Potential to double-crop plastic mulch

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Waterer, D., Hrycan, W. and Simms, T. 2008. **Potential to double-crop plastic mulch.** Can. J. Plant Sci. **88**: 187–193. Double-cropping of plastic (polyethylene) mulches has the potential to increase the cost-effectiveness while reducing the environmental impact of this technology for enhancing growth of vegetable crops. In regions with a short growing season, double-cropping of soil mulches hinges on being able to leave the plastic in the field over winter. This extended exposure to the elements may alter the physical and optical characteristics of the mulch, thereby influencing crop productivity in the second year of use. This study evaluated the physical characteristics and efficacy of black, clear and infrared transmitting (IRT) mulches over two cropping seasons in Saskatchewan. The crops planted were pepper (*Capsicum annuum*) and cucumber (*Cucumis sativus*) in the first year and tomato (*Lycopersicon esculentum*) in the second year. Early-season soil temperatures appeared highest under the clear mulch in the first year, but once the crop canopy was established there was little difference in soil temperature among plots having different mulches. Higher yields of both cucumber and pepper were produced in the first year by clear mulch than by black mulch or without mulch. All mulches were still physically sound at the end of the first growing season, but light transmission through the clear and IRT mulches was reduced relative to new mulch. Much of this change was due to soil and other debris on the surface of the mulches. There was little further change in the physical condition or light transmission characteristics of the mulches through the second year of use. Weed growth under clear mulch in its second year appeared to reduce soil temperatures, particularly relative to new clear mulch. Mulch type, either newly laid or year-old, had no impact on yields of marketable tomatoes. More fruit reached full red color prior to harvest in response to clear mulch than to no mulch (bare soil). Yields of marketable tomato fruit obtained on year-old mulch of all types were comparable to yields obtained with new mulch. These data suggest that double-cropping of plastic mulches can be done without loss of crop yield and provide significant savings in materials, labor and disposal costs. While clear mulch was generally the most beneficial for the production of warm season vegetable crops, it did not prevent weed growth in the second year which was problematic.

Key words: Wavelength selective, light transmission, cucumber, pepper, tomato

Waterer, D., Hrycan, W. et Simms, T. 2008. **Possibilité d'une double culture sur le paillis de plastique**. Can. J. Plant Sci. **88**: 187–193. Une culture double sur paillis de plastique (polyéthylène) augmenterait la rentabilité des cultures maraîchères tout en atténuant l'incidence de cette technologie sur l'environnement. Dans les régions à courte période végétative, pareille pratique suppose néanmoins qu'on puisse laisser le plastique au champ durant l'hiver. Une exposition prolongée aux intempéries pourrait cependant modifier les propriétés physiques et optiques du paillis, donc influer sur le rendement de la culture la deuxième année. L'étude devait évaluer les propriétés physiques et l'efficacité des paillis en plastique noir, translucide et émetteur d'infrarouges (EI) pendant deux saisons de croissance, en Saskatchewan. À cette fin, les auteurs ont cultivé du poivron *(Capsicum annuum)* et du concombre *(Cucumis sativus)* la première année, et des tomates *(Lycopersicon esculentum)* la seconde. En début de saison, on a obtenu une température plus élevée du sol avec le paillis translucide, la première année, mais une fois le feuillage développé, la température variait peu entre les parcelles paillées différemment. La première année, le paillis translucide a donné un meilleur rendement en poivrons et en concombres que le paillis noir ou l'absence de paillis. Les paillis étaient encore tous en bon état à la fin de la première saison de croissance, toutefois les paillis translucide et EI laissaient moins passer la lumière que le paillis neuf. Ce changement résulte en grande partie du sol et d'autres débris maculant la surface du paillis. L'état et les propriétés de transmission de la lumière des paillis ne changent pas tellement plus la deuxième année. L'apparition de mauvaises herbes sous le paillis translucide la deuxième année semble réduire la température du sol, surtout comparativement au paillis neuf. Le type de paillis, neuf ou vieux d'un an, n'a aucune incidence sur le rendement de tomates commercialisables. Le nombre de fruits qui rougissent avant la récolte est plus élevé avec le paillis translucide qu'en l'absence de paillis (sol nu). Peu importe le type, le paillis d'un an donne le même rendement en tomates commercialisables que le paillis neuf. Les résultats laissent croire qu'on peut produire deux cultures sur les paillis en plastique sans que le rendement en souffre et avec des économies appréciables de matériaux, de main-d'æuvre et d'élimination. Bien qu'il soit généralement le plus utile pour produire les légumes de saison chaude, le paillis translucide n'empêche pas la croissance des mauvaises herbes la deuxième année, ce qui s'avère problématique.

