Subtropical Plant Science, 59:95-103.2007

Use of Fabric and Plastic Barriers to Control Weeds in Blackberries

D. J. Makus

U.S. Dept. Agriculture, Agricultural Research Service
Weslaco, TX 78596

ABSTRACT

Weed control in blackberries (*Rubus* spp.) is a serious problem for organic producers and those who wish to reduce their reliance on herbicides. Three landscape fabrics (Dewitt, Texel, and a white polyester weave) and one industrial grade white on black plastic were used for weed control in conjuction with newly planted 'Kiowa' root cuttings in Feb. 2006. In the no-fabric treatment, weeds were controlled mechanically by hand. The reflectant white plastic and weave weed barriers reduced mid-summer soil temperatures at 10 cm and reduced the magnitude in soil temperature fluctuation. None of the weed barriers had an effect on soil water content measured at 0 to 20 cm. Plant vigor and height were improved by use of weed barriers. White plastic improved the cumulative season yield by 30% in 2007 compared to other barriers or bare soil. Fruit from bare soil plants showed the greatest decline in average fruit size during the picking season. Fruit from plants grown in bare soil were lowest in soluble solids and sugar:acid ratio compared to fruit from weed barrier treatments. Fruit grown over white plastic had the highest mean soluble solids and sugar:acid ratios; both reflectant weed barriers improved berry anthocyanin levels.

Additional Index Words: *Rubus* spp., anthocyanins, weed barriers, white plastic, organic weed control

---

Mention of a proprietary product does not constitute endorsement or recommendation for its use by the U.S. Dept. of Agriculture.

About 7,160 ha of blackberries (*Rubus* spp.) are grown in North America (Strik et al., 2007). Several cultivars have been reported to be adapted to south Texas (Lukefahr and Scott, 1994). Weeds are the major cultural pest, particularly because of the long growing season in the Rio Grande Valley. Weed control by non-chemical methods would be highly desirable from both an environmental and organic market standpoint. Numerous landscape fabrics, though expensive, are effective weed barriers. Because of the high value of the fruit and perennial nature of blackberries, weed barriers having several years of field utility would be desirable for weed control in both blackberries and similarly-grown cane fruits. The objective of this study was to evaluate several of these fabric materials and an industrial strength white plastic for the control of weeds during the first fruiting year of the thorny, erect, cultivar Kiowa.

MATERIALS AND METHODS

Four materials were tested: Dewitt (BWI, Shullenberg, TX) is a black polypropylene with polyester blend; Texel (BWI) is a black (gray on the other side) polypropylene / polyester permeable membrane; a white-on-black UV-stabilized polyethylene weave (PAK Unlimited, Cornelia, GA); and a nylon-reinforced white on black plastic (T-65, Reef Industries, Houston). The first three materials allow air, water and vapor exchange, while the fourth does not. A soil only treatment was included, which was kept weed-free at monthly intervals. Material objective color (lightness, chroma and hue), including that of the bare soil at two soil moisture conditions, was determined with a Minolta Model 200 Chroma meter. The planting site was located near Monte Alto, Texas (Lat. 26º 26' N, Long. 97º 58' W) on a Hargill fine sandy loam (Fine-loamy, mixed, hyperthermic Udic Paleustolls) soil.

A single 91 m row was rotovated to 15 cm, a 20 mil bi-wall irrigation tape placed 46 cm deep, and two similar 0.6 m wide strips of each barrier material placed parallel and 23 cm from the row center to allow for the blackberry roots (15 to 20 cm in length) to be planted 5 cm deep and 0.6 m apart in-the-row. Fabric installation and planting were done on 2 Feb and 15 Feb 2006, respectively. After shoot emergence, 10 cm of bagasse were placed over the 0.5 m-wide bare soil between the weed barrier treatments on 29 Mar. Each 3.6 m experimental plot consisted of 6 plants, and each of the 5 weed control methods were replicated 5 times as a randomized complete block design. A 3 m width of grass sod was on either side of the 25 plots.

