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Effect of film mulches on edible lily (*Lilium davidii* var. *unicolor*) in semiarid areas

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Abstract

Plastic film mulching is an effective agricultural practice to improve crop productivity in semiarid areas. A field experiment (using *Lilium davidii* var. *unicolor* as an indicator crop) was carried out during 2006–2008 at sloping land located in southeast of Lanzhou (35 degrees 52' N, 104 degrees 09' E), Gansu province, China. The soil of the experimental site is *Calcaric Cambisol* (CMc). Three planting patterns were tested in open fields: contour ridge cultivation (RC), contour ridge by ordinary plastic film mulched (R-OPFM), and contour ridge by water-permeable plastic film mulched (R-WPPFM). Soil temperatures under mulches were higher than those under RC. Compared with R-OPFM, soil temperatures under R-WPPFM were lower than those under R-OPFM in hot seasons. Soil water content under R-WPPFM was always the highest among the three planting patterns. Mulches improved plant growth and biomass production. Marketable yield (17268.56 kg ha⁻¹) under R-WPPFM was markedly higher than that under R-OPFM (16655.67 kg ha⁻¹). In comparison with RC, water use efficiency (WUE) was significantly higher under mulches treatments, and the highest value of WUE was obtained under R-WPPFM.

Key words: water-permeable plastic film, ordinary plastic film, soil temperature, soil water content, yield-formation processes, yield, water use efficiency.

Introduction

Lilium davidii var. *unicolor* is one of the plants with great economic value due to its applications in food, medicine, and gardening (Niu, 2000). It is one of the species in the genus *Lilium* of the family *Liliaceae*, and it is rich in protein, sugar, vitamins, and mineral nutrients (Wang, 2001). Studies have shown that its bulb has multiple medical and healthful effects, including: effectively relieving cough, phlegm, and anxiety symptoms; improving human immunity; anti-oxidation; preventing tumor development, etc. (Ma et al., 2005). Its flower

contains abundant nutrition, and has become a new food source (Shen, 2008). Though in China, more than ten lily species are known edible, only *Lilium davidii* var. *unicolor* has grown into large scale production. In the semi-arid areas of northwestern China, *Lilium davidii* var. *unicolor* is even more important to local economy since alternative economic crops are limited by the low, unpredictable water supply and infertile farmland, etc. While due to the irrational planting and blindly pursuing economic benefits, the yield and quality of *Lilium davidii* var.

unicolor in these areas has been declining continuously recently (Wang, Wang, 2002), and it becomes imperative to have thorough understanding of how planting practice affects *Lilium davidii* var. *unicolor* growth in order to improve its yield and quality, and promote the ecologically sustainable industry.

Studies on vegetable crops have demonstrated that mulching with plastic film provides several benefits to crop production through improved weed control, more effective utilization of the water and fertilizers, reduced soil erosion from wind or water, and the prevention of plant diseases coming from the soil (Green et al., 2003; Scarascia-Mugnozza et al., 2006). Mulching improves the topsoil temperature. This favours root development, and the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest (Lamont, 1993; Li et al., 1999). Plastic film mulching directly affects the microclimate around the plant by changing the soil energy balance and restricting soil water evaporation (Liakatas et al., 1986). The decrease in soil water evaporation results in a more uniform soil moisture content and a reduction in the amount of irrigation water, which is very beneficial in dry areas.

Soil mulching with plastic film has been used in agriculture in the semiarid areas of north-western China. A few studies have revealed that film mulching indeed increased crop production (Wang et al., 1998; Li et al., 1999). However, light rainfall (≤ 10 mm) accounts for 70% of the natural precipitation in these areas, and the total rainfall of light rain reaches to 100 mm during the growth period of spring crop (Yao et al., 1998). In fact, this rainfall resource is not fully utilized even under plastic film mulching conditions. To obtain maximum storage of moisture under any rainfall conditions, the soil

needs to absorb as much water as possible when it rains. Water-permeable plastic film with better water permeability and water preserving capability is an alternative for plastic film.

The objective of the present study was to determine the influence of plastic film mulching on soil temperature and soil water content, as well as the effect on growth and yield in an open-air *Lilium davidii* var. *unicolor*.

