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EFFECT OF THE USE OF COLOURED PLASTIC MULCHES ON GROWTH, YIELD COMPONENTS, AND FRUIT QUALITY OF LE-CONTE PEAR TREES

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ABSTRACT: ***The effect of the use of transparent, white, silver, red, and black polyethylene mulch sheets, compared with unmulched (control), on Le-Conte pear (Pyrus communis L.) tree growth, yield components, and fruit quality attributes was studied in a randomized complete block design during the 2006 and 2007 seasons. Sixteen-year-old pear trees were grown in a sandy soil and drip-irrigated. Temperature was recorded 10 cm above soil surface and 10 cm below plastic sheets twice daily at 9.00 AM and 2.00 PM. Data were recorded on foliage characters (number of leaves/shoot, leaf area, leaf chlorophyll content, shoot length, increment of trunk cross-sectional area (TCSA) and leaf N, P and K content), yield components (fruit set percentage, retained fruits percentage, and number of fruits/tree), and fruit quality attributes (fruit weight, size, dimensions, firmness, soluble solid concentration (SSC), titratable acidity (TA), and skin colour). By far, the black plastic mulch treatment was significantly more effective in improving all characters measured than most treatments tested. It was followed closely by, and sometimes not significantly different from, the silver mulch treatment; while the bare, uncovered soil was the least in all characters measured. For instance, the three treatments black plastic, silver plastic and control had the following values, respectively, for some representative characters : increments in TCSA 18.5%, 17.6% and 9.5% in 2006 and 19.9%, 18.8% and 10.18% in 2007; number of fruits per tree 1533, 1367, and 750 fruits in 2006 and 1629, 1456, and 850 in 2007 fruits; and fruit weight 160.0, 103.2, and 96.4 g in 2006 and 175.3, 161.2 and 123.0 g in 2007. These effects of various soil mulches were nearly closely associated with respective relative increases in air and soil temperature, while temperature increases were generally higher in soil than in air, at 2.00 PM than at 9.00 AM, and late in the season than in its beginning.***

Black plastic mulch was recommended for use in Le-Conte pear tree culture in sandy soil under drip-irrigation system.

Key words : ***Pears, Pyrus communis, fruit quality, coloured plastic mulch, trunk cross-sectional area.***

INTRODUCTION

The application of soil plastic mulch has become a common cultural practice for yield and quality improvement of agricultural crops. Also, plastic mulch prevents soil moisture loss through surface evaporation and prevents salt accumulation on soil surface as they move along with evaporating water to edges of plastic cover far away from most of the surface roots. Additionally, plastics which prevent transmittance of photosynthetic active radiation, e.g., black plastic, control weeds (Davis, 1975).

Young pear trees grown in black plastic-covered soil were more vigorous in vegetative growth and had more flowers than unmulched plants. Leaf N and chlorophyll a and b content were also higher (Frimanslund, 1984). The use of black plastic mulch increased pear shoot length, number of leaves per shoot, fruit set percentage, fruit yield and fruit dimensions, and weight and number of seeds per fruit than in control unmulched trees (Saeid *et al.,* 1993). Both black polyethylene plastic mulch and rice straw mulch increased shoot growth, fruit set percentage, yield, and fruit quality characters; i.e., weight, dimensions, soluble solids concentration (SSC) and titratable acidity (TA) of Le-Conte pears (El-Seginy, 2000). The use of 'Extenday', a commercial reflective mulch produced by a NewZealand company, with 'Clara Frijs' pear trees improved fruit size and yield, but had no significant effect on the rate of fruit maturation, firmness, SSC, starch degradation and colour. Also, trees from the 'Extenday' treatment were found to have twice as many flower buds as the control trees (Bertelsen, 2005).

The use of 80 µm black polyethylene film mulch with 'Granny Smith' apple on M.9 had positive effects on tree growth, trunk growth and yield. Yield varied from 40 to 70 t/ha with mulching and 35 to 50 t/ha with bare soil. Mulching had little effect on fruit flavour but gave higher commercial yields of fruits of 65-70 mm diameter (Guiheneuf, 1985). Apple yield was significantly higher under black plastic relative to unmulched control treatment. Leaf N and Mg concentrations were usually significantly higher under black plastic, while leaf P and K were consistently higher. Also, leaf Ca and Zn were occasionally higher in the unmulched control (Neilsen *et al.,* 1986). Likewise, yield of 'Granny Smith' apple on M.9 with plastic mulch exceeded that in bare soil by 30% (Guiheneuf, 1988). Plastic mulch significantly increased apple tree trunk cross-sectional area (TCSA), yield and fruit size (Minarro and Dapena, 2003).

Likewise, the use of black or white plastic mulch increased fruit dimensions and weight of 'Methly' plum than in control trees, but they had no significant effect on fruit SSC and TA (Mokhtar *et al.,* 1993). White, reflective mulch was used as ground cover between apple trees from full blossom to the end of the harvest period. The treatment produced significant increases in fruit number and harvest weight but no significant effects on size grading or colouring. The light reflected from the mulch increased available photosynthetic active radiation in the lower canopy. The canopy structure

was altered and provided more flower buds and subsequently more fruit (Grout *et al.,* 2004).

The use of plastic mulch improved grapevine root development and increased the number of fibrous roots (Mikhalake, 1987). Also, the use of black plastic mulch significantly increased grapevine stem and branch diameters and yield relative to these measures in control vines (Ibarra-Jimenez *et al.,* 1996). Covering the ground around vines with plastic film improved yield and quality of grapes (Shen *et al.,* 2003).

In cucurbits, black plastic mulch enhanced earliness of winter squash (Rulevich *et al.,* 2003). Watermelon early vine growth was longer and yield was higher with different coloured plastic mulches than with the bare-ground treatment. Higher yields were due to higher fruit number per unit area. Meanwhile, coloured plastic mulch treatment had no effect on fruit weight, length, diameter, and SSC (Andino and Motsenbocker, 2004).

MATERIALS AND METHODS

This study was conducted in a private farm located at Km 76 of Cairo/Alexandria desert road during the 2006 and 2007 seasons. Sixteen-year-old 'Le-Conte' pear (*P. communis*) trees grafted on *P. communis*, grown in sandy soil, and planted 4 × 6 m apart were used in the study. Trees were selected for homogenity in growth, and different trees were used in the two seasons.

Five plastic soil mulch treatments were applied, viz., transparent, white, silver, red, and black polyethylene. The control treatment was bare soil. Plastic sheets used were 80µ thick. Plastic mulch treatments covered a 2 × 4 m area around each tree trunk.. Treatments were applied starting from 24th and 17th of January in 2006 and 2007 seasons, respectively.

A randomized complete block design with three replicates was used. Each experimental unit consisted of one tree.