In replication two, thermocouples were placed on 9 May on the south side of the row and in the middle of the respective weed barrier and corresponding soil only location. The thermocouples were set at a depth of 10 cm and temperatures recorded hourly with a CR-10 data logger (CSI, Logan, UT). Ten 20-cm long EC-20 moisture sensors (Decagon Devices, Pullman, WA) were installed vertically from the soil surface in the center of each treatment in replications two and four on 7 July and soil water content was measured six times between 18 July 2006 and 10 Jan. 2007.

On 20 June 2006, 22 kg N / ha (as 15-35-15) was applied to all treatments through the irrigation system. On Aug. 2, 0.62 kg of S.T.E.M. (Scotts, Marysville, OH) soluble trace elements was added. On 6 Apr 2007, at initial flowering, 1 t poultry litter (50 kg N / ha equivalent) was applied. Average plant height and plot vigor (scale: 1=poor to 5=highest vigor) ratings were made on 17 Oct 2006 and 22 Jun 2007. Primocane pruning cuts were made to keep plant height to approximately 75 to 90 cm, maintain plot integrity, and to remove trailing type cane growth throughout the growing season.

In 2007, fruit was harvested on 15 May, 21 May, 24 May, 29 May, 5 Jun, and 12 Jun from 1.8 m of row. Harvested fruit were placed into 1 L clam-shell plastic containers and plot yield determined. Just prior to the beginning and after the final harvests, 25 fruit per plot were collected to determine average fruit weight and to measure fruit quality parameters. After weighing, fruits were stored at -20C until used.

Fruit quality. Approx. 70 g of fruit were blended, then vacuum filtered through a Whatman #3 pre-filter, followed by a Whatman #1 filter for 10 min. The filtrate volume was measured, then subsamples were used for soluble solids determination (Atago PR-32α digital refractometer), initial pH and titratable acidity (Mettler DL 12 titrator). Total anthocyanins (as cyanidin-3-glucoside) were estimated by spectrophotometry at 520 nm in 0.01% methanolic HCl (w:v).

Data were analyzed by SAS Version 8.2 using the PROC GLM and MIXED procedures (SAS Institute, 1999). The Ryan-Einot-Gabriel-Welsch multiple range test was used for mean comparisons at the appropriate probability levels shown in the tables and Fig. 3. Differences between response means in Fig. 4 were tested using the PDIFF option of the LSMEANS statement of PROC GLM. Single degree orthogonal contrasts were made between no-fabric and all fabrics and between white plastic and 'other' treatments.

RESULTS AND DISCUSSION

The initial cost of the fabric materials (FOB factory) are given in Table 1 along with their objective color properties of 'L' (lightness), 'chroma' (color intensity), and 'hue' (color). The 'L' value is the most important attribute in terms of soil cooling and light reflectance into the canopy. White weave and white plastic had the highest 'L' values. Soil 'L' values were higher than the Dewitt (black) but lower than the Texel (black) fabrics. All fabrics, except white weave, appear to be durable enough to last at least one growing season. The white weave began decomposing after about 1 year in the field. The local erythemal (UV) index is typically 11 during the summer months. In a companion study, the Dewitt and white plastic materials have withstood UV degradation after two years in the field (Makus and Jifon, 2007). The use of

Table 1. Cost, durability after one year's use, and differences in objective color (CDM) attributes (P<0.01) of fabric materials and soil used.

	Initial cost ($ / ft²)	Durability	CDM Value 'L'	Chroma	Hue
None	0.00	NA	41.6 c	14.3 a	73.0 c
Texel (black)	0.13	+++	54.0 b	1.7 b	76.1 c
Dewitt (black)	0.15	+++	25.5 d	1.5 b	64.9 d
White plastic	0.15	+++	85.0 a	1.7 b	240.3 b
White weave	0.07	+	81.6 a	1.7 b	253.3 a

the bagasse-mulch strip suppressed, but did not eliminate all weed growth. Projected barrier material installation costs would be comparable to that of laying two double 0.6 m rows of plastic, which in our case, were on 3.65 m row centers.