Mots clés: Sélection de longueur d'onde, transmission de la lumière, concombre, poivron, tomate

Plastic (polyethylene) mulches have the potential to alter soil temperatures, reduce crop water use, improve crop quality and in some cases reduce competition with

Abbreviations: IRT, infrared transmitting mulches; **PAR**, photosynthetically active spectrum weeds, thereby improving crop development and increasing yields (Waterer 1999, 2000; Lamont 2005; Ngouajio and Ernest 2005). Mulch color can influence soil temperatures and weed control, thereby altering crop growth. Black mulch warms the soil by absorbing light then transferring heat by conduction to the underlying soil, provided that the mulch is in close contact with the soil (Tarara 2000; Lamont 2005). As black mulch transmits little light, it also inhibits weed growth. Clear mulch transmits light over a wide range of wavelengths. The transmitted light is absorbed by the soil, resulting in increased daytime soil temperatures. At night, condensation on the underside of the mulch absorbs the longwave radiation emitted by the soil thereby slowing cooling of the soil (Lamont 2005). As clear mulches transmit the majority of light in the photosynthetically active spectrum (PAR), weed growth can be substantial under clear mulch (Waterer 2000). Wavelength selective mulches or infrared transmitting mulches (IRT) absorb a significant component of the light in the PAR range, resulting in substantially less weed growth than under clear mulch. As the wavelength selective mulches are transparent to most other wavelengths, their soil warming characteristics are intermediate between clear and black mulch (Lamont 2005).

There are economical as well as environmental costs associated with using plastic mulches. One method to reduce these costs is to grow more than one crop on the mulch prior to its disposal. In regions with a longer growing season, it may be possible to grow two or more crops on the mulch within a single calendar year (Hanna 2000). In other regions, double-cropping requires the mulch to be over-wintered in the field (Ngouajio and Ernest 2005). Double-cropping of mulches is only practical if the mulch stays intact through the second season and also retains the optical characteristics that benefit the crop. In Michigan, Ngouajio and Ernest (2005) found that after one growing season, soil coverage by wavelength selective IRT-green mulch was reduced as the mulch started to physically breakdown. Gaps in the IRT mulch allowed weed growth and reduced the soil warming effects of the mulch. Light transmission by the IRT mulch was also reduced after the first season in the field, further reducing the soil warming effect of the mulch. Soil warming by black mulch was also reduced in the second season of use because the mulch either broke apart or pulled away from the soil. Ngouajio and Ernest (2005) concluded for all much types tested that crop yields during the second year could be negatively affected by the observed losses in mulch integrity and performance.

In regions like Saskatchewan that have a relatively short and cool growing season, clear plastics tend to be most effective for enhancing development of warm season vegetable crops (Waterer 1999, 2000). The benefits of using clear plastic can be attributed to the greater degree of soil warming achieved with this mulch type, but this benefit can be tempered by excessive weed growth under the mulch. Because application of foliar or soil applied herbicides is not possible under existing mulch, weed control may be particularly problematic when attempting to use clear plastics through a second cropping season.

This study evaluated the potential for double cropping plastic mulches in Saskatchewan. Light transmission characteristics and crop enhancement effects of new and year-old clear, black and IRT plastic mulches were examined over two growing seasons.