Temperature was recorded twice daily at 9.00 AM and at 2.00 PM. At each recording, temperature was taken nearby tree-trunk 10 cm above and 10 cm below soil surface in both seasons, but soil temperature was not recorded in bare soil. Average weekly temperature was calculated for graphing.

Experimental plots were closely watched for earliness of flowering, and harvest maturity in both seasons.

Tree measurements were made on 10 nearly similar 2-year-old branches around each tree in both seasons. Data were recorded on : (a) number of leaves/shoot during July, (b) leaf area during August using a CL 203 Area Meter (CID, Inc., U.S.A) based on measurements

recorded on 10 leaves, (c) leaf chlorophyll during Aug. using a SPAD 502 chlorophyll meter (Minolta Corporation, Ramsy, NJ, U.S.A) based on readings recorded on 10 leaves as above, (d) shoot length in Aug., (e) increments in trunk cross-sectional area (TCSA) between February and August, (f) percentage of fruit set, (g) percentage of retained fruits in July to total fruit set in May and (h) number of fruits per tree.

Fruit measurements were conducted on 5 harvested fruits/experimental unit and included fruit weight, size, firmness using a pressure tester with a ¼ inch plunger (catalytic Generators, Inc., Norfolk, VA, U.S.A), polar and equatorial dimensions, soluble solids concentration (SSC) using a hand refractometer, titratable acidity (TA) as percent of malic acid (A.O.A.C, 1975), and fruit colour according to the colour chart of the Royal Horticultural Society, London (Robert and Wilson, 1938).

Leaf nutrient analysis included N by the Kjeldahl digestion method as described by Jackson (1973), P using the ammonium molybdate method as described by Trough and Mayer (1949), and K using wet digestion (Piper, 1950) and the flame photometer method according to Brown and Lilleland (1946). Leaf samples were collected for chemical analysis in late Aug. of both seasons. Each sample consisted of 30 leaves/tree taken from the middle of branches. Leaves were washed several times with tap water, rinsed with distilled water, and then dried at 70^{o}C to a constant weight. Dried leaves were ground in a stainless steel rotary mill, screened through 20 mesh screen, and 0.5 g dried samples were taken for analysis.

Data obtained were statistically analyzed, and mean separation was according to the L.S.D. test (Steel and Torrie, 1981).

RESULTS

Air and soil temperature :

The effect of various plastic mulch treatments on air temperature (10 cm above plastic) and soil temperature (10 cm below plastic) at 9:00 AM and 2:00 PM is presented in Fig. 1-2 for the 2006 season and Fig. 3-4 for 2007.

At 9:00 AM temperature was nearly similar among all treatments in the early season from late February to early March, but treatments started to show some differences thereafter, as the black and, to a lesser extent, the silver mulch treatments slightly increased air temperature. These differences in air temperature were particularly evident beginning from June in both seasons. Wherever differences were noticed in air temperature, the control temperature, i.e., bare soil, had the least temperature. These differences were observed in both seasons (Fig. 1A and Fig. 3A).

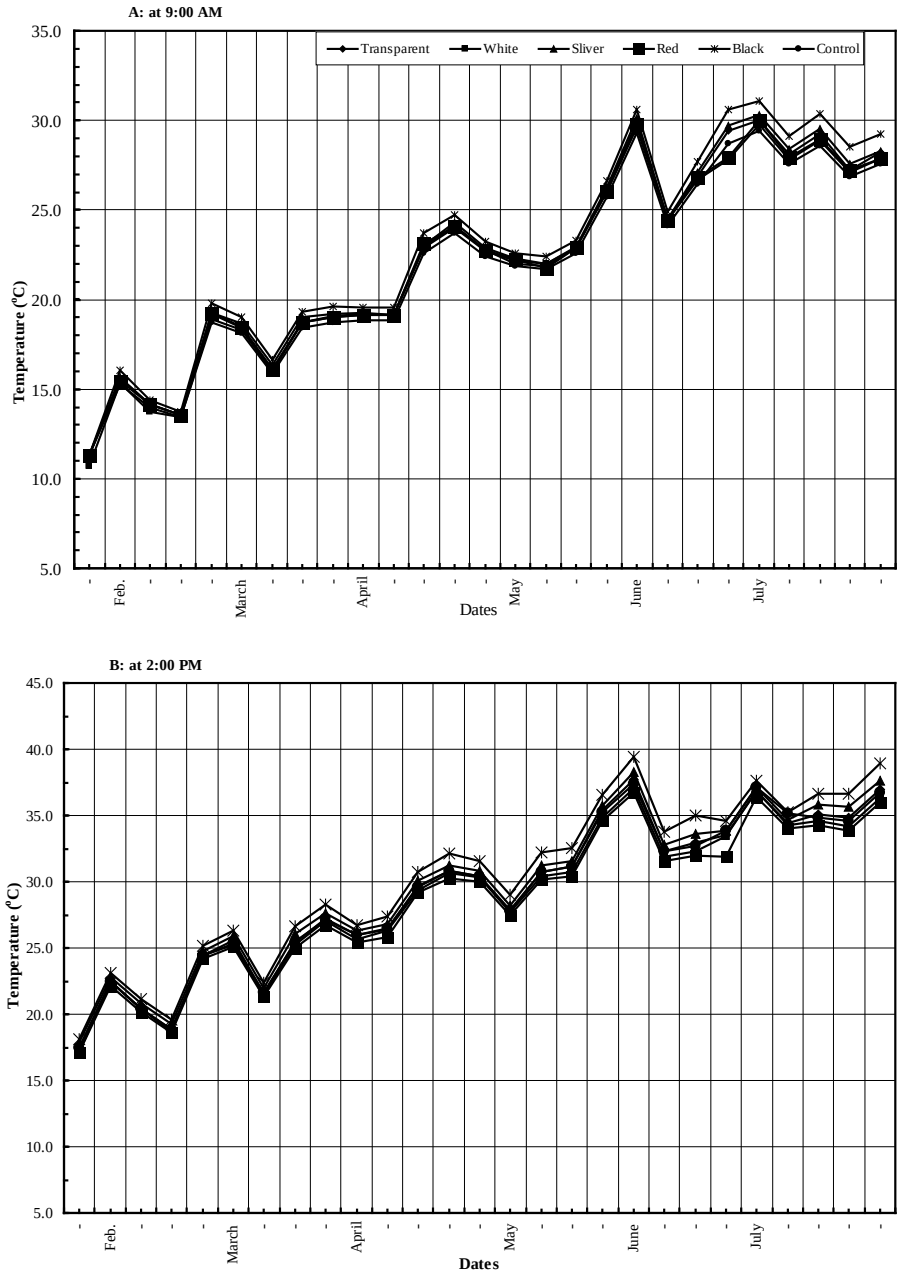

Fig.1: Effect of plastic mulch on air temperature 10 cm above plastic mulch at (A) 9:00 am and (B) 2:00 pm during the 2006 season.