Materials and methods

Experimental site. The field experiment was carried out at sloping land located in southeastern of Lanzhou (104°09' E, 35°52' N), Gansu province, China. Annual precipitation is about 350 mm and annual average temperature of 6.2°C. Monthly mean air temperature and mean rainfall in the last 30 years show that the warm and rainy season occurs in the same period. The soil of the site is classified as *Calcaric Cambisol (CMc)* according to the FAO taxonomy and the preceding crop in the experimental field is wheat. Soil samples from 0 to 20 cm depth were collected and air dried for determination of soil organic matter (Walkley and Black method), total N (Kjeldahl digestion method), total P ($\text{HClO}_4\text{-H}_2\text{SO}_4$ method), alkali-hydrolyzable N (alkali-hydrolyzed diffusing method), 0.5M sodium bicarbonate (NaHCO_3^- , pH 8.5)-extractable P and 1N NH_4OAC -extractable K, following Bao (2000). The soil pH (8.2) was determined by 1:2.5 soil: water suspension by a glass electrode pH meter. Soil organic matter was 9.4 g kg⁻¹, total N 0.82 g kg⁻¹, total P 0.78 g kg⁻¹, alkali-hydrolyzable N 0.075 g kg⁻¹, readily available P 0.008 g kg⁻¹, and readily available K was 0.12 g kg⁻¹. The slope of the field is about 10 degrees.

Table 1. Characteristics of RC, R-OPFM and R-WPPFM treatments

Treatments	RC	R-OPFM	R-WPPFM
Row spacing cm	20	20	20
Length between plants within each row cm	15	15	15
Ridge breadth cm	30	30	30
Ridge furrow breadth cm	30	30	30
Ridge height cm	15	15	15
Number row per ridge	2	2	2
Water-permeable plastic film width cm		75	80
Water-permeable plastic film thickness μm		5	6

Note. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μm thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μm thick and 80 cm wide) mulched.

Experimental design and treatments. The experiment was arranged in a completely randomized design with three replicates per treatment. Three planting patterns for edible lily were compared: contour ridge cultivation (RC), contour ridge by ordinary plastic film (5 μm thick and 75 cm wide) mulched (R-OPFM), and contour ridge by water-permeable plastic film (6 μm thick and 80 cm wide) mulched (R-WPPFM). Each elementary plot was 20 m long and 4 m wide. The characteristics of the three planting patterns are summarized in Table 1. Seed bulb (average weight 21 g) was planted on March 15, 2006, and harvested in early November 2008. To simplify the discussion, 2006, 2007 and 2008 were designated as the first growth period (GP-1), the second growth period (GP-2) and the third growth period (GP-3), respectively.

Prior to planting, the experimental field was ploughed and harrowed, and the contour ridges were banked up with the earth. *Lilium davidii* var. *unicolor* was rain-fed grown for the three growth periods. With manual bunch-planting methods, one seed bulb was dropped in each hole into the prepared furrow. Terminal bud of seed bulb was placed upwards when planting. Seed bulbs were first covered with moist soil and then mulched plastic film along rows under mulches. After emergence, seedlings were freed from the mulch by cutting the film above holes. For uniformity in growth and size, the seedlings were thinned to the target plant density (22.5 plants m^{-2}) at seedling stage. Under RC, cultivations were carried out, while under R-OPFM and R-WPPFM, cultivations were unnecessary. Plastic films were replaced at the beginning of GP-2 and GP-3. During the experiment, weeds were manually removed. At pre-bloom, multi-pinching was conducted for all plots to promote bulb growth. In GP-1, basal application equivalent to 352 kg N and 296 kg P_2O_5 ha^{-1} was applied at the time of main soil plowing. In GP-2 and GP-3, side dressing of 104 kg N ha^{-1} was applied before emergence.

Measurements and data analysis. Soil temperature at the 10 cm depth was recorded daily by earth thermometer during 8:00–9:00, 13:00–14:00 and 19:00–20:00. Daily mean soil temperature was calculated as the average of the three intraday readings.

Soil water content was measured gravimetrically to a depth 0–30 cm. Soil samples were collected by soil auger from each plot at different growth stages. Soil samples were weighed to determine both fresh and dry weight, after drying for 12 h at 105°C, and then soil water content was calculated by the following formula:

$$SWC(\%) = \frac{W_1 - W_2}{W_2} \times 100\%,$$

where SWC, W_1 and W_2 are soil water content, soil fresh weight and soil dry weight, respectively.

Seedling height, basal diameter and leaf number were recorded at flowering stage in GP-1, GP-2 and GP-3. Yearly bulb weight was recorded at different growth stages of GP-1, GP-2 and GP-3. At the end of destructive harvest, plant organs were divided into roots, stems, leaves and bulbs. The images of leaves were recorded and then the images were digitized with the SKYE Leaf Area and Root Length Image Analyzer in order to determine leaf area. Then they were dried in an oven for 48 h at 75°C to a constant weight for biomass determination. Total plant biomass was the sum of roots, stems, leaves and bulbs. *Lilium davidii* var. *unicolor* samples of 1 m^2 were harvested from the middle of each plot at the end of the experiment, and marketable bulb and bulblet yield were measured and given in kilogram per hectare (kg ha^{-1}). Cuiller number per bulb, bulb number and bulblet number per area, and bulblet weight were recorded, and bulb volume was calculated using the following formula (Yang, 2004):

$$V = \frac{\pi R^2 \cdot H}{8},$$

in which V is volume of bulb, R is diameter of bulb, and H is height of bulb.

