the risk of frost had passed in early June. Tomato (cv. Celebrity) (6 wk old transplants) was also tested in 2009. The melon and pepper plants were spaced 30 cm apart within each row, while the tomatoes were spaced 0.5 m apart. Each test plot was 3 m long and the rows were 2m apart. Immediately after transplanting, row covers were installed on all plots except for a non-covered control. The cover materials tested were;

a) perforated clear polyethylene – transmits about 85% of the light in the visible spectrum. Clear perforated polyethylene creates a very warm environment.
b) non-perforated clear polyethylene – would be expected to create an environment even warmer than the equivalent perforated clear poly.
c) perforated green polyethylene - filters out about 41 % of incoming light within the visible spectrum, resulting in cooler temperatures. Filtering certain wavelengths out of the incoming light may also alter the growth pattern of the covered crops.
d) perforated white polyethylene - filters out about 26 % of the incoming visible light.
e) Novagryl woven polyester - filters out about 20 % of the incoming visible light and is also highly perforated.

The covers were supported by metal hoops (45 cm tall at peak) installed over each row to create a low tunnel. Each treatment was replicated 3 times in a randomized complete block design. Temperatures and crop condition were monitored inside the tunnels. The tunnels were removed once the crop started to flower - except for the non-perforated treatments where the tunnels had to be removed earlier due to problems with overheating and crop stress. No problems with insect pests or diseases were observed in 2008 trial and no pest management measures were required. In the 2009 trial some of the pepper plants were lost at mid-season to root rot. Problems with this disease were uniform across the tunnel treatments. Mouse damage to the fruit was a problem in all treatments in the tomato trial.

The peppers were taken in a once-over harvest in mid-September. The fruit were graded into red ripe, mature green and immature categories. The melons were harvested weekly, with the fruit picked at half slip maturity. Any melons remaining after the first killing frost were taken in a once-over final harvest (Sept 22 in 2008, Oct 5 in 2009). Tomatoes reaching the breaker stage of maturity were harvested weekly. Any fruit remaining on the plants were harvested just after a killing frost in early October.

Results

2008 growing season – temperatures in May and June were cooler than normal but there were no frosts after the trial had been established. Temperatures in July and August were close to normal, while September was abnormally warm. The frost free season (May 26 to Sept 26) was about 4 days longer than the 30 year average.

2009 growing season – May and June of 2009 were exceptionally cool. Frost was recorded on four

occasions after the trial was established (June 1, 4, 6 and 9). Some frost damage was observed on the plants covered with clear polyethylene as well as the non-covered plants. This frost damage coupled with wind damage resulted in the loss of about 10% of the plants in the treatments that were not protected by a row cover. Temperatures remained slightly below normal through July and August, but September was exceptionally warm, with the first frost delayed by two weeks relative to the longterm norm. The near-perfect fall conditions allowed the otherwise delayed crops to mature. The total length of the frost free season in 2009 was about 10 days shorter than normal.

Temperature profiles - Temperature profiles under the various tunnel materials for the period when the tunnels were in place in 2008 (June 5-July 2) are presented in Fig 1, while the temperature profiles for 2009 (June 3-July 3) are presented in Fig 2. Temperature monitors in the Novagryl treatment failed in 2009 and no data were collected. Temperature profiles for the various tunnel treatments were similar in the two years of testing. On sunny days, all of the covering materials increased air temperatures inside the tunnels relative to having no cover. The tunnels had little impact on temperatures at night or on cloudy days. Temperatures under the opaque materials (white, green and Novagryl) were comparable, running about 5C warmer than air temperatures in 2008, with slightly less temperature enhancement seen during the cooler conditions encountered in spring of 2009. Temperatures inside tunnels constructed of clear poly were far higher than for the other materials tested. The perforated clear poly tunnels produced daytime temperatures that were a few degrees cooler than the non-perforated covering.

During the frost events that occurred in 2009, none of the tunnel treatments provided any significant degree of frost protection and in many cases temperatures under the tunnels were marginally lower than when no cover was used. As polyethylene is both a poor insulator and fairly transparent to long wavelength radiation its potential to retain heat through the night is limited.