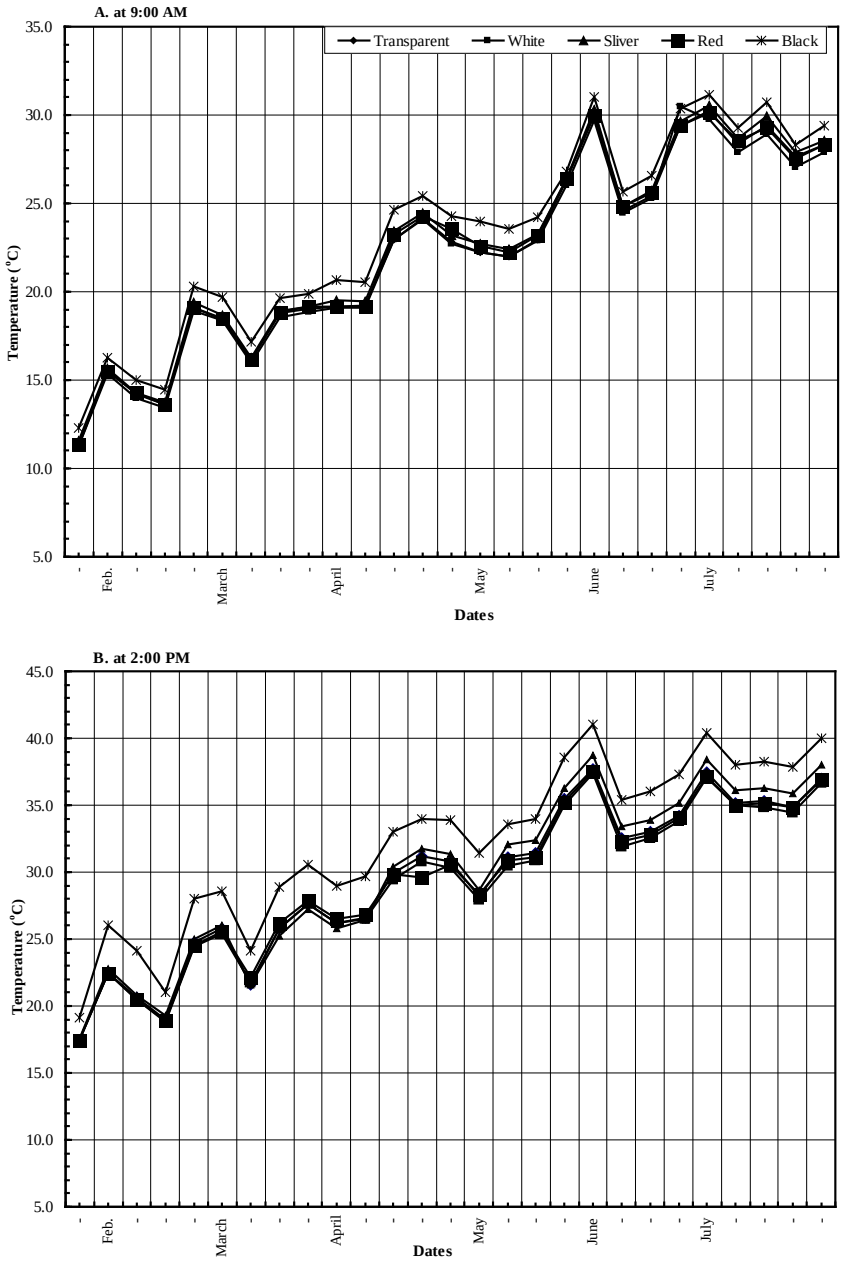

Fig.2: Effect of plastic mulch on temperature 10 cm below soil surface at (A) 9:00 am and (B) 2:00 pm during the 2006 season.

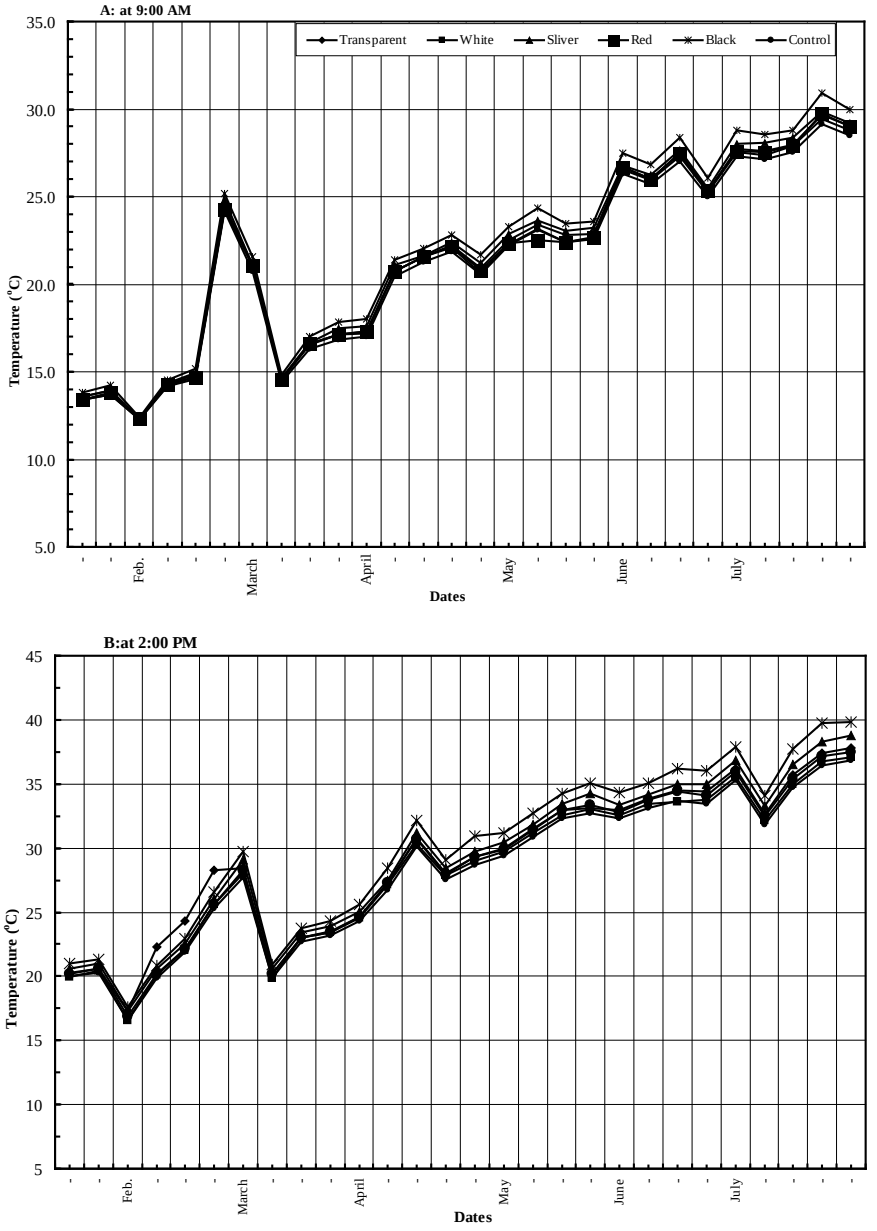

Fig.3: Effect of plastic mulch on air temperature 10 cm above plastic mulch at (A) 9:00 am and (B) 2:00 pm during the 2007 season.