The treatments were analyzed using the analysis of variance (*Anova*). For *Anova*, $\alpha = 0.05$ was set as the level of significance to determine whether significant differences existed among the means of the various treatments. Multiple comparisons were performed for significant effects with Fisher's protected least significant difference (LSD) test at $\alpha = 0.05$.

Results and discussion

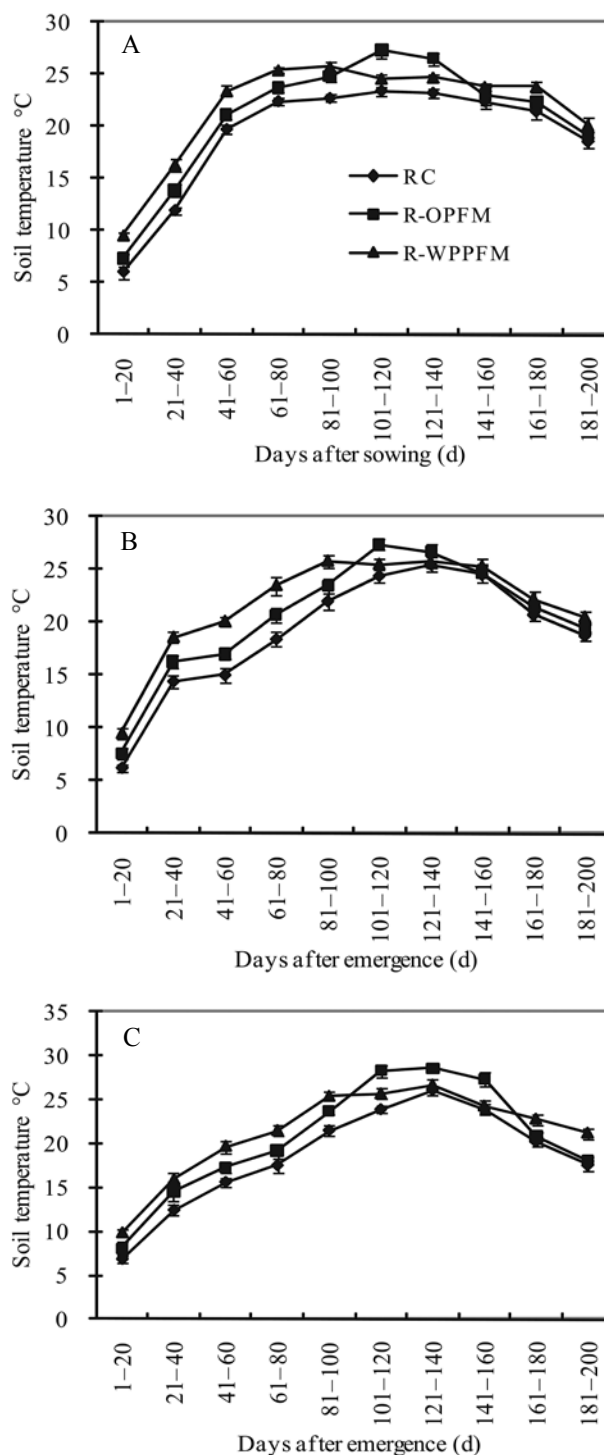
Soil temperature and soil moisture. Increased soil temperature is an important benefit associated with the use of plastic film mulching (Snelgar et al., 1999). Low soil temperature in the early *Lilium davidii* var. *unicolor* negatively influences germination and seedling growth (Sun et al., 2003), and film mulching solves this problem. Soil temperature at the 10 cm depth was 0.1–4.4°C higher under R-OPFM plots than under RC plots, 0.2–5.1°C higher under R-WPPFM plots than under RC plots during the three growth periods (Figure 1). Seed bulb germination was 7 and 5 days earlier on average, respectively under R-WPPFM and R-OPFM than under RC during the three growth periods.