MATERIALS AND METHODS

The trial was conducted in 2005 and 2006 at the University of Saskatchewan Horticulture Field Research Station in Saskatoon, Saskatchewan. The site features a Sutherland Series clay soil, which is slow to warm in the spring. Soil tests indicated that the soil contained adequate amounts of all nutrients except nitrogen. The soil was prepared by rotovating prior to laying the mulch. The nitrogen fertilizer required for the first cropping season was incorporated at that time. In the pepper plots, the herbicide trifluralin (Treflan) was applied to the soil surface and incorporated just prior to laying the mulches. No herbicides were used in the cucumber trial. Black, clear and green colored IRT plastic mulches were laid using a mechanical mulch layer 1 wk prior to planting the crops. All plastics were 0.038 mm thick (DuBois Mfg. St-Remi, QC). Control treatments had no mulch applied. Drip irrigation was used to maintain soil water potentials at 15 cm depth above −40 kPa.

Cucumbers (cv. Fanfare) were direct seeded through the mulch on 2005 May 31. Six week old pepper transplants (cv. Whopper Improved) were planted on the same day. The cucumbers were planted 30 cm apart in a single row at the center of the mulch strip. The peppers were planted in twin rows with 30 cm between plants within a row and 30 cm between rows. Each test plot was 5 m long. Mulch treatments were arranged in a randomized complete block design with four replicates. Mulched rows were 2 m apart. Both crops were protected with spunbonded polyester row cover (Reemay, Reemay Inc., Nashville, TN) stretched over hoops from the time of planting through late June. The non-mulched plots were hand-weeded four times over the growing season. No effort was made to control weeds in the mulched plots. Soil temperatures were recorded at a depth of 10 cm every 10 min between plants near the center of the row in one replicate of each of the four mulch types in both crops (Hobo U10 temperature loggers, Onset Computer Corp., Pocasset, MA.)

Mature cucumbers were harvested weekly beginning the first week of August until the first killing frost on 2005 Sep. 19. The peppers were once-over harvested just prior to the frost. Yields of marketable and unmarketable fruit were determined based on local grade standards for required fruit size and tolerances for defects.

Crop residues were not removed from the mulches until 2 wk prior to planting the 2006 crop. Soil tests taken at that time indicated that the only nutrient lacking under the year-old mulch was nitrogen. Four-week-old tomato seedlings (cv. Ultrasonic) were transplanted into the year-old mulch on 2006 Jun. 01. The seedlings were planted 50 cm apart into new holes cut in the mulch rather than attempting to re-use the holes left by the 2005 crops. No crop covers or other methods of microclimate modification were used. The required amount of supplemental nitrogen (50 kg N ha^{-1}) was applied though the drip irrigation system within 2 wk of transplanting. The tomato crop was once-over harvested following the first killing frost (2006 Sep. 21). Fruit were considered to be marketable if they were free of excessive physical defects, greater than 4 cm in diameter and had reached at least the mature green stage of development by the time of harvest.

A parallel trial using new mulch was established adjacent to the year-old mulch plots in 2006. Clear, black and IRT mulches, as well as non-mulched control plots, were established as described for the 2005 trial. The herbicide metribuzin (Sencor) was applied to the new plot area just prior to laying the mulches. Tomato seedlings (cv. Ultrasonic) were transplanted into this trial site on Jun. 04, 3 d after transplanting the year-old mulch trial. This plot was otherwise managed in a manner identical to the year-old mulch trial.

A scanning spectrophotometer (Spectronic GENESYS 6 UV-Vis, Thermo Fisher Scientific Inc., Waltham, MA) was used to compare the light transmission characteristics of new, used and used but then cleaned samples of mulch taken at various intervals over the 2-yr cropping sequence. The mulch samples (ca 144 cm^2) were removed from the center of each row at the end of the first cropping season (4 mo), just prior to planting in the second cropping season (12 mo) and at the end of the second cropping season (16 mo). A 1 $\times$ 5 cm piece of the mulch was placed in the sample chamber of the spectrophotometer and its transmission was evaluated from 190–1100 nm at 5-nm intervals. Three sub-samples taken from each replicate were scanned. These pieces were rescanned after they had been cleaned by being rinsed in water and then wiped with a moistened cloth. The physical integrity of the mulches was also visually assessed at regular intervals over the two cropping seasons.