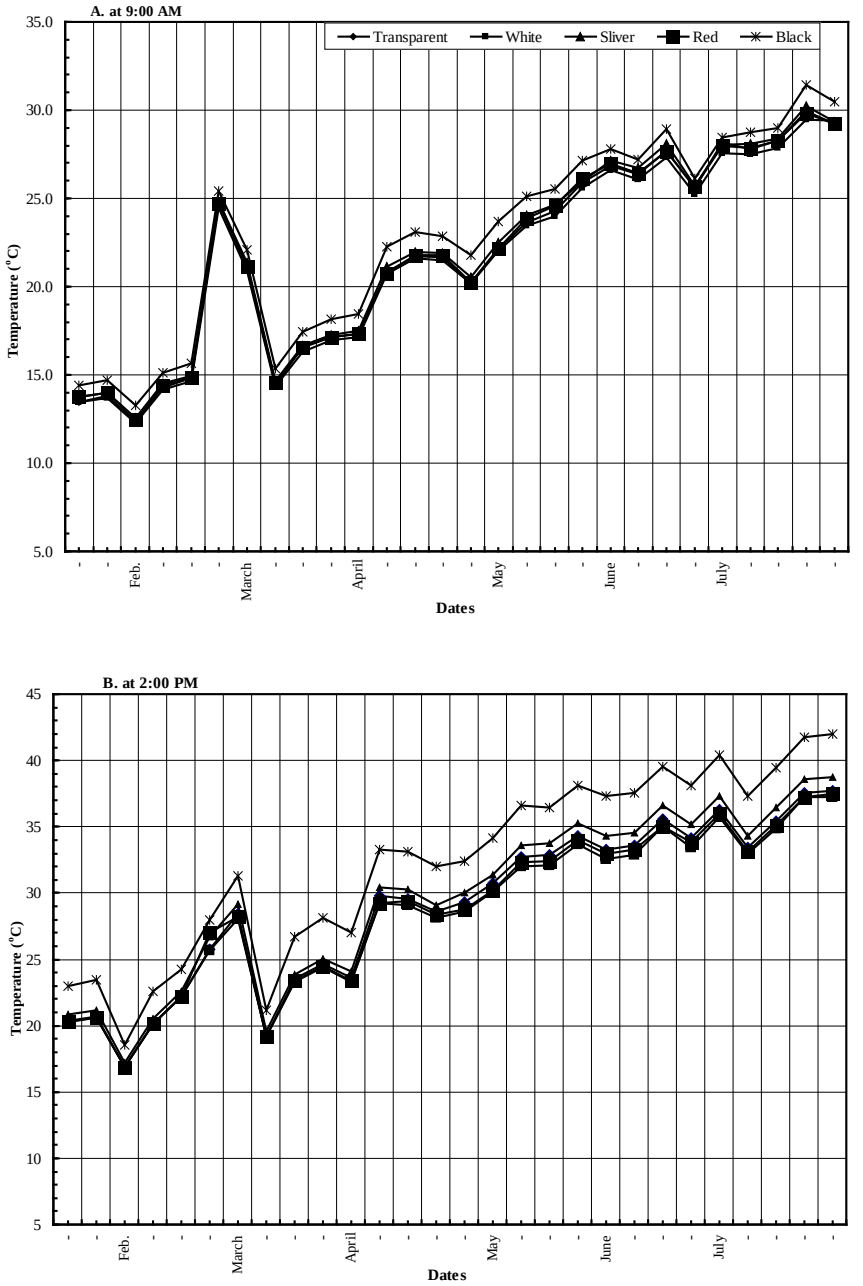

Fig.4: Effect of plastic mulch on temperature 10 cm below soil surface at (A) 9:00 am and (B) 2:00 pm during the 2007 season.

Trend noticed in air temperature at 2.00 PM was similar to that noted at 9:00 AM, but with earlier and greater differences. Black and, to a lesser extent, silver mulch treatments had greater effects on increasing air temperature at 2:00 PM than at 9:00 AM. These effects were evident beginning from early season, though they increased as the season advanced (Fig. 1B and Fig. 3B).

Temperature recorded 10 cm below soil surface under various plastic mulch colours tended to be highest under black plastic, followed mostly under silver mulch, while it was mostly lowest under red and white plastic. This trend in the effect of plastic mulch on soil temperature was greater and easily noticed from the beginning of the season at 2:00 PM (Fig. 2 B and Fig. 4B) than at 9:00 AM (Fig. 2A and Fig. 4A).

Leaf measurements and leaf chlorophyll content :

Treatments applied had a significant effect on leaf characters measured, with the black mulch treatment being significantly the highest, and the control treatment the least in number of leaves/shoot, leaf area, and leaf chlorophyll content in both seasons (Table 1).

While the black plastic mulch treatment resulted in the highest number of leaves/shoot (88 and 91 leaves in the 2006 and 2007 seasons, respectively), it was not significantly different from transparent plastic in both seasons and from silver and red mulch treatments in 2006. Also, the control treatment which had the least number of leaves/shoot (50.2 and 53.3 leaves in the two seasons, respectively) was not significantly different from the white mulch treatment in 2006. Other treatments were intermediate in this character.

Black mulch was significantly the largest in leaf area (40.8 and 42.3 cm^2, respectively, in 2006 and 2007), though it was not significantly different in this regard from the silver mulch treatment in both seasons. Control treatment which was the smallest in leaf area (30.8 and 33.7 cm^2 in both seasons, respectively) was not significantly different from the white mulch treatment in both seasons and from transparent and red mulch treatments in 2007. Intermediate leaf area values were obtained in other treatments.

Leaf chlorophyll content followed, in 2006, a trend similar to that of number of leaves/shoot in the same year. In 2007, black plastic mulch was the top treatment in leaf chlorophyll content (56.4 SPAD reading), while the control, which was the least in this regard (49.5 SPAD reading), was not significantly different from the white mulch treatment. Leaf chlorophyll readings were intermediate in other treatments (Table 1).

Table (1) : Effect of plastic mulch colour on leaf number/shoot, area, and chlorophyll content of Le-Conte pear trees.