Lilium davidii var. *unicolor* plants under mulches treatments grew more rapidly and vigorously than under RC. However, under conditions of high ambient temperature and high solar radiation, which are common during the summer in the semiarid areas of northwestern China, plants often show poor growth and low yield. Under those conditions, mulching can raise the soil temperature to a level that is deleterious to plants growth and yield (Miller, 1986; Tindall et al., 1990). In the present study, the use of water-permeable plastic film increased soil temperature even higher at the beginning of *Lilium davidii* var. *unicolor* growth than ordinary plastic film, while in hot seasons, soil temperature at the 10 cm depth was 1.0–3.0°C lower under R-WPPFM plots than under R-OPFM during the three growth periods (Figure 1). The better plant growth and the highest bulb yield at the end of experiment under R-WPPFM demonstrated that the adjustment of soil temperature of water-permeable plastic is effective in avoiding deleterious consequences resulting from plastic film mulching.

In semiarid areas, crop production is generally dependent on rainfall, so soil moisture conservation is vital for crop production (Zhao, 1996). Mulching of soil may reduce water loss through evaporation, and therefore may increase water availability to plants in relation to bare soil. Here, soil water content in 0–30 cm soil layer under R-OPFM and R-WPPFM increased 2.65–18.73% and 6.08–22.96% in GP-1, respectively, compared with that under RC. In GP-2, soil water content in 0–30 cm soil layer under R-OPFM and R-WPPFM increased 6.05–18.28% and 14.18–24.44%, respectively, compared with that under RC. And in GP-3, they increased 4.96–17.43% and 10.0–24.44%, respectively (Figure 2).

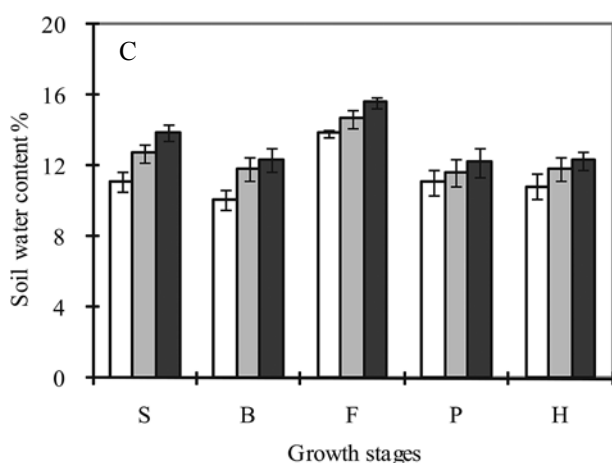
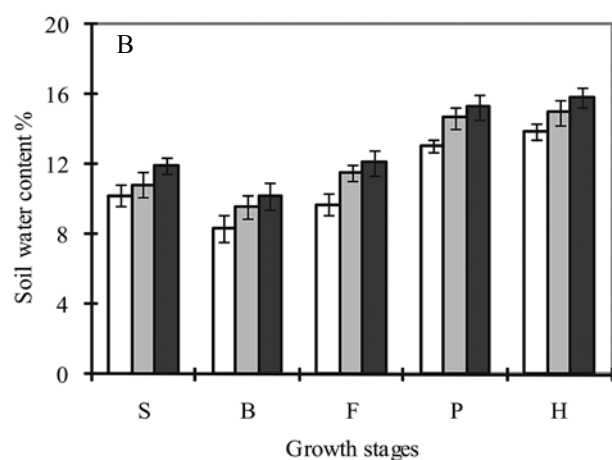
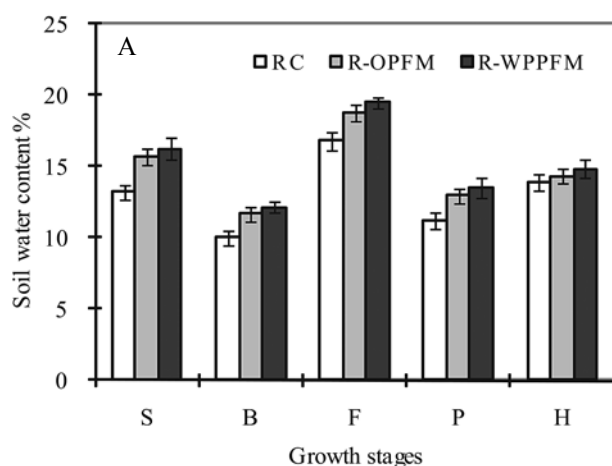
Plant growth and biomass production.

Plastic film mulches can improve the soil thermal conditions in the early growth stage of crop, promoting plant growth (Yang, Chen, 2005). Crop growth characteristics, such as seedling height, basal diameter, leaf number, leaf area, root weight and dry matter, were affected by different planting patterns. Those growth characteristics of *Lilium davidii* var. *unicolor* under different planting patterns are presented in Figure 3, Tables 2 and 3, respectively. Seedling height, basal diameter, leaf number kept increasing from GP-1 to GP-3 under all the three treatments. Though no significant differences between mulches were observed, seedling height, basal diameter and leaf number were always higher under R-WPPFM than that under R-OPFM (Figure 3). Compared with RC at the end of the experiment, mulches significantly improved leaf number, leaf area, and root length and root weight (Table 2).



