Growing Conditions and Crop Performance in High Tunnels

High tunnels are easily to build, low cost, low tech greenhouses constructed by covering relatively lightweight aluminium framing with a single layer of polyethylene. There is no supplemental heat or power, but the sides and/or endwalls can be opened manually to provide ventilation. Previous research conducted by the Vegetable Crops Research Program at the University of Saskatchewan has demonstrated the potential production and economic benefits of growing high value, warm season vegetable crops in high tunnels. A major limitation of the 1st generation high tunnels was that their small size (14' wide * 8' tall * 100' long) limited the range of crops that could be grown and the equipment that could be used in the high tunnel. The small size of these 1st generation tunnels also increased the material cost/unit production area and made it difficult to maintain suitable temperatures.

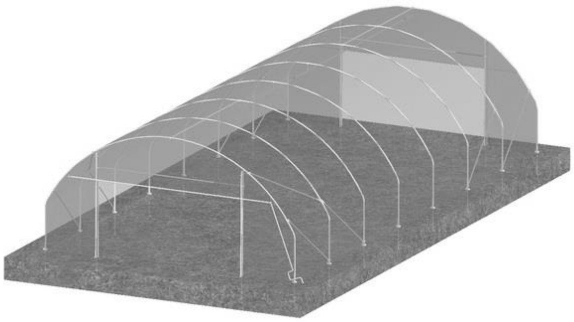
In 2010 a 2nd generation high tunnel complex was built. The complex consisted of 8 gutter connected high tunnels – with each high tunnel being 28' wide, 18' tall at the peak, 6' tall at the eaves and 200' long. In 2011and 2012 the performance of a range of high value vegetable crops was evaluated in these 2nd generation high tunnels, with earliness, yields and quality compared to crops growing in smaller 1st generation tunnels or under open field conditions. It was easier to establish and maintain the crops in the more spacious 2nd generation high tunnels. Temperatures were more moderate and light levels lower in the larger 2nd generation tunnels than in the smaller 1st generation high tunnels. Watermelon, muskmelons, peppers, tomato and lettuce were earlier, with higher yields and superior quality in the new larger tunnels than in the smaller 1st generation tunnels. No benefits were observed in the corn, squash, cucumber or strawberry crops growing in the larger high tunnels relative to producing these crops in open field conditions.

In June 2012 a wind event (96 km/h peak gusts) collapsed 4 of the 8 tunnels in the complex. In the fall of 2012 a heavy snow event caused the collapse of the remaining tunnels. **The high winds and untimely snow are common occurrences in Saskatchewan led to the conclusion that this type of high tunnel system is not well suited to local use.**

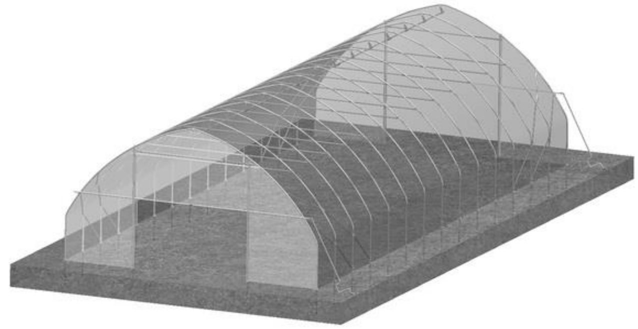
In 2013 two freestanding 3rd generation high tunnels were constructed (Fig. 1). These structures are built of heavier materials and have a lower profile than the 2nd generation tunnels – so they should better withstand weather events. However, the 3rd generation structures are considerably more expensive than the 2nd generation tunnels previously tested. The Gothic type tunnel system is designed to stay covered all winter – its peaked roof is designed to shed snow and its stronger and more closely spaced arches are designed to withstand some snow and wind load. Price per unit production area of the Gothic type tunnel is nearly double the lighter duty standard tunnel.

It took about 40 person hours to construct each tunnel and to get the plastic cover installed.