Plastic mulch	Number of leaves/shoot		Leaf area (cm^2)		Chlorophyll (SPAD reading)	
	2006	2007	2006	2007	2006	2007
Transparent	76.0	91.7	35.3	36.7	57.7	53.2
White	66.4	73.7	31.4	35.0	51.7	50.5
Silver	78.8	82.3	36.7	41.0	57.7	54.3
Red	73.8	71.7	35.6	36.0	53.6	51.6
Black	88.0	91.0	40.8	42.3	58.6	56.4
Control (bare soil)	50.2	53.3	30.8	33.7	50.1	49.5
L.S.D. 0.05	17.5	5.7	4.3	3.1	2.0	1.9

Shoot and trunk growth :

Once again, black plastic mulch treatment was significantly the highest, and control treatment the least in shoot length and increments in TCSA in both seasons (Table 2).

Shoot length was longest in black plastic mulch treatment and measured 85.0 and 101.7 cm in 2006 and 2007, respectively, but it was not significantly different from shoot length in the transparent and silver mulch treatments in 2006, while the control treatment was significantly the least in shoot length (65.0 and 71.7 cm in both seasons, respectively), other treatments resulted in intermediate values.

Results obtained on the effect of plastic mulch colour on the increment in TCSA was clear-cut and similar in trend in both seasons. Black plastic mulch resulted in the largest increments (18.5% and 19.9% in 2006 and 2007, respectively), followed in a significant descending order by silver, transparent, red, and white plastic mulches, while the control treatment was significantly the least in this character (9.5% and 10.8% in both seasons, respectively; Table 2).

Table (2) : Effect of plastic mulch colour on shoot length and increments in trunk cross-sectional area (TCSA) of Le-Conte pear trees.

Plastic mulch	Shoot length (cm)		Increment in TCSA (%)	
	2006	2007	2006	2007
Transparent	81.7	88.3	16.7	17.5
White	73.3	79.0	11.6	12.3
Silver	82.7	90.0	17.6	18.8
Red	76.7	82.7	14.8	15.6
Black	85.0	101.7	18.5	19.9
Control (bare soil)	65.0	71.7	9.5	10.8
L.S.D. 0.05	5.5	4.0	0.018	0.019

Leaf NPK analysis :

Treatments applied had significant effects on leaf NPK analysis in both seasons. Black plastic mulch resulted, by far, in the highest significant NPK analysis while the control treatment was the least in this regard, but it was not significantly different from the white mulch treatment in P content in 2006 and in K content in 2007 (Table 3).

Differences in leaf N analysis were clear-cut and consistent in both seasons. Black plastic mulch, which resulted in the highest significant leaf N content (2.76% and 2.89% in 2006 and 2007 seasons, respectively), was followed in a significant descending order, by silver, transparent, red, and white mulches; while the control treatment resulted in the least leaf N content (1.55% and 1.68% in the two seasons, respectively).

While the black plastic mulch resulted in the highest significant leaf P content (0.23 and 0.25% in the two seasons, respectively), and the control treatment in the least content (0.15 and 0.13%, in both seasons, respectively), other treatments were intermediate with a slight overlapping of significance.

Leaf K analysis showed a trend similar to that of leaf N analysis in response to mulch treatments, with the exception which was previously mentioned, i.e., the control treatment resulted in leaf K content in 2007 (0.85%) not significantly different from that obtained in the white mulch treatment (Table 3).

Table (3) : Effect of plastic mulch colour on leaf NPK analysis (%) of Le-Conte pear trees.

Plastic mulch	N		P		K	
	2006	2007	2006	2007	2006	2007
Transparent	2.50	2.70	0.18	0.20	0.95	1.08
White	1.82	1.96	0.16	0.17	0.83	0.86
Silver	2.63	2.75	0.20	0.22	1.08	1.20
Red	1.95	2.20	0.17	0.19	0.86	0.90
Black	2.76	2.89	0.23	0.25	1.20	1.40
Control (bare soil)	1.55	1.68	0.15	0.13	0.81	0.85
L.S.D. 0.05	0.018	0.019	0.020	0.021	0.018	0.022

Yield components :

To start with, various plastic mulch treatments, relative to the unmulched control, were in both seasons nearly one week earlier in the beginning of flowering (Feb. 20 and Feb. 23 for mulched treatments in the two seasons, respectively, relative to Feb. 27 and March 1 in the control) and the beginning of harvest maturity (July 20 and July 22 for the mulched treatments in the two seasons, respectively, relative to July 27 and July 30 in the control).

Yield components measured, viz., percentages of both fruit set and retained fruits and number of fruits per tree, were significantly affected by the mulch treatments, with the black plastic being significantly the top treatment and the control being significantly the least treatment in all characters measured (Table 4).

Fruit set percentage ranged in the two seasons, respectively, from 3.6% and 4.0% in the control treatment to 8.6% and 9.0% in the black plastic mulch treatment. Other treatments were intermediate in their effect on fruit set percentage with silver mulch being significantly the second highest and the white mulch the second lowest in their effects.

The percentage of retained fruits followed a trend similar to that of fruit set percentage in response to plastic mulch treatments. Values of percentage of retained fruits ranged from 44.7% and 45.2% in the control treatment to 82.0% and 88.1% in the black plastic mulch treatment in 2006 and 2007, respectively.

In accordance with percentages of fruit set and retained fruits, the number of harvested fruits per tree was significantly the highest (1533 and 1629 fruits/tree in 2006 and 2007, respectively) and significantly the least in the control treatment (750 and 850 fruits per tree in the two seasons, respectively). In both years, silver plastic mulch treatment was significantly the second highest, while the white mulch treatment was the second lowest treatment in number of fruits harvested per tree (Table 4).

Table (4) : Effect of plastic mulch colour on fruit set, retained fruits and number of fruits per tree of Le-Conte pear trees.

Plastic mulch	Fruit set (%)		Retained fruits (%)		No. of Fruits/tree	
	2006	2007	2006	2007	2006	2007
Transparent	6.5	7.0	66.0	74.5	1237	1300
White	5.5	5.9	57.3	60.7	1067	1107
Silver	7.8	8.2	69.4	76.0	1367	1456
Red	5.6	6.3	60.0	62.0	1100	1200
Black	8.6	9.0	82.0	88.1	1533	1629
Control (bare soil)	3.6	4.0	44.7	45.2	750	850
L.S.D. 0.05	1.4	0.2	3.7	6.8	161.4	72.7

Fruit quality attributes :

Fruit weight, size, and dimensions were significantly affected by the mulch treatments. The black plastic mulch was significantly the top treatment in each of these characters and the control was significantly the lowest (Table 5).

Table (5) : Effect of plastic mulch colour on fruit weight, size and dimensions of mature fruits of Le-Conte pear trees.