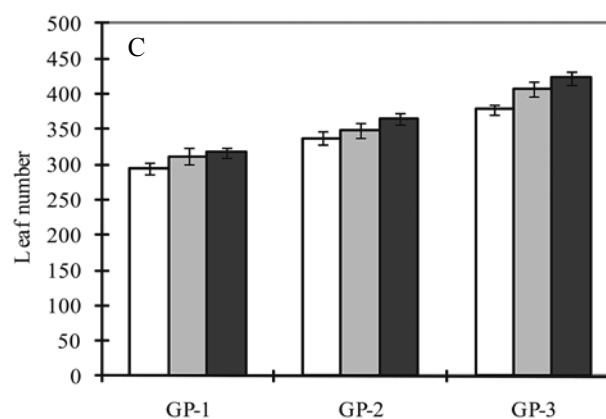
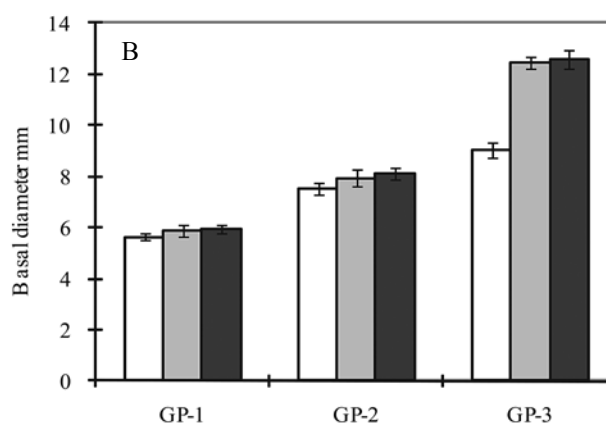
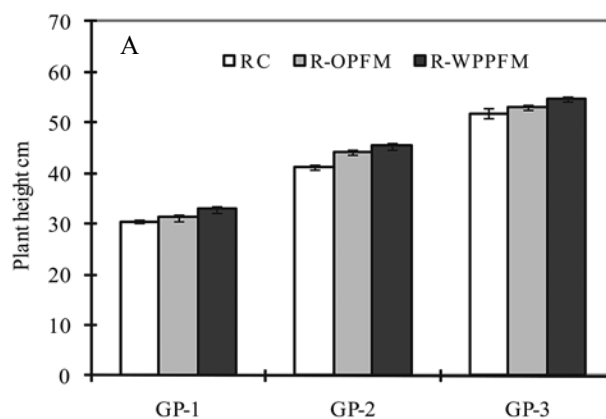
Notes. Data measured at 8:00–9:00, 13:00–14:00 and 19:00–20:00, daily mean of soil temperature was calculated as the average of the three intraday readings. Soil temperature at a depth of 10 cm. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μ m thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μ m thick and 80 cm wide) mulched. The vertical bars denote SE among treatments at $P < 0.05$.

Figure 1. (A–C) Evolution of soil temperature under RC, R-OPFM and R-WPPFM over 20-day periods in the first growth period (GP-1), the second growth period (GP-2), and the third growth period (GP-3)



Notes. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μm thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μm thick and 80 cm wide) mulched. S – seedling, B – bud, F – flowering, P – productive, H – harvest. The vertical bars denote SE among treatments at $P < 0.05$.

Figure 2. (A–C) Evolution of soil water content under RC, R-OPFM and R-WPPFM in the first growth period (GP-1), the second growth period (GP-2), and the third growth period (GP-3)



Notes. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μm thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μm thick and 80 cm wide) mulched. The vertical bars denote SE among treatments at $P < 0.05$.

Figure 3. (A–C) Yearly dynamics of seedling height, basal diameter and leaf number of *Lilium davidii* var. *unicolor* seedlings under RC, R-OPFM and R-WPPFM in the first growth period (GP-1), the second growth period (GP-2), and the third growth period (GP-3)

Table 2. Seedling height, basal diameter, leaf number, leaf area, root length and root weight (\pm SE) of *Lilium davidii* var. *unicolor* seedlings under RC, R-OPFM and R-WPPFM at the end of the third growth period (GP-3)

Treatments	Height cm	Basal diameter cm	Leaf number	Leaf area cm ²	Root length cm	Root weight g
RC	42.75a* \pm 7.10	8.60b \pm 0.18	92b \pm 4.04	98.16c \pm 1.49	12.50b \pm 0.34	13.54c \pm 0.43
R-OPFM	46.20a \pm 0.90	9.05ab \pm 0.26	142a \pm 3.61	153.36b \pm 2.72	15.34a \pm 0.59	16.67b \pm 0.43
R-WPPFM	47.80a \pm 1.36	9.45a \pm 0.16	148a \pm 5.04	167.24a \pm 2.06	16.78a \pm 0.70	19.54a \pm 0.51

Notes. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μ m thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μ m thick and 80 cm wide) mulched. * – within columns followed by different letters are significantly different at $P < 0.05$ based on LSD test.