In 2006, mean weekly mid-summer soil temperatures at 10 cm were reduced by the lighter textured fabrics, white weave and white plastic, and increased by the Dewitt and Texel fabrics compared to the bare soil temperatures (Fig. 1.). This temperature pattern was less pronounced in 2007, particularly as the white weave fabric began to deteriorate and the white plastic became covered with soil (Fig. 2.). In 2006, mean mid-summer weekly temperature deviations were reduced by fabrics, particularly the light textured fabrics, compared to those of the bare soil. Differences in mean weekly standard deviations became less apparent by mid-2007. Cane growth over the thermocouple locations were not always removed in a timely fashion, perhaps contributing to measurement inaccuracies. Soil water content in the 0 to 20 cm zone, which were measured six times between Jul 2006 and Jan 2007, showed no consistent pattern between treatments (data not shown).

Phenological development, based upon plant height and vigor rating, was different between the soil-only and fabric-grown blackberry plants (Table 2.). There were date but no date by fabric interactions. Hand weeding removal time per plot was significantly reduced with the use of weed barriers.

In 2007, the first fruiting year, treatment yield differences occurred on four of the six harvest dates (Fig. 3.). On every harvest date, blackberries grown over white plastic weed barriers had the highest mean harvest weights. Bare ground plots had the lowest mean yields for the first four harvests. Cumulative season yield was significantly higher (*P*<0.02) from blackberries grown on white plastic compared to all other treatments (Fig. 3. inset). The 2007 experiment-wise average yield was 5.8 t / ha. Shorter harvest intervals would have improved total yields across all treatments. Based on previous blackberry research in South Texas (Lukefahr and Scott, 1994), we can expect the 2008 or second fruiting season yields to be higher. Mean fruit weight was not affected by fabric use at the beginning of the picking season (Table 3.). Fruit from plants grown without fabric had the lowest mean berry wt. (*P*<0.06) at the end of the season and had the lowest (*P*<0.07) average season weights. Season weight reduction was also greatest in blackberries grown without fabrics (*P*<0.12), which declined by 36% between the first and last harvest.

There were season differences (*P*<0.01) in several fruit raw quality attributes (Table 4.). Late-harvested compared to early-harvested fruit were 19% lower in soluble solids, 17% lower in titratable acidity (as malic acid) and 41% higher in total anthocyanins. A contrast of bare soil vs. other treatments indicated that the absence of fabric use resulted in fruit with the lowest soluble solids and sugar acid ratio (*P*<0.01). A contrast between fruit grown under white plastic to the other treatments indicated that fruit grown under white plastic had the highest soluble solids and sugar:acid ratio and lowest initial pH. Based on a contrast comparing the white fabrics (weave and plastic) versus other treatments, anthocyanins were higher in fruit grown under the more reflectant weed barriers (*P*=0.05, data not shown). Initial pH values were lower (more acid) in the early harvested fruit. In early harvested fruit, fruit pH was lowest in Texel and no fabric compared to Dewitt and white plastic treatments (Fig.4.). In late harvested fruit, initial pH values were significantly higher in white plastic- verses Dewitt-grown fruit. Whether this is a meaningful interaction will be re-visited in the 2008 fruiting season.

Table 2. Blackberry plant height and vigor ratings taken on 17 Oct. 2006 and 22 June 2007 and weed removal times (WRT) per plot in seconds (s). There were no weed barrier X date interactions.

	Plant ht. (cm)	Vigor score[Z]	WRT (s)
Date:			
17 Oct. 06	52.2 b	4.0 a	-
22 Jun. 07	64.5 a	3.9 a	-
	**[Y]	NS	
Weed barriers:			
None	52.4 b	3.5 b	210 a
Dewitt (black)	59.7 a	4.0 a	44 b
Texel (black)	59.2 a	4.1 a	30 b
White plastic	61.4 a	4.1 a	20 b
White weave	59.2 a	4.1 a	65 b
	0.16[X]	*	*
Contrast:			
'none' vs. 'others'	**	**	**

[Z] Scale: 1= least to 5= greatest plot vigor.
[Y] N, *, ** = not significant or significant at *P*=0.05 and *P*=0.01, respectively.
[X] Prob. > 'F' value.