Starting in July and running through early November of 2013 cool season crops such as spinach, lettuce, peas, beets, and radish were grown in the Gothic tunnel. The crops all did well. The tunnel provided a surprising degree of frost protection – allowing the crops to continue to grow well into November – even though air temperatures had reached as low as -14C during this production period.



Standard high tunnel



Gothic-type high tunnel

Fig. 1. Tunnel schematics courtesy of Haygrove UK

2014 Cropping Season

The cover was left on the Gothic tunnel over the winter of 2013/2014, as this would eliminate the labor cost associated with removing and then re-installing the cover (Fig. 2). Keeping the production area snow-free all winter would also accelerate drying and warming of the production area in the spring – potentially allowing an earlier start to the growing season.

Fig. 2. Gothic (right) and supersolo (left) high tunnels in early winter of 2013/2014.

In January of 2014, a storm event with record setting high winds speeds (> 120 km/h) blew the cover off the Gothic high tunnel (Fig. 3). The structural elements of the tunnel were not damaged. The cover was replaced at a cost of $900. The adjacent Supersolo high tunnel did not sustain any damage as it was not covered at the time of the storm.

Fig. 2. Wind damage to cover of Gothic high tunnel over winter of 2013/2014.

Because of excessively wet field conditions the plastic cover for the tunnels could not be installed until early May. The production area inside the high tunnels was prepared by spreading N fertilizer on the soil surface and then rotovating the soil.

Black plastic soil mulch was laid in the tunnels and in adjacent open field plots (Fig. 4). The three 1 m wide rows of mulch were spaced 2 m apart (center to center) in each tunnel. A drip irrigation line was installed beneath the mulch.

Fig. 3. Rows of plastic soil mulch in the Supersolo high tunnel - 2014

In late May, pepper, tomato and eggplant crops were transplanted into the Gothic tunnel and into a check trial conducted in an adjacent area of the field. The peppers and eggplants were spaced 30 cm apart and the tomatoes were spaced 50 cm apart. As it was expected that the tomatoes would become they tallest crop they were located in the center row of the tunnel.

The check plots of pepper and eggplant were covered with low tunnels constructed of perforated green polyethylene film. The tomatoes in the check trial were not covered, as previous research had shown that covers provide little benefit to tomato crops.

Fig. 5. Lettuce growing in 'waste" areas between the main crops (eggplant) and the outside edge of the high tunnel.

As it would be several weeks before the pepper, eggplant and tomato crops required much space, bibb lettuce was transplanted between the mulch rows in the Gothic tunnel (Fig. 5). Growing quick maturing short stature crops between the rows of the slower growing main crops or in the "waste" areas of the tunnel allowed more efficient use of the valuable growing space in the high tunnel.

In the 1st week of June dormant plants of 6 cultivars of raspberry (3 primocane and 3 floricane) and 5 cultivars of strawberry (3 day-neutral cultivars and 2 June-bearing) were planted into the Supersolo tunnel (Fig. 6).

Fig. 15. Day-neutral strawberries planted on mulch in the high tunnel

In the 2nd week June, melons (3 cvs of watermelon, 2 cvs of muskmelon and 1cv of honeydew) were transplanted through plastic mulch in the Supersolo tunnel and in a parallel trial established in the adjacent open field. The plants were spaced 0.5m apart within the row. Clear polyethylene low tunnels were used to protect the melon seedlings in the check trial.

In the 2nd week of June a 45 cm wide strip of plastic mulch was laid around the periphery of both high tunnels – and then a 15 cm thick layer of bark mulch was added on top of the plastic (Fig. 7). This combination of plastic + bark mulch provided very effective control of weed growth along the edges of the tunnel and also provided a high and dry walking path following rain events.

Fig. 7. Bark mulch around the periphery of the high tunnel.

The 3rd week June several heavy rain events flooded the high tunnels. The open field trials were on slightly higher ground than the tunnels and they were completely open to air flow – both of which would have facilitated quicker drying.

In the 3rd week of June and again in mid-August, insecticide sprays had to be used to control aphids on the peppers in the Gothic tunnel. No corresponding problem was observed in the open field trial.