Plastic mulch	Weight (g)		Size (cm^3)		Polar diameter (cm)		Equatorial diameter (cm)	
	2006	2007	2006	2007	2006	2007	2006	2007
Transparent	124.7	142.0	124.4	142.8	8.0	7.7	5.8	6.4
White	103.2	129.7	112.2	130.0	7.1	7.3	5.6	6.1
Silver	136.3	161.2	134.4	159.3	8.0	7.9	5.9	6.4
Red	110.2	135.2	106.7	135.2	7.2	7.6	5.4	6.1
Black	160.0	175.3	160.0	175.3	8.1	8.3	5.9	6.5
Control (bare soil)	96.4	123.0	100.0	128.9	7.0	7.5	5.3	5.8
L.S.D. 0.05	8.4	10.6	7.8	19.0	0.48	0.55	0.35	0.45

Fruit weight ranged from 96.4 and 123.0 g in the control treatment to 160.0 and 175.3 g in the black plastic mulch treatment in 2006 and 2007, respectively. The silver plastic mulch had the second highest values, followed by the transparent mulch in both seasons. The red mulch was not significantly different from the white in fruit weight, and the latter treatment was not significantly different from the control treatment in this character in both seasons.

Fruit size followed a nearly similar trend, as it ranged from 100.0 and 128.9 cm^3 in the control to 160.0 and 175.3 cm^3 in the black plastic mulch treatment in both seasons, respectively. However, some overlapping of effect occurred among some treatments. In 2006, silver mulch was significantly the second highest in fruit size and transparent mulch the third, while white and red mulch occupied the fourth position, with the latter being not significantly different from the control. In 2007, silver mulch was neither significantly different from black mulch, nor from the transparent which was significantly the second highest treatment in fruit size. However the latter treatment was not significantly different in its effect on fruit size from the remaining treatments, including the control.

Considerable overlapping occurred in fruit dimensions among treatments. Black plastic mulch treatment which was the top one in polar diameter (8.1 and 8.3 cm in 2006 and 2007, respectively), was not significantly different in this character from silver mulch treatment in both years and from transparent mulch in 2006. Likewise, control treatment which was the least one in polar diameter (7.0 and 7.5 cm in the two seasons, respectively) was not significantly different from white and red mulches in this character in 2006 and from all other treatments in 2007. Meanwhile, black plastic mulch which was the top treatment in equatorial fruit diameter (5.9 and 6.5 cm in 2006 and 2007, respectively) was not significantly different from all other characters except the control treatment (5.3 and 5.8 cm in 2006 and 2007, respectively) in both seasons and the red mulch treatment in 2006 (Table 5).

Fruit firmness was the least in the silver mulch treatment in 2006 (18.4 lb/inch^2). In that season, transparent mulch was neither significantly different in this character from the silver mulch treatment, nor from all other treatments which were the highest in fruit firmness, but were not significantly different from each other. A nearly opposite trend was obtained in 2007, with the silver mulch being the top treatment in fruit firmness.

The SSC was highest in fruits of the black plastic mulch treatment (12.0% and 13.0% in 2006 and 2007, respectively), and was least in the control treatment (10.3% and 11.0% in both seasons, respectively). However the black plastic mulch treatment was not significantly different in SSC from all other treatments in 2006 and from transparent and red mulches in 2007.

While fruit TA was not significantly different among treatments in 2006, the control treatment was highest in this character in 2007 (0.35%), while the silver mulch was the least (0.24%), though the latter treatment was not significantly different from transparent and black plastic mulch treatments.

The effect of mulch treatment on fruit skin colour was nearly consistent between the two seasons. Transparent and black plastic were nearly equal in their effect on skin colour, as fruits of both treatments were chartreuse green levels 663/3, 663/1, respectively in 2006 and level 663/2 for both in 2007. Likewise, fruits of both white and red plastic mulch treatments were sap green level 62/3 in 2006 and level 62/2 in 2007. The effect of silver mulch treatment was consistent in the two seasons as fruits were pea green level 61/3 in 2006 and 61/2 in 2007. Meanwhile, fruits of the control treatment were POD green levels 061/2 and 061/1 in 2006 and 2007, respectively (Table 6).

Table (6) : Effect of plastic mulch colour on firmness, soluble solids concentration SSC content, titratable acidity and colour of mature fruits of Le-Conte pear trees.

Plastic mulch	Firmness (lb/inch^2)		SSC (%)		Titratable acidity (%)		Skin colour	
	2006	2007	2006	2007	2006	2007	2006	2007
Transparent	19.4	18.9	10.7	13.0	0.33	0.24	Chartreuse Green 663/3 part II page 90	Chartreuse Green 663/2 part II page 90
White	20.4	17.7	10.7	12.2	0.34	0.27	Sap Green 62/3 part II page 62	Sap Green 62/2 part II page 62
Silver	18.4	19.2	11.3	12.0	0.29	0.24	Pea Green 61/3 part II page 61	Pea Green 61/2 part II page 61
Red	20.8	17.6	11.0	12.7	0.34	0.26	Sap Green 62/3 part II page 62	Sap Green 62/2 part II page 62
Black	20.4	16.9	12.0	13.0	0.32	0.25	Chartreuse Green 663/1 part II page 90	Chartreuse Green 663/2 part II page 90
Control (bare soil)	20.8	17.0	10.3	11.0	0.33	0.35	POD Green 061/2 part II page 120	POD Green 061/1 part II page 120
L.S.D. 0.05	1.6	1.4	1.4	0.52	N.S.	0.02		

DISCUSSION AND CONCLUSION

Differences in temperature among soil mulch treatments were higher for soil (Fig. 2 and 4) than for air (Fig. 1 and 3) temperature, as temperature increased during the season (Fig. 1-4), and at 2:00 PM (Fig. 1B, 2B, 3B and 4B) than at 9:00 AM (Fig. 1A, 2A, 3A, and 4A). Though plastic mulch cover could affect its adjacent air temperature through (a) reflection by silver plastic, (b) transference and conductance from dark plastics especially black, which absorbs light energy of all wave lengths and transfers it to heat energy, and (c) irradiation of far red light energy from heated soil through transparent plastic; such gains in air temperature are easily drained by the slightest air breeze. However heat is captured in the soil under plastic, except for loss of far red radiation energy when transparent plastic mulch is used. The black plastic heats up as it absorbs radiant energy, and transmits this energy to soil where it remains captured under the cover which prevents far red radiation from passing through it to the atmosphere. White mulch is neither heated, nor it permits irradiation to pass through it, but reflects light again into the atmosphere, perhaps with less efficiency than silver mulch. The red mulch reflects only red light, but absorbs light at all other wave lengths.

Such effects of various plastic mulch colours normally increase as temperature increases during the day and during the growing season. Other factors that may affect efficiency of plastic colours in inducing temperature changes are clouds which may prevail more during early season (late Jan. to mid-March) than later, and level of shade provided by tree canopies as season advances (Davis, 1975).