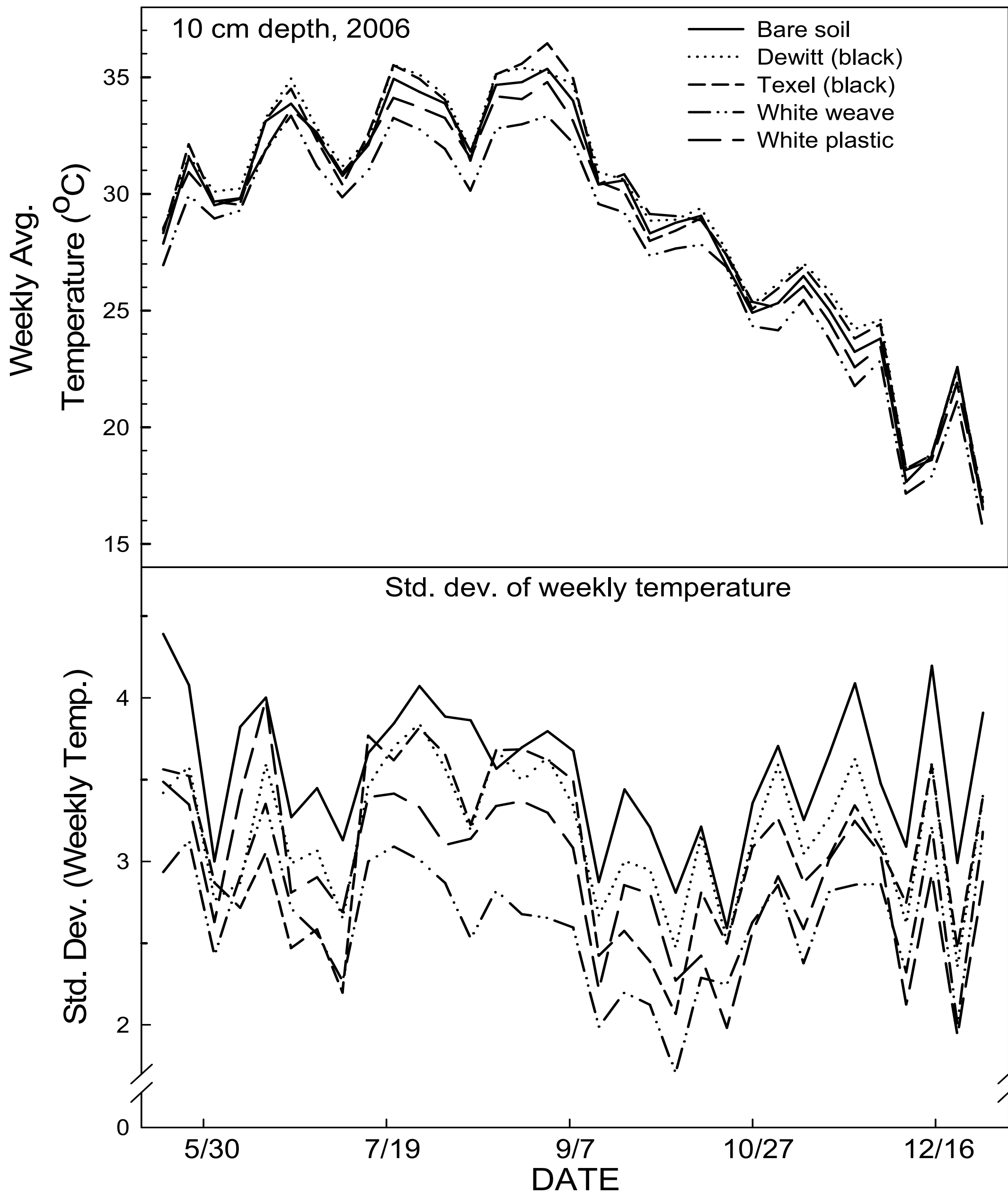

Fig. 1. Mean weekly soil temperatures and their mean standard deviations at 10 cm beneath the four weed barriers and bare soil in replication two from the week beginning May 12 and ending December 29, 2006.