The clear poly coverings were clearly beneficial to growth of the crops early in spring when conditions were cool. However, by mid-June of 2008 temperatures inside the non-perforated clear poly tunnels were becoming excessively high, especially for the peppers which were showing signs of heat stress (marginal firing of leaves). In the 3rd week of June of 2008, outdoor temperatures reached the mid-20^{o}C range and none of the peppers and few of the melons in the non-perforated clear poly tunnel survived, as temperatures in the tunnels exceeded 65^{o}C for several days in a row. Some heat stress damage was also observed on peppers in the perforated clear poly tunnels where peak temperatures reached 60^{o}C. There were fewer indications of heat stress under the clear poly tunnels during the cooler conditions experienced in 2009. Nonetheless temperatures in excess of 55^{o}C were recorded under the clear poly tunnels in 2009. There were no obvious differences in crop growth under the various opaque coverings. At the time of tunnels removal, all covered crops appeared to be larger than the crop grown without a covering but it did not appear that flowering was advanced or enhanced by the tunnels.

Fig 1. Average daily air temperatures under various opaque (a) or clear (b) tunnels in 2008.

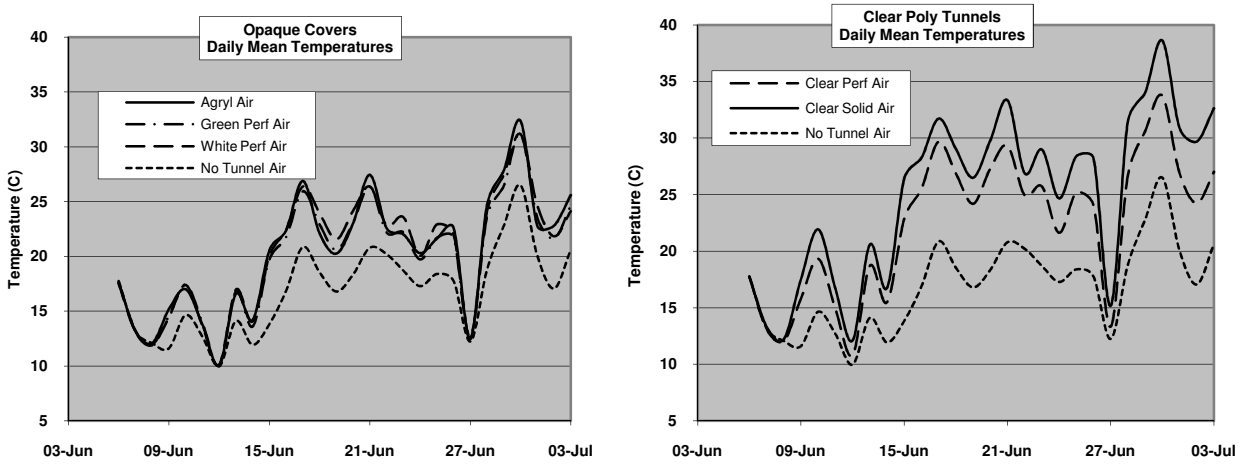
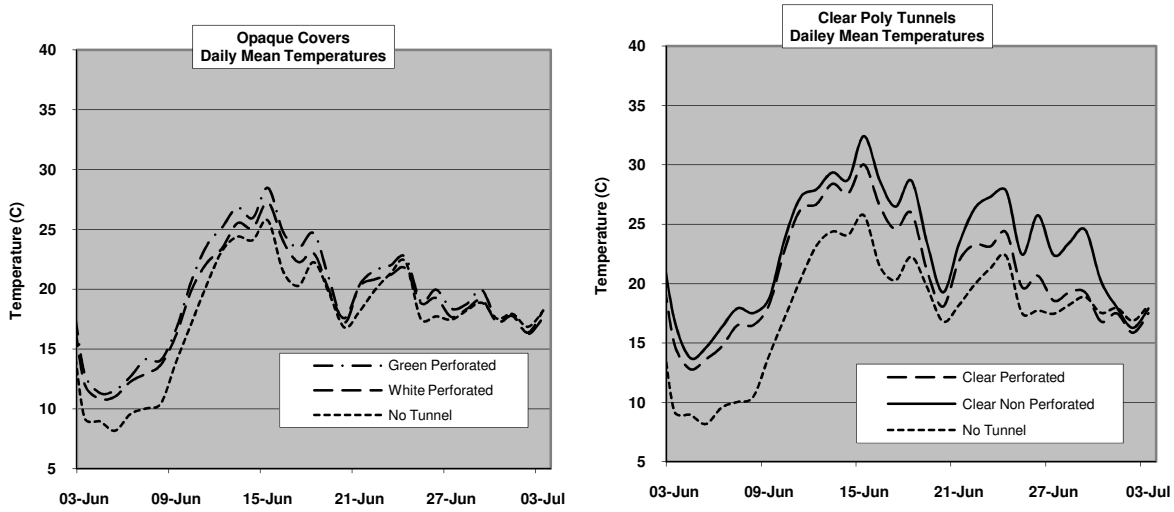