RESULTS AND DISCUSSION

Growing Conditions

May and June of 2005 were below average for both temperature and sunshine hours. July through September had near-average temperatures but several heavy rain events caused localized flooding in the test plots. The date of the first fall frost (Sep. 19) was near average.

Unusually warm temperatures in late May of 2006 were followed by cool and wet conditions through June. Growing conditions from early July through to the second week in September of 2006 were excellent. The date of the first killing frost (Sep. 21) was near-average for this site.

Crop Health

Both crops tested in 2005 were vigorous and had no apparent insect or disease problems. The tomato crop planted into the year-old mulch in 2006 exhibited significant transplant shock as indicated by slow initial growth and loss of the lower leaves. About 15% of the seedlings died and had to be replaced. This problem occurred on all mulch types, but appeared most severe on the clear mulch. The crop recovered with the onset of favorable growing conditions. Crop health through the remainder of the 2006 cropping season was excellent. No transplanting shock was observed in the adjacent trial involving newly laid mulch. This difference may reflect: (a) the much hotter weather when the seedlings were transplanted in the year-old mulch trial compared with the weather three days later when the crop was transplanted in the new mulch trial, or (b) more soil compaction under the year-old than new mulch, which may have slowed establishment of the seedlings' root systems, rendering the plants more susceptible to heat and moisture stress. Soil compaction under year-old mulch might be less problematic in the lighter-textured soils preferred in commercial vegetable production.

There was minimal weed growth under the IRT and black mulch during the first and second seasons of use. Weeds were slow to establish under the clear mulch during the first cropping season, irrespective of whether herbicides had been applied. By contrast weeds emerged quite quickly in the non-mulched treatments. This suggests that the clear mulch produced conditions that were not immediately conducive to weed development. High temperatures may have suppressed weed germination or may have damaged emerging weed seedlings. The ability of clear mulches to produce soil temperatures high enough to control weeds, plant pathogens and nematodes forms the basis for the soil solarization process (Stapleton et al. 2005). Eventually weeds did establish under the clear plastic but their growth was limited to the small space available between the mulch and the soil surface. The dominant weeds under the clear mulch were common groundsel (*Senecio vulgaris*) and annual sowthistle (*Sonchus oleraceae*). These species were also the dominant weeds in the non-mulched treatments. In the second year of the trial, common groundsel and annual sowthistle were already well established by the time the tomato crop was transplanted into the year-old mulch. It appears that by increasing soil temperatures in the spring, the clear mulch promoted the early and robust development of these weeds. This weed growth was sufficient to lift the clear mulch several centimeter off the soil surface, but did not otherwise disrupt the physical integrity of the mulch rows.

Table 1. Monthly mean soil temperature (°C) over the 2005 growing season under different mulches used in cucumber and pepper crops ($n = 1$)

		Monthly mean soil temperature (°C)				
Mulch	Crop	June	July	August	September	Growing season
Black	Cucumber	20.7	20.5	15.9	7.8	16.4
	Pepper	19.1	21.1	15.7	8.5	16.4
IRT	Cucumber	20.8	21.0	17.3	13.0	18.1
	Pepper	–	–	–	–	–
Clear	Cucumber	21.7	21.3	16.1	10.3	17.4
	Pepper	22.5	23.9	16.9	10.9	18.7
No mulch	Cucumber	19.3	19.9	16.4	12.2	17.1
	Pepper	19.9	19.2	–	–	–

[z] – values missing due to equipment failure.

Soil Temperatures

Year 1. Localized flooding resulted in the loss of some temperature data in the pepper plots. During the periods when measurements were recorded, soil temperatures under the various mulch types appeared comparable for cucumbers and peppers (Table 1). Although air temperatures peaked midway through the growing season, soil temperatures trended lower over the course of the growing season. This likely reflects increased shading of the soil by the developing crops. Early in the growing season, monthly average soil temperatures appeared slightly higher under the clear mulch than under the other mulches (Table 1), but as the season progressed this difference was diminished, likely due shading by the developing crop canopies.