In late June and again in mid-July, bacterial blight (Fig. 8) struck the leaves of the tomato and pepper crops in the Gothic tunnel. Again there was there was no parallel problem in the open field trial.

Fig. 8. Bacterial blight affecting leaves of peppers growing in the high tunnel.

In the 2nd week of July, 2,4-D + glyphosate spray applied to an adjacent fallow field drifted into the high tunnel project. Within days crop damage typical of 2,4-D exposure (leaf twisting, raised leaf veins, loss of bloom and formation of adventitious roots)(Fig. 9) became apparent on the tomatoes and peppers and to a lesser degree on the eggplants and melons. The degree of damage was greater on the crops inside the tunnel than in the crops growing in the adjacent open field trial.

Fig. 9. Damage to foliage of tomato and melon crops and fruit of peppers in high tunnel following exposure to drift of 2,4-D + glyphosate herbicide

In the last week of August late blight hit the tomato trial growing in the open field. The disease spread rapidly, destroying the leaves and damaging the fruit. Little additional marketable yield was obtained from the open field tomato crop. **No late blight was detected on the tomatoes growing in the Gothic tunnel only meters away from the infected material.**

In anticipation of frost events from mid-Sept onwards, the sides of the tunnel were lowered and a sheet of Agryl P-17 field cover was installed over all the plants in the tunnel (Fig. 10). A -2C frost on Sept 12 killed all of the crops growing in the open field check trial – but no damage occurred inside the tunnels.

Fig. 10. Field cover installed over top of crops in a high tunnel in anticipation of a frost event

The final harvest of the melons in the high tunnels occurred on Sept. 26. The tomatoes, peppers and eggplants in the Gothic tunnel continued to produce a few fruit until late October.

In the 2nd week of Nov. the cover was removed from the Supersolo tunnel. This process took three workers 4 hours to complete. **The cover was left on the Gothic tunnel for the winter.** Straw mulch was applied over the strawberry plots both inside and outside the high tunnels.

Temperature Management in 2014

The objective of employing high tunnels is to produce a growing environment more conducive to crop development than conditions in the open field. When growing high value warm season vegetable crops within the relative short cool growing season available in Saskatchewan, the primary function of the high tunnels will be to increase air temperatures – especially during spring and fall. If the tunnels can also provide some frost protect this will extend the growing season, increasing the yield potential of the crops, while also extending the marketing season. The tunnels can also protect the crops from damaging wind, heavy rain and hail events. There is however potential for the tunnels to produce conditions not suited to optimum crop growth. Excessively high temperatures can cause the plants to fail to flower or can interfere with pollination and normal fruit development. The optimum temperature for fruit development, pollination and fruit set are 18-26^{o}C for tomatoes, 16-24^{o}C for peppers and 18-30^{o}C for eggplant. In melons, persistent high temperatures cause the plants to produce nothing but male flowers. The female flowers that develop into the fruit will only form if the crop is exposed to cooler temperatures for several days in a row. The bees required to pollinate melon flowers also do not spend time in areas where temperatures are excessively high.

Given the crop development considerations outlined above – the overall objective for temperature management of the high tunnels in 2014 was to maintain temperatures within the optimum range for as much of each day as possible and on as many days as possible over the course of the growing season. Meeting this objective was complicated by;

a) Day to day and hourly changes in temperatures, sunlight levels and wind speeds and direction
b) Differences in temperature in different areas of a tunnel
c) Different optimum temperatures for the various crops grown within a single tunnel
d) Weekends – at which time there were no staff available to manage the tunnels

When attempting to optimize temperatures within a high tunnel, the major management tool available to the growers is the ability to raise and lower the side walls and to open/close the end doors. Raising the sides of the tunnel involved repositioning the plastic cover between ropes that hold the cover in place and then holding the raised sides in place by cinching the tensioning ropes tighter with clips supplied with the tunnels. The process of raising the sides of the tunnel took one person about 10-15 minutes. Lowering the sides took slightly less time. The end doors of the tunnels were on a crank mechanism and could be raised within a few seconds. The degree to which the side walls were raised and the doors opened was also influenced by the prevailing wind speed and direction.