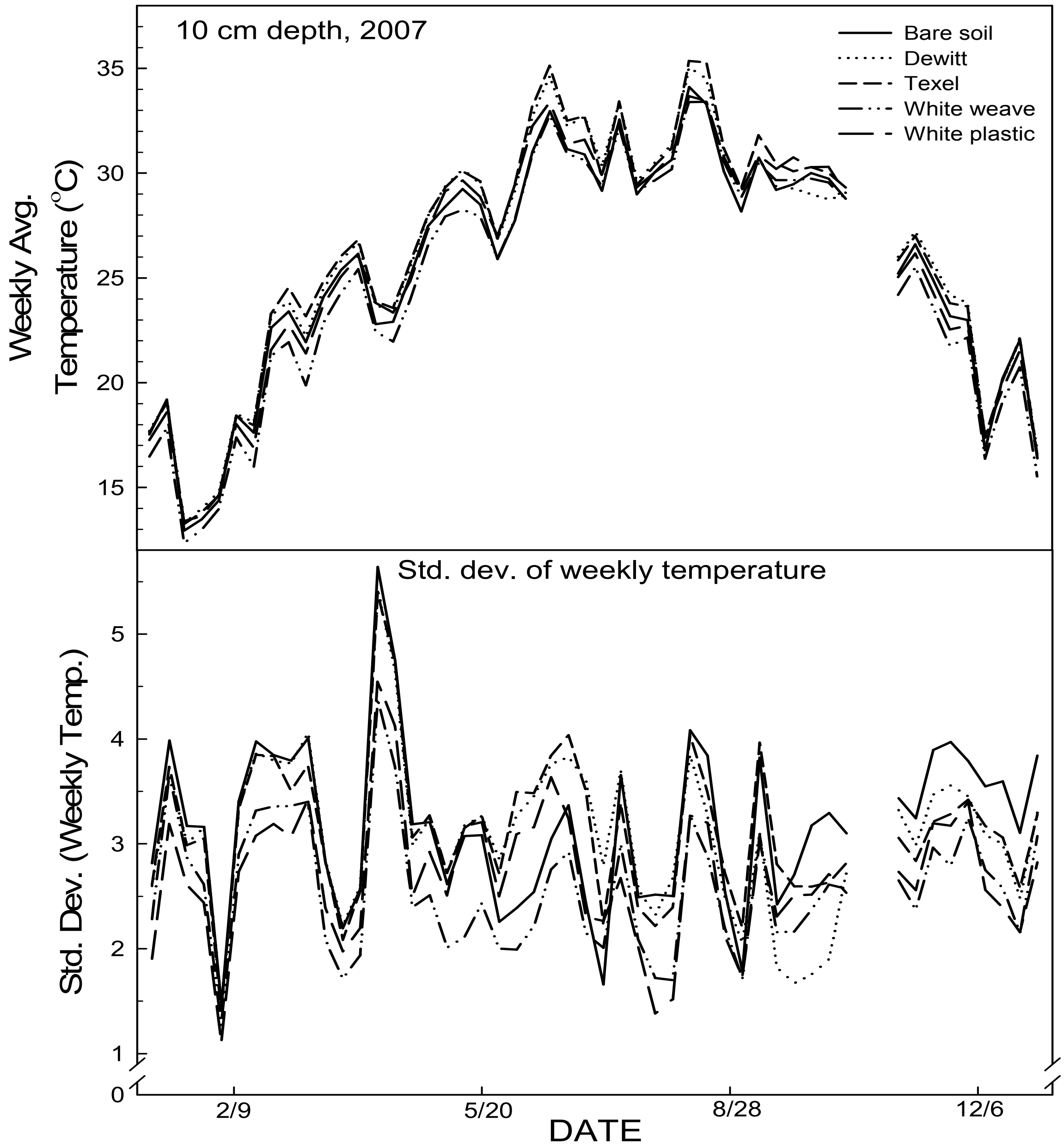

Fig. 2. Mean weekly soil temperatures and their corresponding standard deviations at 10 cm beneath the four weed barriers and bare soil in replication two for the weekly periods January 7 to December 30, 2007.