The present results agree with those obtained by Schmidt and Worthington (1998) in their study on watermelon in which accumulated heat units (HU) were mostly significantly higher 10 cm above the mulch surface, at the mulch surface, and at the soil surface under mulch for black than for white over black mulch. Daily mean soil surface heat gain was 3.29 HU higher under black than under white mulch in early season, 6.21 higher in late April and early May, 5.19 higher in late May and June and 4.19 higher in late June through July. Values for soil at 10 cm depth paralleled those for soil surface. Also, Diaz-Perez *et al.* (2005), working on tomatillo (*Physalis ixocerpa*) found that mean root zone temperature was highest under black mulch compared with temperature under gray and silver mulches, and lowest in bare soil.

The present results are in agreement with former studies concerning the superiority of the use of black plastic mulch over bare soil in increasing (a) number of leaves per shoot (Saeid *et al.,* 1993) and leaf chlorophyll content (Frimanslund, 1984) in pears, (b) shoot length in pears (Frimanslund, 1984; Saeid *et al.,* 1993; El-Seginy, 2000), apple (Guiheneuf, 1985), and watermelon (Andino and Mostenbacker, 2004); (c) trunk growth in apple (Guiheneuf, 1985; Minarro and Dapena, 2003) and stem growth in grape (Ibarra-Jimenez *et al.,* 1996); (d) leaf N content in pear (Frimanslund, 1984), apple (Neilsen *et al.,*

1986) and red raspberry (Strik *et al.,* 2006); (e) fruit set percentage in pear (Saeid *et al.,* 1993; El-Seginy, 2000); (f) fruit yield in pear (Saeid *et al.,* 1993; El-Seginy, 2000; Bertelsen, 2005) and apple (Guiheneuf, 1985, 1988; Neilsen *et al.,* 1986; Minarro and Depena, 2003); (g) fruit weight, size, and/or dimensions in pear (Saeid *et al.,* 1993; El-Seginy, 2000), apple (Minarro and Dapena, 2003), and plum (Mokhtar *et al.,* 1993); and (h) fruit firmness, SSC, TA, and/or colour in pear (El-Seginy, 2000; Bertelsen, 2005), and plum (Mokhtar *et al.,* 1993).

According to Kasperbauer and Hunt (1998), a higher far-red photon ratio affects photosynthate allocation and yield of tomato over red mulch than over other plastic mulch colours. However, these effects of red mulch on yield was not noticed in the present study.

Ultraviolet-reflective mulches (metalized aluminum and painted aluminum on white plastic film) increased tomato yield and fruit size in the spring season than in the control black mulch (Csizinszky et al., 1999). These effects on both yield and fruit size were noticed for silver mulch relative to the control in the present study. However, under a different climate, the use of reflective sheet mulching had no significant effect on pear fruit, though it increased photosynthetic rate by approximately 3.2 micro mol CO_2/m^2 per second (Yamamoto and Miyamoto, 2005).

In the present study, white which had no effect on fruit size relative to the unmulched treatment. These results confirm those obtained by Grout *et al.,* (2004) for apple.

The positive effect of the various plastic mulch treatments on growth parameters, which in turn, were reflected on improving yield and fruit quality, especially weight, size, dimensions, and SSC, may be due to various reasons including (a) raising ambient and soil temperature, (b) conserving moisture by preventing surface evaporation and (c) permitting branch roots to grow close to soil surface without injury by cultivation and (d) where these roots benefit from higher nutrient levels and higher soil aeration than in deeper soil (Carolus, 1970). In former studies, the use of plastic mulch improved grapevine root development and increased the number of fibrous roots (Mikhalake, 1987).

The fact that all plastic mulch treatments were, relative to the unmulched control, equal in being one week earlier in the beginning of flowering and harvest maturity indicates that, irrespective of the effect of various plastic mulch treatments on air and soil temperature, they also exert their effects through other mechanisms as those mentioned above.

Reflective mulches, such as silver and white plastics, induce their effects partially through light reflection from the mulch which increases photosynthetic active radiation in the lower canopy with a red: far red ratio close to that of incident light (Grout *et al.,* 2004). In another study, the reflected light has enhanced far-red radiation, which had beneficial effects on both apple fruit-colour and weight. The effect of enhanced far-red radiation

on increased apple fruit weight might had been due to a phytochrome-mediated process affecting dry matter partitioning (Glenn and Puterka, 2007).

In conclusion, the use of black plastic mulch is recommended in drip irrigated Le-Conte pear orchards for the improvement of foliage growth, yield and fruit quality. Plastic sheets should cover most of the ground under canopy. In this study 2 × 4 m sheets were used with 16-year-old trees planted 4 × 6 m apart in sandy soil.

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تأثير استعمال الأغطية البلاستيكية الملونة للتربة علي النمو ومكونات المحصول وجودة ثمار أشجار الكمثرى الليكونت

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درس تأثير استعمال الأغطية البلاستيكية للتربة بألوانها الشفافة والبيضاء والفضية والحمراء والسوداء مقارنة بمعاملة الكونترول بدون غطاء على نمو أشجار الكمثرى الليكونت (*P. communis*) ومكونات محصولها وصفات جودة ثمارها وذلك فى تجربة بتصميم القطاعات العشوائية الكاملة خلال موسمي ٢٠٠٦ ، و ٢٠٠٧ . كانت أشجار الكمثرى بعمر ستة عشر عاماً نامية فى تربة رملية وتروى بالتنقيط وسجلت درجة حرارة الهواء على ارتفاع ١٠سم من سطح التربة ، وحرارة التربة على عمق ١٠سم تحت البلاستيك مرتان يومياً الساعة التاسعة صباحاً والثانية بعد الظهر. وقد درس تأثير المعاملات على صفات النمو الخضرى (عدد الأوراق بالفرع ومساحة الورقة ومحتوى الأوراق من الكلوروفيل وطول الفرع والنسبة المئوية للزيادة فى مساحة مقطع الجذع ومحتوى الأوراق من عناصر النتروجين والفوسفور والبوتاسيوم) ، ومكونات المحصول (نسبة عقد الثمار ونسبة الثمار المتبقية وعدد الثمار بالشجرة) ، وصفات جودة الثمار (وزن الثمار وحجمها وقطريها وصلابتها ومحتواها من المواد الصلبة الذائبة الكلية وحموضتها المعايرة ولون جلدها). أحدثت معاملة البلاستيك الأسود للتربة أكبر زيادة معنوية في جميع الصفات المقيسة عن معظم المعاملات الأخرى. ولقد تلتها في التأثير معاملة البلاستيك الفضي التى لم تختلف معنوياً فى بعض الصفات المدروسة عن معاملة البلاستيك الأسود ، بينما كانت معاملة الكنترول أقلها فى جميع الصفات المقيسة. وعلي سبيل المثال فإن المعاملات الثلاث البلاستيك الأسود والبلاستيك الفضي والكنترول كانت قيمها –علي التوالي – كما يلى فى بعض الصفات : الزيادة فى مقطع الجذع ١٨.٥٪ ، و ١٧.٦٪ ، و ٩.٥٪ فى ٢٠٠٦ ، و ١٩.٩٪ ، و ١٨.٨٪ ، و ١٠.٨٪ فى ٢٠٠٧ ، وعدد الثمار بالشجرة ١٥٣٣ ، و ١٣٦٧ ، و ٧٥٠ ثمرة