Each day during the work week the tunnels were visited on at least 3 occasions (9 am, 1 pm and 4:30 pm) at which time the position of the side walls and doors was managed in an effort to optimize the temperatures. Thermometers positioned in the crop canopy and the weather forecasts were consulted before deciding what changes, if any, to make in the position of the sidewalls and end-doors. In general, the tunnels were kept closed or partially closed through

June, fully open through July and August, partially or fully closed through September and fully closed through October. If the sidewalls and doors were only partially open during the day, they were usually closed at night but if they were fully open in the day, they were kept at least partially open at night.

Temperature management on the weekends was problematic as there were no staff available to conduct any changes. Instead, late on Friday afternoon the forecast for the coming weekend was reviewed and then the sidewalls and doors were placed into a position thought least likely to result in temperature conditions damaging to the crops

Daily high and low temperatures in the Gothic tunnel over the course of the 2014 growing season are presented in Fig 11.

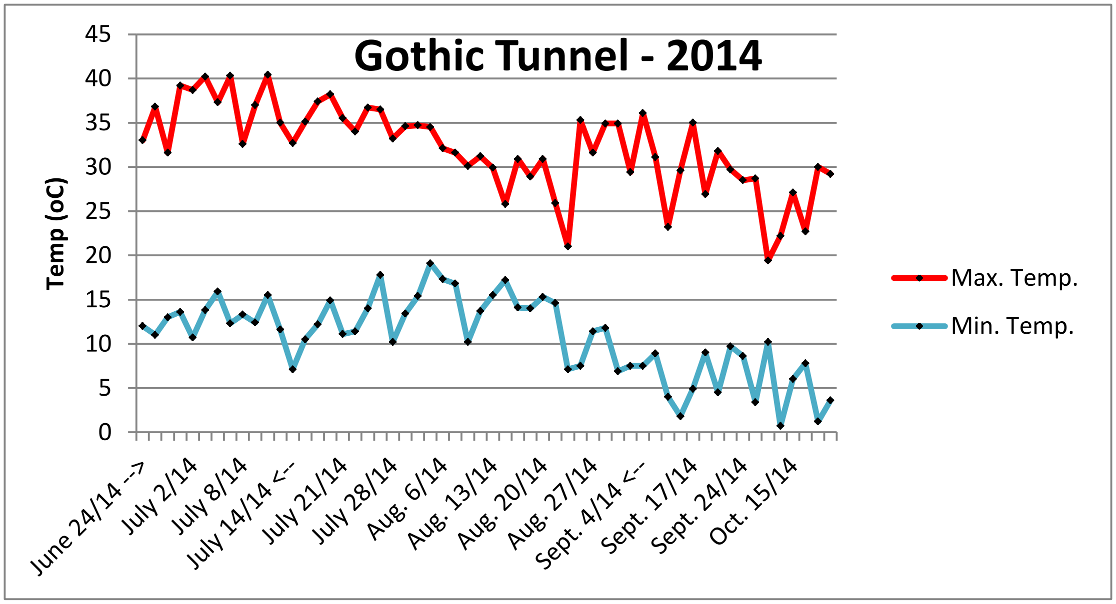


Fig. 11. Daily high and low temperatures in a gothic high tunnel

Temperatures exceeding the optimum for fruit set of the test crops occurred frequently in both types of high tunnels over the full duration of the growing season. As elsewhere in this report, delayed and uneven fruit set was common in the various crops growing in the high tunnels. By contrast, the check crops growing in the cooler conditions of the open field did not seem to have the same problems with delayed fruit set. We could not identify a readily implemented management practice that would rectify the problem – as the problem was occurring even in situations where the side walls and end doors were fully open.

Some less practical solutions that were considered were;

a) Cutting holes in the roof to allow hot air to escape. This would however, have compromised structural strength of the plastic covering and also would have allowed rain into the tunnel
b) The covering could have been replaced with a more opaque plastic. While this would have reduced peak temperatures in the summer – by restricting light levels in the tunnel this plastic would also have slowed crop growth.
c) Because of past experiences with wind damage, the tunnels were purposely constructed in a very sheltered location. However, on hot days this shelter interfered with the wind movement required to ventilate the tunnels.