Planting patterns significantly influenced the total biomass of *Lilium davidii* var. *unicolor* seedlings at the end of the experiment. Mulches ob-

viously increased the total biomass, with reduced shoot and root percentages, and improved bulb percentage (Table 3).

Table 3. Accumulation and distribution of dry matter (\pm SE) of *Lilium davidii* var. *unicolor* under RC, R-OPFM and R-WPPFM at the end of the third growth period (GP-3)

Treatments	Total g plant ⁻¹	Stem dry weight g	Leaf dry weight g	Basal root + stem root dry weight g	Bulb + bulblet dry weight g
RC	57.05c* \pm 0.91	2.97a \pm 0.21 5.21%	0.96b \pm 0.05 1.68%	1.76b \pm 0.06 3.09%	51.36c \pm 1.24 90.03%
R-OPFM	65.00b \pm 1.03	3.12a \pm 0.08 4.79%	1.42a \pm 0.04 2.18%	2.00ab \pm 0.10 3.02%	58.43b \pm 1.20 90.05%
R-WPPFM	70.11a \pm 1.24	3.37a \pm 0.09 4.81%	1.47a \pm 0.03 2.10%	2.15a \pm 0.04 3.07%	63.12a \pm 1.54 90.29%

Note. Explanations under Table 2.

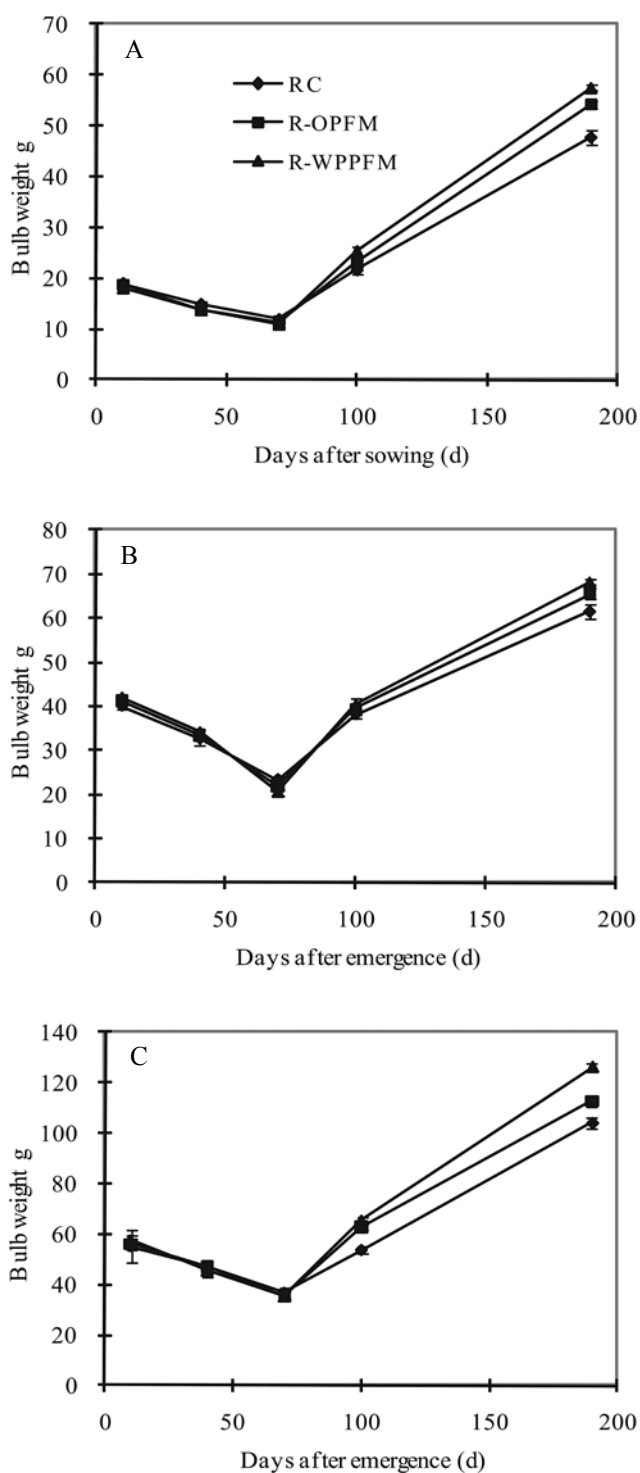
Plastic film improved topsoil water content, but due to increased plant growth higher plant transpiration rates reduced subsoil soil water content (Li et al., 1999). The alteration of soil temperature under mulching treatments did not directly affect photosynthesis and transpiration rate. Regarding how the relatively lower subsoil water content under mulching supports greater shoot weight, the previous study found that film mulching can promote the development of plants root and improve their water and nutrient absorption capacity, thereby the uptake of plant nutrients in topsoil is enhanced by favourable soil temperature and moisture conditions (Tindall et al., 1990). In this study, the larger root system, the larger leaf number and area, and the greater biomass of mulched plants support these conclusions.