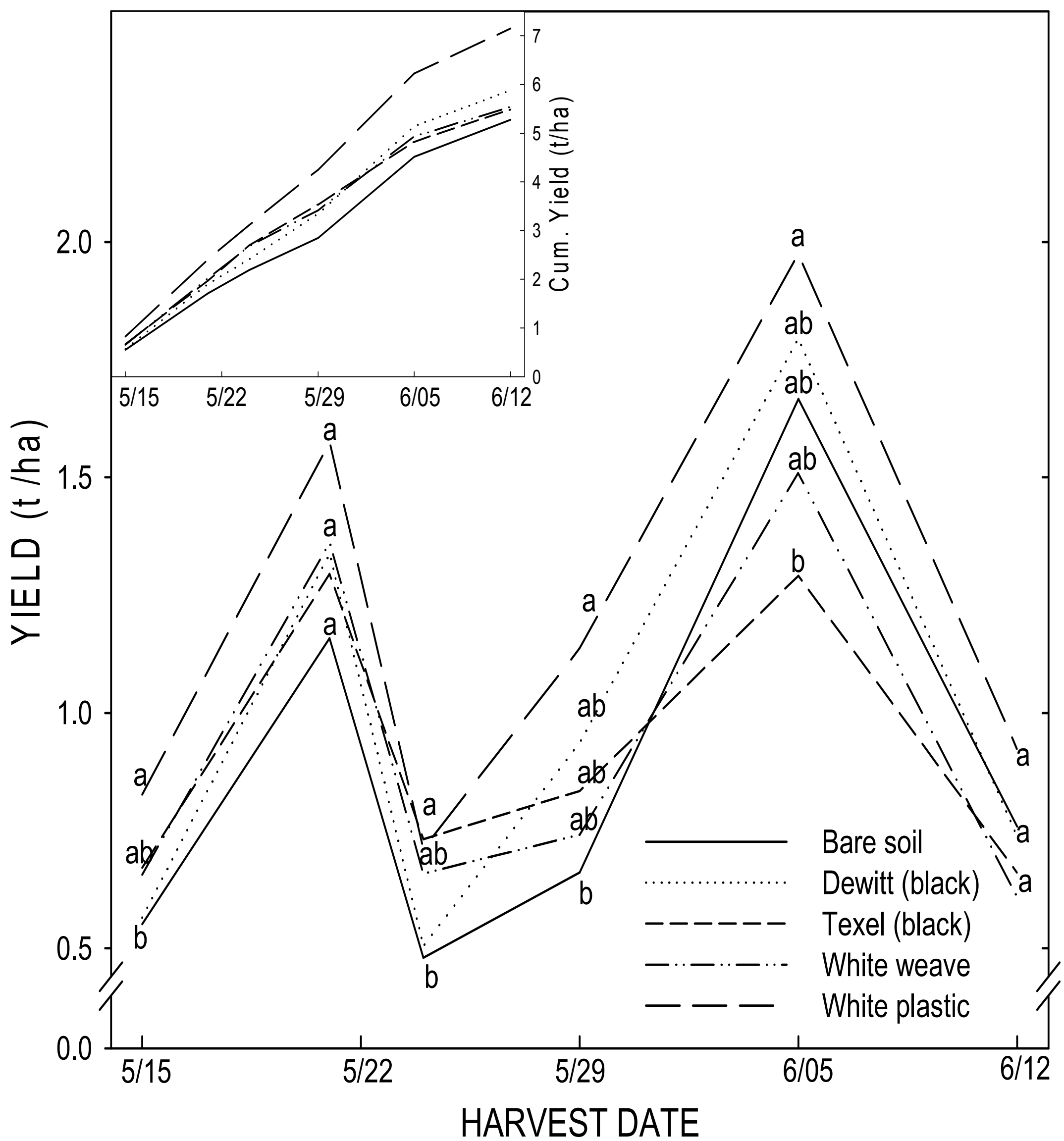

Fig. 3. Mean yield separation of fruit grown under five weed control methods at six harvest dates (P=0.05). Inset: White plastic improved season yield compared to other treatments (P=0.02).