For weeks at a time, the humidity levels in the high tunnels at night exceeded the dew point (Fig. 12), resulting in very heavy dew on the plants and condensation on the cover which subsequently rained down onto the crop. High humidity levels can interfere with pollination of tomatoes and will also promote the development of a range of diseases – such as bacterial blight.

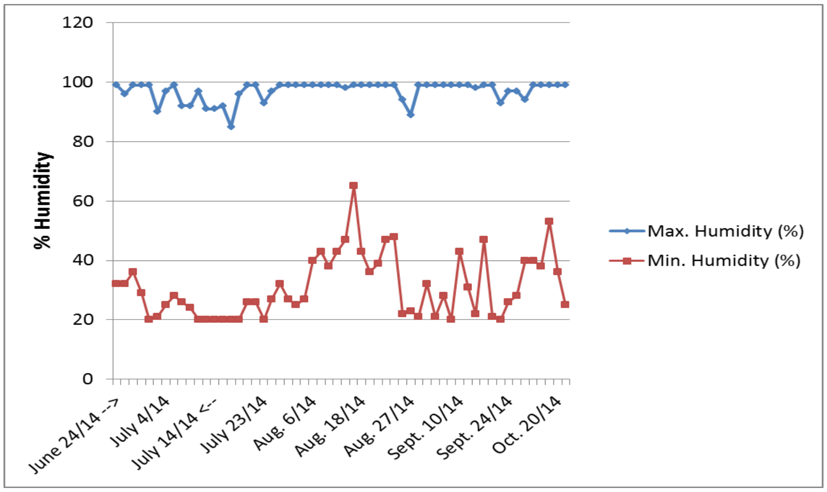


Fig. 12. Maximum and minimum relative humidity values for a high tunnel in 2014

While dew formation is common in a typical Saskatchewan growing season, it is very unusual to see the dew point being exceeded for weeks at a time as occurred in the high tunnels in 2014. This situation could be attributed to a combination of three factors;

a) The summer of 2014 was unusually humid
b) The soils inside the high tunnel were flooded in late June and did not really dry until August
c) Air movement through the tunnels was restricted by the tunnel structure and the adjacent shelterbelts.
d) The difference between the daily high and the daily low temperatures in the tunnels was much greater than in the field. During the day, the warm air in the tunnel could hold more moisture than the cooler air outside the tunnel – but at night the temperatures were similar inside and out of the tunnels. This resulted in the deposition of huge amounts of condensation inside the high tunnel.

Like the previously discussed problem with excessive temperatures, we could not come up with any easy solutions to the problem of excessively high humidity levels in the high tunnel.

Crop Specific Performance in 2014

Tomatoes - the performance of 6 cultivars of tomatoes grown in the Gothic type high tunnel was compared against the same cultivars growing in the open field. The cultivars varied in their fruit size and quality, yield potential and speed of maturity.

As noted elsewhere, the tomato crop in the Gothic tunnel showed excellent vegetative growth but flowering and fruit set were sporadic. This sporadic fruit set could be attributed to; a) damage to the plants from herbicide spray drift, b) heat stress and c) flooding stress. The first fruit matured in the high tunnels at about the same time (Aug. 5) as in the crop growing in the open field. However, as the plants in the high tunnel were much larger than those growing in the open field, their yields at subsequent harvest dates were much greater than in the open field. The average total yield of marketable quality mature red fruit was 12 times greater for the crop grown inside the high tunnel than in the open field (Table 1). Despite the extremely long growing season available within the high tunnel, only about 40% of the fruit actually turned red before the trial was terminated in late October. This again reflects the delay in fruit set caused by the stress events in the high tunnel. Only 10% of the fruit in the open field had matured within the available growing season. Flooding and herbicide stress slowed fruit set in the open field while the combination of disease and frost terminated fruit development in early September.