Year 2. In the second year, soil temperatures again trended lower as the growing season progressed. Early in the season, monthly average soil temperatures in the clear mulched plots were higher than in plots with other mulches (Table 2). Later in the season soil temperatures were more similar among the mulched plots. Soil temperatures under year-old black and IRT plastics were generally slightly higher than temperatures under new plastic of the same types (Table 2). This may have resulted from the year-old mulch being in place from the onset of the growing season, thereby providing a longer period for soil warming, especially prior to planting the crop. However, temperatures under year-old clear plastic were considerably lower than under new clear plastic. Weed growth under the year-old clear plastic may have intercepted much of the incoming light preventing it from reaching the soil and leading to lower soil temperatures.

Table 2. Monthly mean soil temperature (°C) over the 2006 growing season under new mulch (new) and mulch in its second season of use (used) ($n = 1$)

		Monthly mean soil temperature (°C)				
Mulch	Mulch condition	June	July	August	September	Growing season
Black	New	18.2	22.9	17.0	12.1	18.8
	Used	19.0	24.3	18.5	13.3	20.1
IRT	New	19.1	22.0	17.4	12.0	19.5
	Used	19.7	24.9	18.3	12.1	20.7
Clear	New	23.0	26.9	19.4	14.1	22.2
	Used	20.0	23.4	19.7	12.0	20.4
No mulch	New	17.4	21.5	16.4	11.6	16.6
	Used	17.8	21.7	17.1	11.4	18.9

Light Transmission Characteristics of the Mulches

Light transmission by the black mulch was minimal ($<1\%$) at all wavelengths tested during both the first and seconds seasons of use (Fig. 1). New clear mulch transmitted substantially more light than did the other mulches (Table 3), including about 20% of light at 200 nm but more than 80% at wavelengths >500 nm (Fig. 1). Clear mulch that was used for a season transmitted far less light than did new mulch (Table 3), with the degree of attenuation appearing fairly consistent across all wavelengths examined (Fig. 2). Washing largely restored the transmission characteristics of the year-old clear mulch, suggesting that the observed attenuation was due to the accumulation of soil or crop residues on the mulch surface. Total light transmission by the clear mulch as measured just prior to planting the crop in the second season of use was somewhat higher than the readings obtained the previous fall (Table 3). Spring rains may have washed away some of the soil and crop residues that were present at the end of the previous cropping season. By the end of the second growing season, light transmission by the clear mulch was only slightly lower than after the first season of use.

New IRT mulch transmitted an average of 13% of the light over the range of 190–1100 nm (Table 3), with little light transmitted in the UV range; about 7% over the PAR range, but about 30% transmission at wavelengths above 800 nm (Fig. 1). After a season of use, the light

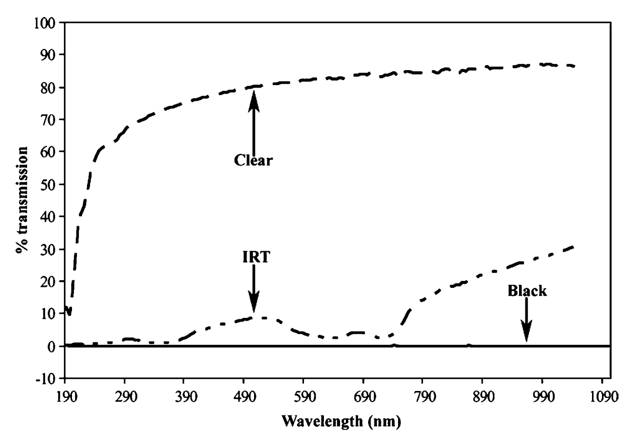

Fig. 1. Light transmission (%) characteristics of new clear, IRT and black plastic mulch.