Fig 2. Average daily air temperatures under various opaque (a) or clear (b) tunnels in 2009.



Peppers

In previous trials we had found peppers to be sensitive to heat stress under any form of tunnel. As a consequence we have not recommended the use of any type of clear poly cover and have instead advocated the use of woven cover materials like Novagryl that keep the crop relatively cool. However, as these woven materials are relatively expensive, in this test we looked at two poly type materials that also might be expected to keep the plants cool - white or green plastic. Results in both years of testing were generally comparable (Table 1). While using the tunnels appeared to accelerate early growth in 2008, this had relatively little impact on total fruit yields. The treatments that accelerated early growth without causing excessive heat stress (white and green poly and Novagryl) had a greater proportion of fruit that reached full maturity and turned red by harvest. A similar but less obvious positive effect of the white, green or Novagryl tunnel treatments on yields of ripe red fruit was observed in 2009. As prices for red peppers are

much greater than for mature green or immature fruit, this difference would have substantially enhanced the value of the crop. All of the tunnel treatments enhanced total yields relative to the control in 2009 – this likely reflects the loss of stand that occurred due to frost and wind damage in the unprotected treatments. Using clear tunnels appeared to have the potential to delay crop development – especially in warm years and/or when non-perforated tunnel materials were used. This delay likely reflects heat stress caused by the excessively high temperatures that commonly occurred within the clear poly tunnels.

Table 1. Influence of various types of tunnel covering on fruit yields of peppers in 2008 and 2009.

Covering Material	Ripe (kg/m)	Mature green (kg/m)	Immature (kg/m)	Total (kg/m)	Ripe %	Avg. fruit wt (g)
	2008					
Clear (non-perforated)	-	-	-	-	-	-
Clear (perforated)	0.1 b[1)]	3.0 a	0.3 a	3.4 a	2 c	89 b
White	0.9 a	3.0 a	0.1 b	4.0 a	23 a	114 a
Green	0.5 ab	3.3 a	0.2 b	4.0 a	13 abc	116 a
Novagryl	0.7 a	3.0 a	0.2 ab	3.8 a	16 ab	112 a
No Cover	0.1 b	3.2 a	0.2 ab	3.5 a	4 bc	125 a
	2009					
Clear (non-perforated)	0.2 c	1.9 c	1.3 a	3.4 b	7 b	85 d
Clear (perforated)	0.4 bc	2.6 b	0.4 c	3.5 b	13 a	107 ab
White	0.6 ab	3.0 a	0.8 b	3.4 b	14 a	104 ab
Green	0.8 a	3.0 a	0.8 b	4.5 a	17 a	112 a
Novagryl	0.5 abc	3.0 a	0.8 b	4.4 a	12 a	95 c
No Cover	0.4 bc	1.8 c	0.6 c	2.8 c	16 a	99 bc

[1)] *Values within columns followed by the same letter are not statistically different (P=0.05)(n=3)*

Melons

In previous trials melons had responded favorably to tunnel materials that created a relatively warm environment - with perforated clear polyethylene representing the standard recommended tunnel treatment. Early in both 2008 and 2009 the melons appeared to thrive in the warm conditions provided by clear polyethylene tunnels - but in 2008 the crop was killed when temperatures in these tunnels spiked above 65^{o}C. Less extreme high temperatures were observed in 2009 and at the time of tunnel removal the crop under the non-perforated clear poly tunnel appeared to be the most advanced.