Table 1. Productivity of six cultivars of tomato grown in a Gothic high tunnel versus the open field in 2014.

	Total yield (kg/m)		Total mrkt yield (kg/m)		% immature		%cull		Date of 50% harvest	
Cultivar	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside
Scotia	27.4	8.7	20.4	1.6	12.0	77.2	13.5	4.4	Oct 2nd	Aug 15th
Early Girl	30.0	12.6	11.1	1.4	56.1	86.3	6.8	3.0	Oct 5th	Aug 26th
Defiant	29.7	12.7	14.6	1.3	22.7	86.6	28.2	3.2	Sept 24th	Sept 4th
Siberian	23.4	12.6	5.7	1.2	70.5	89.6	5.0	1.1	Sept 18th	Aug 29th
Roma	30.2	8.6	10.3	0.5	50.6	93.8	15.2	0.2	Oct 5th	Sept 4th
Booty	26.5	9.3	11.4	0.1	50.3	99.0	6.7	0.4	Sept 18th	Sept 4th
Avg	**27.9**	**10.8**	**12.3**	**1.0**	**43.7**	**88.7**	**12.6**	**2.0**	**Sept 28**	**Aug 29th**

Eggplant

The eggplants crop in the high tunnel was negatively affected by the same herbicide spray drift, heat stress and flooding stress issues that damaged the tomato crop – while the eggplant crop in the open field was largely unaffected by any of these stresses.

The first fruit matured in the high tunnels about 2 weeks earlier (July 31) than in the open field. During subsequent harvests, yields from the high tunnel crop were about double those in the open field. The final harvest was taken from the open field trial on Sept 9 just prior to a killing frost. By contrast, the eggplant crop in the Gothic tunnel remained largely undamaged by frost through to the end of October, however yields were low during the fall period.

Averaged over the cultivars tested, the total yield of marketable quality mature eggplants from the crop grown inside the high tunnel was roughly double that obtained from a crop produced using standard plasticulture techniques (Table 2). Growing the eggplant within the protected environment reduced the % of fruit culled due to fruit scarring.

Table 2. Productivity of six cultivars of eggplant grown in a Gothic high tunnel versus the open field in 2014.

Cultivar	Total Yield (kg/m)		Market yield (kg/m)		% Cull		Fruit weight (g)		Date of 50% Harvest	
	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside
Clara	7.6	-	3.2	-	58.7	-	360	-	Sept 4th	-
Galine	6.5	3.2	4.5	1.2	30.7	62.7	358	342	Sept 4th	Aug 25th
Megal	5.3	2.8	3.5	1.0	34.8	64.8	218	197	Aug 29th	Aug 29th
Nadia	2.5	3.2	2.1	1.3	18.9	59.9	391	364	Sept 4th	Sept 4th
Night Shadow	7.0	2.1	4.2	1.5	41.0	28.9	415	390	Sept 4th	Aug 29th
Traviata	3.5	3.4	2.1	1.4	39.9	57.7	469	380	Aug 22nd	Aug 25th
Avg	**5.4**	**2.9**	**3.2**	**1.3**	**37.3**	**54.8**	**369**	**335**	**Sept 1**	**Aug 28**

Peppers

The pepper crop grown in the tunnel in 2014 suffered from a range of problems – flooding, overheating, herbicide drift, aphids and disease. The check pepper crop growing in the open field was affected to a lesser degree by these stresses. The combination of disease and frost terminated the pepper crop in the open field by mid-Sept. By contrast, the pepper crop in the Gothic tunnel remained unaffected by the late blight and escaped frost until the late October.

Averaged over the 6 cultivars tested, yields of mature marketable fruit from the high tunnels were 3X higher than in the open field.

Table 3. Productivity of six cultivars of pepper grown in a Gothic high tunnel versus the open field in 2014.