Table 3. Percentage of light transmission averaged over 190–1100 nm for various mulch types at different times over two cropping seasons

	Season 1 (2005)		Season 2 (2006)			
Mulch	New	Fall	Spring	Spring – washed	Fall	Fall – cleaned
Clear	77	24	36	74	21	73
IRT	13	3	4	10	3	12
Black	<1	<1	<1	<1	<1	<1

transmission of IRT mulch had declined across all wavelengths measured (Fig. 3), resulting in a 4% transmission rate averaged over all wavelengths tested (Table 3). After cleaning, light transmission characteristics of the used IRT mulch were comparable with new material. As with the clear mulch, a second year in the field resulted in little change to the light transmission characteristics of the IRT mulch.

Yields

Cucumber. In the first year, clear mulch produced a higher total marketable yield than did black mulch and bare soil (no mulch) (Table 4). Fruit weights were higher on average from clear mulch than black mulch. Mulch type had no impact on the proportion of fruit that made the marketable grade standard.

Pepper. In the first year of use, clear and IRT mulches produced the highest yields of marketable green pepper fruit, followed by black mulch and no mulch (Table 4). Average fruit weights were highest in response to no mulch, and lowest when black mulch was used. The proportion of the fruit that met market standards was higher in response to the clear and IRT mulches than to black mulch or no mulch. The primary causes of fruit grade out were blossom end rot and sunscald. Few fruit matured to red under any of the treatments.

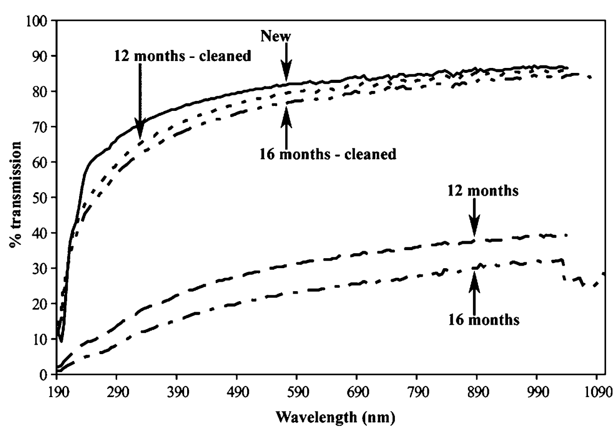

Fig. 2. Light transmission (%) characteristics of clear mulch when new, after 12 and 16 mo in the field, and after cleaning following 12 or 16 mo in the field.

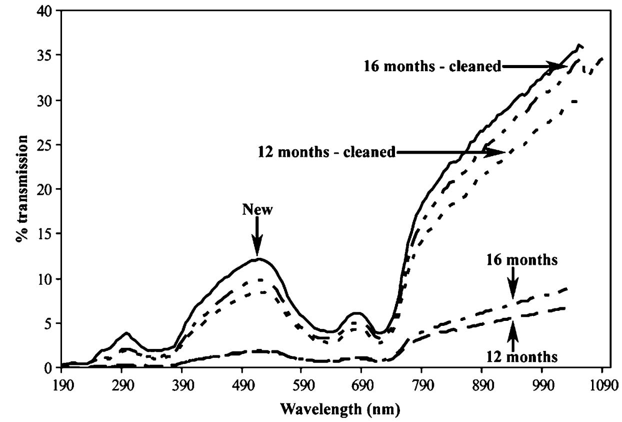

Fig. 3. Light transmission (%) characteristics of IRT mulch when new, after 12 and 16 mo in the field, and after cleaning following 12 or 16 mo in the field.

The greater yields obtained using the clear and IRT mulches indicate the importance of soil warming when producing warm season crops in a region with a cool, short growing season.

Tomato. Mulch type had no effect on marketable tomato fruit yields, irrespective of the age of the mulch (Table 5). Waterer (2001) found that under Saskatchewan growing conditions, tomato showed less yield response to various soil mulches than did other warm season vegetable crops. However, in our trials with the new and used mulch reported here, clear mulch produced more fruit that reached full color development prior to harvest than if no mulch was used. This suggests that development of the tomato crop was enhanced by the greater degree of soil warming provided by the clear mulch. Although statistical comparisons of the effect of mulch age on yields are not possible, marketable fruit yields for the all types of year-old mulch appear comparable with new mulch (Table 5). Although use of the new mulch appeared to improve total fruit yields (data not presented), grade out due to physical defects and disease was also higher in the newly mulched plots. The basis for this difference in grade out could not be determined. Yields of mature red fruit appeared consistently higher from new mulch. For both new and used mulch, average fruit weight from clear mulch was higher than from black mulch.