In 2008 the clear perforated polyethylene treatment produced the highest early yields (by mid-Sept), while in 2009 the Novagryl tunnels had the greatest early yields (Table 2). The no tunnel treatment consistently had the lowest early yields. When yields of mature fruit were calculated over all harvests in 2008, all tunnel treatments produced statistically equivalent yields, with lowest yields occurring when no tunnels were used. By contrast in 2009, the Novagryl and white tunnels produced superior total yields while the other tunnel treatments were no better than the control. In 2008 the yield advantage provided by the

tunnel treatments was strictly due to the tunnels accelerating fruit maturity, as total fruit yields, including immature fruit were not affected by the tunnels. In 2009 the control treatment produced the fewest fruit in total but clearly set these fruit relatively early, resulting in a high proportion of the fruit maturing by the final harvest. The white tunnel treatment had the highest proportion of marketable mature fruit. Fruit in the non-covered control treatments were substantially larger than in the tunnel treatments in 2008 but this effect was less obvious in 2009.

Table 2. Influence of various types of tunnel covering on yields of melons in 2008 and 2009.

Covering Material	Early [1] (kg/m row)	Marketable (kg/m row)	Total (kg/m row)	Market %	Avg. fruit wt (kg)
	2008				
Clear (non-perforated)	-	-	-	-	-
Clear (perforated)	2.6 a	8.8 a[2]	14.2 a	61 a	1.25 b
White	1.4 b	7.4 ab	12.9 a	56 a	1.21 b
Green	1.1 bc	5.8 ab	12.9 a	45 ab	1.29 b
Novagryl	2.0 ab	9.0 a	14.8 a	61 a	1.24 b
No Cover	0.3 d	4.0 b	11.7 a	33 b	1.63 a
	2009				
Clear (non-perforated)	1.0 d	4.4 b	18.9 ab	21 c	1.12 b
Clear (perforated)	2.6 b	4.6 b	17.2 b	25 bc	1.19 b
White	2.0 c	8.0 a	15.4 bc	50 a	1.31 a
Green	2.5 b	5.0 b	16.7 b	28 bc	1.16 b
Novagryl	3.8 a	8.1 a	20.8 a	36 b	1.33 a
No Cover	0.4 d	5.2 b	13.4 c	35 b	1.37 a

[1] *Early harvests = yields by mid-Sept.*

[2] *Values within columns followed by the same letter are not statistically different (P=0.05)(n=3)*

Tomato

In the 2009 tomato trial the white poly tunnel treatment produced the greatest early season yields of mature fruit. The white and Novagryl treatments produced the greatest total yields of mature fruit and had the highest proportion of fruit that ripened prior to frost. The no tunnel treatment produced the greatest combined yield of red and immature green fruit. Use of the non-perforated clear tunnel had a very negative effect on the tomato crop, with many plants dying due to heat stress and the development of the surviving plants being so delayed that only a few small fruit matured prior to the first killing frost.

Conclusion - this trial demonstrated the value of low tunnels in the production of warm season crops within the relatively short and cool growing season available in Saskatchewan. The tunnels enhanced the maturity of pepper, tomato and melon crops – resulting in a substantial increase in market value. The trial also demonstrated the importance of selecting covering materials that match the temperature needs of the crop. Clear poly tunnels are only recommended for use early in the season for heat tolerant crops like melons otherwise there is a risk of heat stress. Special care must be taken when covering tomatoes with

any type of material otherwise fruit set may be delayed. In general the cover materials that provided a more moderate level of enhancement of air temperatures (Novagryl and white) appeared to provide the most consistent benefits.

Table 3. Influence of various types of tunnel covering on yields of tomato in 2009.

Covering Material	Early [1)] (kg/m row)	Marketable (kg/m row)	Total (kg/m row)	Mature %	Avg. Fruit Wt (g)
	2009				
Clear (non-perforated)	0 c[1)]	0.9 d	16.4 c	5 c	39 b
Clear (perforated)	1.2 b	5.0 bc	21.7 b	23 b	72 a
White	3.9 a	7.0 a	23.7 ab	30 a	74 a
Green	0.8 b	3.9 c	22.4 ab	17 b	69 a
Novagryl	1.5 b	6.1 ab	20.8 b	29 a	76 a
No Cover	1.3 b	5.0 bc	26.3 a	19 b	78 a

[1)] *Early harvests = yields by mid-Sept.*

[2)] *Values within columns followed by the same letter are not statistically different (P=0.05)(n=3)*