Cultivar	Total yield (kg/m)		Mkt yield (kg/m)		% Immature		% Cull		Avg. fruit wt (g)	
	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside
Fat n Sassy***	2.8	1.6	0.5	0.8	0.0	43.3	82.7	6.2	327	123
Ancho	2.4	0.5	2.2	0.0	0.0	100.0	9.0	0.0	82	0
Monet	3.8	0.7	3.6	0.6	0.0	18.2	4.8	0.0	43	20
Major League	5.2	1.5	5.1	1.4	0.0	10.6	2.7	0.0	45	20
Ring of Fire***	0.7	0.7	0.6	0.7	0.0	1.7	11.3	7.0	10	4
Red Knight X3R***	3.1	-	2.2	-	0.0	-	28.7	-	262	-
Avg	**3.0**	**1.0**	**2.4**	**0.7**	**0.0**	**34.7**	**23.2**	**2.7**	**128.1**	**33.4**

Melons

As noted elsewhere in this report, the melon crops in the Supersolo tunnel were less affected by the flooding, herbicide drift and overheating issues encountered in 2014 than were the crops in the adjacent Gothic tunnel. Nonetheless, there were several points in the growing season where growth and development of the melon crops in the Supersolo tunnel appeared to stall for a week or more. The watermelons were exceptionally slow to get established in the high tunnel. None of these problems were observed in the crop grown in the open using standard plasticulture techniques – except for mouse damage which occurred everywhere.

The muskmelons were ready for harvest about 2 weeks earlier in the high tunnels than in the open field trial. By contrast, the watermelon crop grown in the high tunnel actually matured later than the crop grown in the open field. Growth and development of all the melon crops growing in the open field ceased in mid-September following a killing frost. At the final harvest on Sept. 15, the vast majority of the muskmelons in the open field trial were still too immature to be considered marketable (Table 4). By contrast, all of the watermelons in the open field trial had reached a marketable stage of maturity at this point in the growing season. The melon crops growing in the high tunnel were not affected by the frost event on Sept. 12 and continued to grow and yield the occasional fruit through until late September. At the final harvest in the high tunnel (Sept. 25) many of the honeydew melons were still too immature to be considered marketable. There were also a few immature muskmelons, but relatively few immature watermelons.

Over the course of the full growing season, use of the high tunnels accelerated fruit development and increased the marketable yields of some but not all of the muskmelon cultivars. No earliness or yield advantage was observed in the watermelon trial.

Table 4. Productivity of muskmelon and watermelon in a Supersolo high tunnel versus the open field in 2014.

Cultivar	Total yield (kg/m)		Marketable yield (kg/m		% Immature		% Cull		Date of 50% harvest	
	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside
Goddess	5.0	8.6	1.7	4.0	5	46	62	7	Aug-25	Sep-18
Orange Sherbet	3.2	5.5	3.0	0.0	0	98	7	2	Aug-21	Sep-04
Summer Dew	7.4	8.2	4.8	0.0	36	100	0	0	Sep-08	Sep-18
Average	**5.2**	**7.4**	**3.2**	**1.3**	**14**	**81.4**	**23**	**3**	**Aug- 29**	**Sep- 13**
Crimson Sweet	10.0	6.7	9.7	6.1	0	0	3	8	Sep-24	Sep-18
New Yellow Baby	5.8	8.8	4.5	8.3	13	0	10	6	Sep-24	Sep-18
Sugar Baby	5.8	6.7	5.8	4.8	0	0	0	28	Sep-04	Sep-18
Average	**7.2**	**7.4**	**6.7**	**6.4**	**4**	**0.0**	**4**	**14**	**Sep-17**	**Sep--18**

Strawberry

The performance of three cultivars of day-neutral strawberry (Seascape, Albion and Charlotte) and two June-bearing cultivars (Kent and Mira) grown in the Supersolo type high tunnel was compared against the same cultivars grown in the open field. The strawberry cultivars tested are representative of the cultivars preferred by growers across Canada.

As noted elsewhere in this report, none of the strawberry plots grown in 2014 looked good. The plants were very slow to get established in the high tunnel as well as in the open field. From mid-July onwards spider mites became a major pest problem of both the strawberries and raspberries in the high tunnel. Spider mites thrive under hot dry conditions – such as those encountered in late summer within the high tunnels. No corresponding problems with mites were seen in the crops growing in the open field. Spider mites are very difficult to control with pesticides.