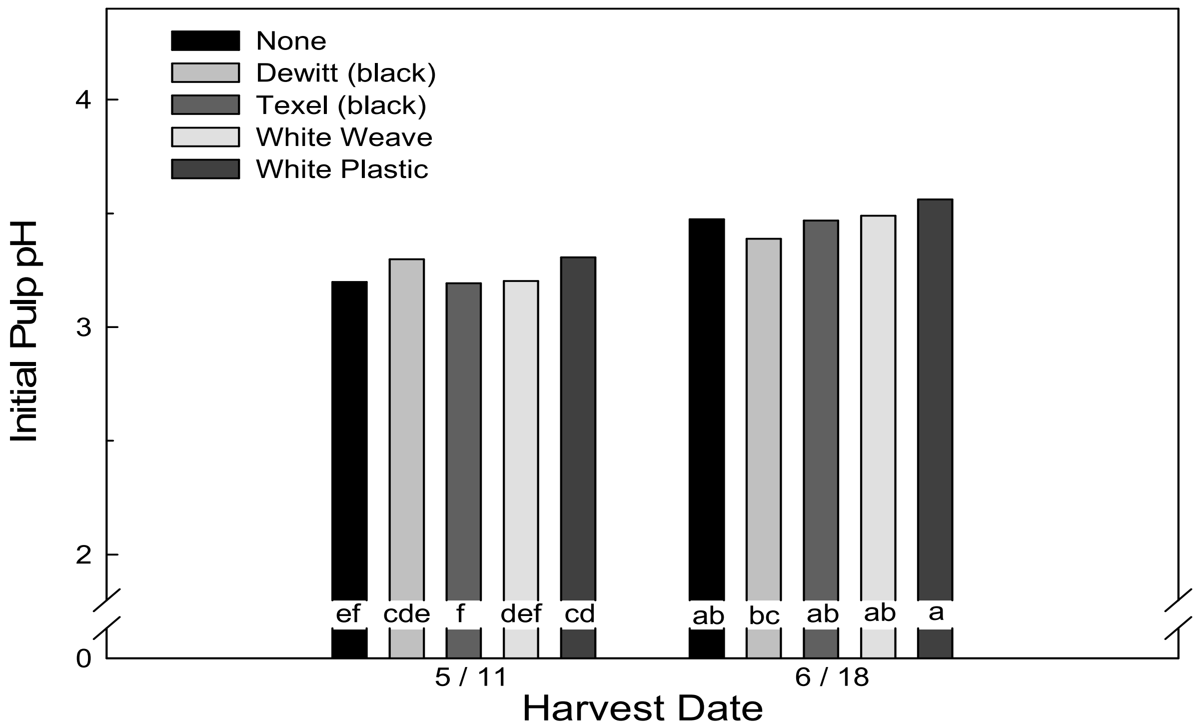

Fig. 4. Interaction means between harvest date and weed control method for initial berry pulp pH (*P*=0.01).

Table 3. Effect of weed barriers on early and late season average fruit weight (g). There was no date x weed barrier interaction.

Weed barrier	5/11	6/18	Season average	Season fruit weight reduction (%)
None	8.85 a[Z]	5.53 b	7.19 b	36.0 a
Texel (black)	8.65 a	7.43 ab	8.04 ab	14.2 b
Dewitt (black)	9.60 a	8.84 a	9.22 a	7.6 b
White plastic	8.96 a	8.11 a	8.54 a	9.8 b
White weave	9.01 a	7.60 ab	8.30 ab	17.0 b
Prob.>'F' value	NS	0.06	0.07	0.12
Contrast: 'None' vs. 'Others'	NS	**	**	**

[Z] LSMEAN separation at the respective probability level shown.
NS and ** = not significant and significant at *P*=0.01.

Table 4. Raw product quality of blackberry fruits picked at the beginning (11 May) and end (18 June) of the 2007 harvest season.