CONCLUSIONS

Black, clear and IRT mulches all appeared suitable for multi-season use under Saskatchewan growing conditions. Even after two seasons of use, none of the plastics showed any sign of loss of physical integrity. By contrast, Ngouajio and Ernest (2005) observed a significant loss of physical integrity for various types of mulch after only a single season of use in Michigan. As the types and thickness of mulch were similar to those used in this study, this difference may be related to

Table 4. Impact of mulch type on fruit weight and yields for cucumbers and peppers (2005)

	Cucumber			Pepper		
Mulch type	Marketable yield (kg m^{-1} row)	Avg. fruit weight (g)	Marketable %	Marketable yield (kg m^{-1} row)	Avg. fruit weight (g)	Marketable %
Clear	13.4*a*	369*a*	90	12.0*a*	216*ab*	88*a*
IRT	10.3*ab*	367*ab*	87	10.7*ab*	215*ab*	88*a*
Black	9.3*b*	343*b*	89	9.7*b*	206*b*	83*b*
No mulch	8.2*b*	344*ab*	89	7.0*c*	236*a*	83*b*

a–c Values within columns followed by the same letter are not significantly different $P = 0.05$.

Table 5. Impact of mulch type and age on tomato fruit weight and yields (2006)

	New mulch				Year-old mulch			
	Marketable yield (kg m^{-1} row)				Marketable yield (kg m^{-1} row)			
Mulch type	Total	Red	Avg. fruit weight (g)	Marketable %	Total	Red	Avg. fruit weight (g)	Marketable %
Clear	22.0	4.3*a*	123*a*	52*b*	26.4	1.9*a*	108*a*	74
IRT	25.5	3.2*ab*	124*a*	57*ab*	23.3	0.7*b*	80*b*	79
Black	20.6	2.1*ab*	105*b*	61*a*	21.6	0.7*b*	82*b*	70
No mulch	20.9	1.9*b*	111*ab*	58*ab*	23	0.2*b*	93*ab*	76

a, b Values within columns followed by the same letter are not significantly different $P = 0.05$.

differences in temperature, snow cover or UV intensity between the two test sites. The clear and IRT mulches provided the greatest benefit to crop yields during the relatively short and cool growing seasons characteristic of Saskatchewan. This yield response likely reflects the greater enhancement of soil temperatures provided by these mulches (Lamont 2005). Accumulation of soil and crop debris on the surface of the clear and IRT mulches appeared to reduce the soil warming potential of these mulches in their second season of use. This limitation might be addressed either by developing a means of cleaning the mulch prior to replanting or by growing crops with lower optimum soil temperatures on year-old mulch. Despite the degradation in performance of the clear and IRT mulches that occurred with time, both mulches were still more effective at enhancing soil temperatures than the black mulch that is presently used by most growers.

Recropping into year-old mulch may require some changes in agronomic practices. Fertilizing in the second year will be restricted to materials that can be added through the drip irrigation system or to the foliage. Soil compaction may be a problem under year-old mulches, especially on fine-textured soils. Weed growth also had the potential to become problematic under the clear mulch, especially during the second season of use. There may be some potential to apply herbicides through the drip irrigation system, but the effective zone of weed control would likely be limited to the area directly under the drip line. Opting to plant a fast-growing crop with a sprawling growth habit as the second crop on clear mulch may help mitigate weed problems during double-cropping of clear mulch.

Replanting into existing mulch would save the direct cost of the mulch, reduce labor for installation and removal of the mulch, and reduce fees for disposal of used mulch. Having mulch from the previous season already in place may have additional benefits. Crops planted early may benefit from the earlier availability of the prepared field and the enhancement of soil temperatures that begins as soon as the snow melts. Having the mulch already in place also reduces the spring work load and avoids delays from heavy soils and/or excessive spring moisture preventing the field preparation required before new mulch can be laid.

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