The first fruit on the day-neutral strawberries were ready at about the same time (late July) in the high tunnels and in the open field plot. The plants in the open field were not damaged by the frost event on Sept. 12 and continued to flower and produce marketable fruit until late September. The day-neutral plants in the high tunnels stayed productive through late October and only ceased to flower and fruit when hit by a -14C frost event. However, the quality of the fruit produced during the late fall was quite poor.

Damage to the fruit by mice and birds was a problem in the tunnels as well as the open field.

Table 5. Productivity of day-neutral Strawberries in a Supersolo high tunnel versus the open field in 2014

Cultivar	Total yield (kg/m)	
	Tunnel	**Shadow**
Seascape	1.2	0.3
Albion	0.4	0.6
Charlotte	1.1	0.4
Average	0.9	0.4

Although overall fruit yields were quite poor, production of day-neutral strawberries in the high tunnel appeared to provide some yield advantage relative to production in the open field. Seascape and Charlotte were clearly more productive than Albion in the high tunnel – in large part because many of the Albion plants in the high tunnel died without producing any fruit. Although the fruit of Seascape were large and looked very good, their flavour and texture was inferior to Albion.

Day-neutral strawberries are typically grown as annuals but if provided with adequate cold protection they can overwinter. Since the over-wintered plants are already established they can be very productive in their 2nd year. The performance of the day-neutral plants inside the high tunnel and in the open field will be compared in 2015.

While the day-neutral strawberries struggled to get established within the high tunnels, the June-bearing strawberries appeared to thrive. By the end of the growing season, both June bearing cultivars had runnered out to the point where they formed a solid, 1 m wide mat. This stand of plants should be very productive in 2015. By contrast, the June-bearing strawberries planted in the open field were much slower to runner out and they struggled to out-compete the weeds.

Recommendations to Enhance Crop Performance in High Tunnels

Given the range of problems that occurred in the high tunnel tomato trial in 2014 there is much room for improvement in production practices – any or all of which should result in greater yields and better quality.

a) The negative impact of flooding on the health and productivity of horticultural crops is well known. Extra care should be taken to locate high tunnels on high ground and on soils well suited to quick drainage and drying (Fig. 13).
b) Many of the crops produced huge amounts of vegetative growth but few fruit. The huge canopy was prone to diseases and insects and it was difficult to find the fruit buried deep within the canopy. While it is possible to grow cultivars that produce a smaller canopy – they tend to have low yields. It likely makes sense to train crops like the tomatoes up wires. Both the Supersolo and Gothic tunnels have been designed to carry the load of trellised crops –

Fig. 13. Unsuitable location for a high tunnel

but the process of training and pruning the plants is labor intensive. The cost/benefit of growing trellising tomatoes in a high tunnel will need to be more fully explored.

c) The herbicide drift event could have been prevented by better communication with adjacent farming operations. The reason why the crop inside the tunnel was more adversely affected by the herbicide drift than the adjacent check crops growing in the open field could not be definitively determined. It is possible that the tunnels trapped in the spray drift.

d) The problem with overheating in the high tunnels on warm sunny days represents a major management concern. Overheating occurred despite the fact that that the sides of the tunnel were rolled all the way up and the doors were wide open. Part of the problem may stem from the fact that the tunnels were situated at a location completely surrounded by a shelterbelt. When it comes time to replace the covers, purchasing a more opaque plastic might be considered – although this will tend to reduce light levels and therefore slow growth at other times of the year.

e) Insect and disease Issues – the hot, humid and crowded conditions within the tunnel were ideal for the development and spread of insects and diseases. Growers will need to scout their crops regularly and have appropriate control measures on hand.

f) The tunnels provide a sheltered, food rich, predator free environment ideal for mice. Traps were ineffective and chemical controls were not an option. Muskmelons, broccoli, tomato and strawberry appeared to be preferred food sources, whereas damage to watermelon and pepper was infrequent.

This project was supported by the Agriculture Development Fund of Saskatchewan Agriculture and Food.