Yield-formation processes, yield and WUE.

The dynamic of yearly bulb weights under RC, R-OPFM and R-WPPFM were summarized (Figure 4). Compared with GP-1 and GP-3, the increment of bulb weight during GP-2 was the lowest, which may be due to the growth rhythm of *Lilium davidii* var. *unicolor*. This kind of performance under

mulches was more obvious, the reasons can be explained not only that early rapid growth of plant during the second growth stage caused more reduction of bulb weight, but also that premature senescence of the plants caused by climate in the late GP-2 affected bulb weight increment. During a GP, the variation of bulb weight reduced quickly from 40 to 70 days after sowing/emergence, and increased slightly afterwards. Rapid bulb expansion occurred between 100 and 180 days after sowing/emergence. This phenomenon is expected, because it has been found during the initial period of growth, bulbs mobilize stored reserves for root and shoot development with a concurrent loss of bulb size and weight (Liu, Wei, 1994). Subsequently, after morphological building, bulb weight begins to increase due to more photosynthetic product transfers to the bulb. Though the reduction of bulb weight was higher under mulches than that under RC, it was still higher under mulches than that under RC, since mulches promote vegetative growth, thus more assimilation products were obtained and transferred to bulb.

Many previous studies have observed that culture temperature had effect on bulb expansion of



Notes. RC – contour ridge cultivation, R-OPFM – contour ridge by ordinary plastic film (5 μm thick and 75 cm wide) mulched, R-WPPFM – contour ridge by water-permeable plastic film (6 μm thick and 80 cm wide) mulched. The vertical bars denote SE among treatments at $P < 0.05$.

Figure 4. (A–C) The dynamics of bulb weight of *Lilium davidii* var. *unicolor* under RC, R-OPFM and R-WPPFM in the first growth period (GP-1), the second growth period (GP-2), and the third growth period (GP-3)

lily (Wang, Gregg, 1992; Yamagishi, 1998). Here, mulches significantly increased bulb volumes (Table 4), which demonstrated that higher temperature under mulches was beneficial for bulb expansion. The significant differences in cuiller number were found among RC, R-OPFM and R-WPPFM (Table 4). Though there were no significant differences in bulb number under three treatments, the number of bulb under mulches was larger. Haruki et al. (1996) reported that the formation of bulblet was interrelated with temperature. In the present study, the increase in bulblet number under mulches support the conclusion (Table 4).

Differences in yield can be attributed to differences in soil temperature when temperature is a limiting factor (Brown et al., 1992). When soil temperatures are high but do not reach the maximum threshold temperature for each crop, mulches do not influence yield (Streck et al., 1995; Lorenzo et al., 2005). In the present study, the range of temperatures under mulches had a marked effect on the bulb yield, which showed that soil temperatures under mulches reached the maximum threshold temperature for *Lilium davidii* var. *unicolor*. Further, the marketable bulb yield and the bulblet yield all reached the highest values under R-WPPFM, and the differences in marketable bulb yield and bulblet yield between R-WPPFM and R-OPFM were significant, which indicated that higher soil temperature under R-OPFM in hot seasons might result in yield reduction (Table 5).

Water use efficiency (WUE) is the functional indicator strongly related to plant growth and health under water deficit conditions. Improvement of WUE by better utilization of soil water appears to be the best way to increase crop growth and biomass production (Liu, Stützel, 2004; Monclus et al., 2006). The main ways of increasing WUE include reducing soil water evaporation, and exploiting deep soil water so as to support shoot biomass accumulation and optimize the dry matter allocation by selectively increasing the reproduction (Li, Zhao, 1997). The present experiment showed that mulches significantly promoted WUE, and the highest value of WUE was obtained under R-WPPFM (Table 5), which contributed greatly to the bulb yield. Mulching treatments promoted the increase of bulb yield due to rainfall and decrease in topsoil evaporation in the late growth stages.