	Soluble solids (%)	Initial pH	Titratable acidity (% malate)	Sugar:acid ratio	Anthocyanin pigments (mg/100g)
Date:					
11 May	11.8 aZ	3.24 b	1.32 a	9.16 a	1749 b
18 June	9.6 b	3.48 a	1.10 b	9.11 a	2463 a
	**	**	**	NS	**
Weed Barrier (WB):					
None	9.8 b	3.34 b	1.29 a	7.72 c	2135 a
Dewitt (black)	10.6 ab	3.34 b	1.29 a	8.38 bc	2014 a
Texel (black)	10.9 a	3.33 b	1.17 ab	9.81 a	1734 a
White plastic (WP)	11.5 a	3.43 a	1.11 b	10.56 a	2309 a
White weave	10.6 ab	3.35 b	1.17 ab	9.20 ab	2339 a
	**	**	0.07Y	**	NS
Contrasts:					
None vs. others	**	NS	NS	**	NS
WP vs. others	*	**	NS	**	NS
Interaction:					
Date x WB	NS	**	NS	NS	NS

[z] Mean separation at the respective probability level shown.
NS, *, ** = not significant, significant at P= 0.05, and P= 0.01, respectively.
[Y] Probability of a greater 'F' value.

Malic acid is the major organic acid in blackberries (Whiting, 1957) and cyanidin-3-glucoside composes 95% of all the anthocyanins in 'Kiowa' (Fan-Chiang and Wrolstad, 2005). The experiment-wise malic acid levels reported for the first harvest date were identical (1.32 vs 1.3% ±0.1) to those reported by Kafkas et al. (2006) for 'Navaho', which was released from the same breeding program as was 'Kiowa'. The potential increase in fruit anthocyanins gained by using reflectant weed barriers would be desirable based on recent reports relating to the anti-tumor properties of cyanidin-3-glycosides (Ding et al., 2006). About 5% of the remaining anthocyanin in 'Kiowa' is cyanidin-3-rutinoside (Fan-Chiang and Wrolstad, 2005), which has been found to selectively kill leukemic cells (Feng et al., 2007). The food industry also finds blackberry juices, because of their intense pigment concentration, useful in product blending.

CONCLUSIONS

Weed barriers effectively reduced the time necessary to control weeds during the first season fruiting of 'Kiowa' blackberries. The white plastic weed barrier improved total yields compared to all other barriers and bare soil (control). Fruit quality was improved when white plastic was used for weed control, compared to other weed control treatments. High soil temperatures and their amplitude were reduced by the more reflective weed barriers. Barriers had little measurable influence on soil water content at 0 to 20 cm but tended to promote more vigorous plant growth.

LITERATURE CITED

Ding, M, R Feng, SY Wang, L Bowman, Y Lu, Y Qlan, V Castranova, B_H Jiang, and X Shi. 2006. Cyanidin-3-glucoside, a natural product derived from blackberry, exhibits chemopreventive and chemotherapeutic activity. J. Biol. Chem. 181:17359-17368.

Fan-Chiang, H-J and RE Wrolstad. 2005. Anthocyanin pigment composition of blackberries. J. Food Sci. 70:198-202.

Feng, R, H-M Ni, SY Wang, IL Tourkova, MR Shurin, H Harada, and X-M Yin. 2007. Cyanidin-3-rutinoside, a natural polyphenol antioxidant, selectively kills leukemic cells by induction of oxidative stress. J. Biol. Chem. 282:13468-13476.

Kafkas, E, M Kosar, N Turemis, and KHC Baser. 2006. Analysis of sugars, organic acids and vitamine C contents of blackberry genotypes from Turkey. Food Chem. 97:733-736.

Lukefahr, MJ and AW Scott, Jr. 1994. Blackberry evaluation and production in the Rio Grande Valley. Subtropical Plant Sci. 46:13-15.

Makus, DJ. and J Jifon. 2007. Impact of weed barriers on newly planted peach trees. HortScience 42:456-457. (Abstract)

SAS Institute Inc., 1999. SAS / STAT User's Guide, Version 8, Cary, NC; SAS Institute Inc., 3884 pp.

Strik, BC, JR Clark, CE Finn, and MP Banados. 2007. Worldwide blackberry production. HortTechnology 17:205-213.

Whiting, GC. 1957. The non-volatile organic acids of some berry fruits. J Sci. Food and Agric. 9:244-48.