فى ٢٠٠٦ ، و ١٦٢٩ ، و ١٤٥٦، و ٨٥٠ ثمرة فى ٢٠٠٧ ووزن الثمرة ١٦٠.٠ ، و ١٠٣.٢ ، و ٩٦.٤ جم فى ٢٠٠٦ ، و ١٧٥.٣ ، و ١٦١.٢ ، و ١٢٣.٠ جم فى ٢٠٠٧ ولقد كانت هذه التأثيرات لمختلف أغطية التربة مصاحبة بزيادات نسبية مماثلة فى حرارة التربة والهواء ، علماً بأن زيادات درجة الحرارة كانت – بصفة عامة – أعلى فى التربة منها فى الهواء ، والساعة الثانية بعد الظهر عنها فى الساعة التاسعة صباحاً ، ومتأخراً فى الموسم عما فى بدايته.

ومن نتائج هذا البحث .. أوصي باستعمال البلاستيك الأسود كغطاء للتربة فى زراعة الكمثرى الليكونت فى الأراضى الرملية تحت نظام الري بالتنقيط.

Table (1) : Effect of plastic mulch colour on leaf number/shoot, area, and chlorophyll content of Le-Conte pear trees.

Plastic mulch	Number of leaves/shoot		Leaf area (cm^2)		Chlorophyll (SPAD reading)	
	2006	2007	2006	2007	2006	2007
Transparent	76.0	91.7	35.3	36.7	57.7	53.2
White	66.4	73.7	31.4	35.0	51.7	50.5
Silver	78.8	82.3	36.7	41.0	57.7	54.3
Red	73.8	71.7	35.6	36.0	53.6	51.6
Black	88.0	91.0	40.8	42.3	58.6	56.4
Control (bare soil)	50.2	53.3	30.8	33.7	50.1	49.5
L.S.D. 0.05	17.5	5.7	4.3	3.1	2.0	1.9

Table (2) : Effect of plastic mulch colour on shoot length and increments in trunk cross-sectional area (TCSA) of Le-Conte pear trees.

Plastic mulch	Shoot length (cm)		Increment in TCSA (%)	
	2006	2007	2006	2007
Transparent	81.7	88.3	16.7	17.5
White	73.3	79.0	11.6	12.3
Silver	82.7	90.0	17.6	18.8
Red	76.7	82.7	14.8	15.6
Black	85.0	101.7	18.5	19.9
Control (bare soil)	65.0	71.7	9.5	10.8
L.S.D. 0.05	5.5	4.0	0.018	0.019

Table (3) : Effect of plastic mulch colour on leaf NPK analysis (%) of Le-Conte pear trees.

Plastic mulch	N		P		K	
	2006	2007	2006	2007	2006	2007
Transparent	2.50	2.70	0.18	0.20	0.95	1.08
White	1.82	1.96	0.16	0.17	0.83	0.86
Silver	2.63	2.75	0.20	0.22	1.08	1.20
Red	1.95	2.20	0.17	0.19	0.86	0.90
Black	2.76	2.89	0.23	0.25	1.20	1.40
Control (bare soil)	1.55	1.68	0.15	0.13	0.81	0.85
L.S.D. 0.05	0.018	0.019	0.020	0.021	0.018	0.022

Table (4) : Effect of plastic mulch colour on fruit set, retained fruits and number of fruits per tree of Le-Conte pear trees.

Plastic mulch	Fruit set (%)		Retained fruits (%)		No. of Fruits/tree	
	2006	2007	2006	2007	2006	2007
Transparent	6.5	7.0	66.0	74.5	1237	1300
White	5.5	5.9	57.3	60.7	1067	1107
Silver	7.8	8.2	69.4	76.0	1367	1456
Red	5.6	6.3	60.0	62.0	1100	1200
Black	8.6	9.0	82.0	88.1	1533	1629
Control (bare soil)	3.6	4.0	44.7	45.2	750	850
L.S.D. 0.05	1.4	0.2	3.7	6.8	161.4	72.7

Table (5) : Effect of plastic mulch colour on fruit weight, size and dimensions of mature fruits of Le-Conte pear trees.

Plastic mulch	Weight (g)		Size (cm^3)		Polar diameter (cm)		Equatorial diameter (cm)	
	2006	2007	2006	2007	2006	2007	2006	2007
Transparent	124.7	142.0	124.4	142.8	8.0	7.7	5.8	6.4
White	103.2	129.7	112.2	130.0	7.1	7.3	5.6	6.1
Silver	136.3	161.2	134.4	159.3	8.0	7.9	5.9	6.4
Red	110.2	135.2	106.7	135.2	7.2	7.6	5.4	6.1
Black	160.0	175.3	160.0	175.3	8.1	8.3	5.9	6.5
Control (bare soil)	96.4	123.0	100.0	128.9	7.0	7.5	5.3	5.8
L.S.D. 0.05	8.4	10.6	7.8	19.0	0.48	0.55	0.35	0.45

Table (6) : Effect of plastic mulch colour on firmness, soluble solids concentration SSC content, titratable acidity and colour of mature fruits of Le-Conte pear trees.

Plastic mulch	Firmness (lb/inch^2)		SSC (%)		Titratable acidity (%)		Skin colour	
	2006	2007	2006	2007	2006	2007	2006	2007
Transparent	19.4	18.9	10.7	13.0	0.33	0.24	Chartreuse Green 663/3 part II page 90	Chartreuse Green 663/2 part II page 90
White	20.4	17.7	10.7	12.2	0.34	0.27	Sap Green 62/3 part II page 62	Sap Green 62/2 part II page 62
Silver	18.4	19.2	11.3	12.0	0.29	0.24	Pea Green 61/3 part II page 61	Pea Green 61/2 part II page 61
Red	20.8	17.6	11.0	12.7	0.34	0.26	Sap Green 62/3 part II page 62	Sap Green 62/2 part II page 62
Black	20.4	16.9	12.0	13.0	0.32	0.25	Chartreuse Green 663/1 part II page 90	Chartreuse Green 663/2 part II page 90
Control (bare soil)	20.8	17.0	10.3	11.0	0.33	0.35	POD Green 061/2 part II page 120	POD Green 061/1 part II page 120
L.S.D. 0.05	1.6	1.4	1.4	0.52	N.S.	0.02		