Table 4. Cuiller number, bulb volume, bulb number, bulblet number and bulblet weight (\pm SE) of *Lilium davidii* var. *unicolor* under RC, R-OPFM and R-WPPFM at the end of the third growth period (GP-3)

Treatments	Cuiller number No. plant ⁻¹	Bulb volume cm ³	Bulb number No. m ⁻²	Bulblet number No. m ⁻²	Bulblet weight g each ⁻¹
RC	2.00c* \pm 0.13	68.64b \pm 2.21	26a \pm 1.15	666b \pm 9.14	1.16b \pm 0.02
R-OPFM	2.33b \pm 0.09	93.55a \pm 1.70	30a \pm 1.53	675b \pm 8.24	1.28a \pm 0.04
R-WPPFM	2.67a \pm 0.06	95.80a \pm 1.50	30a \pm 1.15	734a \pm 6.25	1.21ab \pm 0.03

Note. Explanations under Table 2.

Table 5. Marketable yield, bulblet yield and water use efficiency (WUE) (\pm SE) of *Lilium davidii* var. *unicolor* under RC, R-OPFM and R-WPPFM at the end of the third growth period (GP-3)

Treatments	Marketable yield kg ha ⁻¹	Bulblet yield kg ha ⁻¹	WUE kg ha ⁻¹ mm ⁻¹
RC	14838.65c* \pm 66.11	7703.35c \pm 41.12	17.11b \pm 0.45
R-OPFM	16655.67b \pm 46.79	8671.33b \pm 40.23	19.26a \pm 0.44
R-WPPFM	17268.56a \pm 42.64	8887.44a \pm 40.87	20.43a \pm 0.49

Note. Explanations under Table 2.

Conclusion

In the semiarid areas of northwestern China, under conditions of low air temperature and low rainfall, film mulching is a valuable technique for increasing crop yield. Film mulching increased the temperature and soil water content of topsoil layer, promoted plant growth and biomass accumulation. However, R-OPFM appeared detrimental for plant growth in hot seasons. In contrast, R-WPPFM better utilized soil water and resulted in lower soil temperature than R-OPFM in hot seasons, increased the plant vigour, the bulb yield and WUE, and prevented the potential harm on plant growth and yield resulting from excessively high soil temperature in hot seasons. Moreover, the cost of water-permeable plastic film is not higher than that of ordinary plastic film. Therefore, water-permeable plastic film is a better alternative for ordinary plastic film.

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Mulčiavimo poveikis valgomosios lelijos (*Lilium davidii* var. *unicolor*) auginimui pusiau sausringose vietovėse

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Santrauka

Mulčiavimas plastikine plėvele yra veiksminga žemės ūkio augalų derlingumo didinimo pusiau sausringose vietovėse priemonė. Lauko bandymas, kaip augalų indikatorių auginant valgomąją leliją (*Lilium davidii* var. *Unicolor*), vykdytas 2006–2008 m. nuokalnėje Lanzhou pietryčiuose (35°52' N, 104°09' E), Gansu provincijoje, Kinijoje. Bandymų vietovės dirvožemis – karbonatingas rudžemis, *Calcaric Cambisol* (CMc). Atvirame lauke buvo tiriami trys auginimo būdai: kontūrinis auginimas pašlaitėje, kontūrinis auginimas pašlaitėje mulčiuojant paprasta plastikine plėvele ir kontūrinis auginimas pašlaitėje mulčiuojant vandeniui pralaidžia plastikine plėvele. Dirvožemio temperatūra po mulčiu buvo didesnė negu auginant pašlaitėje. Palyginti su pirmuoju variantu, karštuuju metų laiku dirvos temperatūra buvo mažesnė po vandeniui pralaidžia plėvele, palyginti su paprasta. Iš visų auginimo variantų dirvožemio drėgmė buvo didžiausia po paprasta plėvele. Mulčiavimas pagerino augalų augimą ir padidino biomasės produkciją. Prekinis derlius buvo gerokai didesnis (17268,56 kg ha⁻¹) po vandeniui pralaidžia plėvele nei paprasta (16655,67 kg ha⁻¹). Palyginti su auginimu pašlaitėje, drėgmės panaudojimo efektyvumas (DPE) buvo iš esmės didesnis mulčiuojant, o didžiausios DPE vertės buvo gautos auginant po vandeniui pralaidžia plėvele.

Reikšminiai žodžiai: vandeniui pralaidi plėvelė, paprasta plastikinė plėvelė, dirvos temperatūra, dirvos drėgmė, derliaus formavimasis, drėgmės panaudojimo efektyvumas.