Journal of Zhejiang University SCIENCE B
ISSN 1673-1581 (Print); ISSN 1862-1783 (Online)
www.zju.edu.cn/jzus; www.springerlink.com
E-mail: jzus@zju.edu.cn

# Effect of different mulch materials on winter wheat production in desalinized soil in Heilonggang region of North China*

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Received Jan. 23, 2006; revision accepted May 17, 2006

**Abstract:** Freshwater shortage is the main problem in Heilonggang lower-lying plain, while a considerable amount of underground saline water is available. We wanted to find an effective way to use the brackish water in winter wheat production. Surface mulch has significant effect in reducing evaporation and decreasing soil salinity level. This research was aimed at comparing the effect of different mulch materials on winter wheat production. The experiment was conducted during 2002~2003 and 2003~2004. Four treatments were setup: (1) no mulch, (2) mulch with plastic film, (3) mulch with corn straw, (4) mulch with concrete slab between the rows. The result indicated that concrete mulch and straw mulch was effective in conserving soil water compared to plastic film mulch which increased soil temperature. Concrete mulch decreases surface soil salinity better in comparison to other mulches used. Straw mulch conserved more soil water but decreased wheat grain yield probably due to low temperature. Concrete mulch had similar effect with plastic film mulch on promoting winter wheat development and growth.

**Key words:** Mulch, Plastic film, Corn straw, Concrete, Saline water, Wheat growth
**doi:**10.1631/jzus.2006.B0858 **Document code:** A **CLC number:** S152.5

## INTRODUCTION

Heilonggang low-lying plain is situated in the East Hebei Province of North China. Surface freshwater is especially scarce at winter wheat growing stage because of monsoonal influence. Therefore the problem with the winter wheat production is serious. However there is large amount ($1.3\times10^{11}$ $m^3$) of shallow slightly saline groundwater (2~7 g/L) present throughout the area (Li *et al*., 2004a). If it is used adequately, the problem of water shortage would be alleviated. Without appropriate cultivation method, irrigation with slightly saline water can cause secondary soil salinisation and reduce wheat grain yield. How to use slightly saline water efficiently in irrigating winter wheat was our general objective. Surface-applied mulch is an effective method and widely used in recent years. Efficient use of brackish water to produce wheat is our objective which could be achieved by the application of surface mulch.

Surface-applied mulches provide several benefits to crop production through improving water, heat energy and nutrient status in soil, preventing soil and water loss, preventing soil salinity from flowing back to surface, and controlling weed (Bu *et al*., 2002). Many materials have been used as mulch, such as plastic film, crop residue, straw, paper pellets, gravel-sand, rock fragment, volcanic ash, poultry and live-stock litters, city rubbish, etc. However plastic film and straw were used most commonly (Bu *et al*., 2002; Unger, 2001; Tejedor *et al*., 2002; Li, 2003; Berglund *et al*., 2006). Wheat is the most important grain crop and occupies the largest cultivated area in

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* Project supported by the Hi-Tech Research and Development Program (863) of China (No. 2002AA2Z404), and the Key Innovation Project (No. KZCX3-SW-446) from Chinese Academy of Sciences, China

North of China. Few preliminary studies have been conducted to determine the effect of plastic film, straw and gravel mulches on the wheat production (Li and Lan, 1995; Niu *et al*., 1998; Li *et al*., 2004b; Xie *et al*., 2006). These studies showed that mulch wheat increases grain yield in comparison with unmulched wheat. The main causative reasons for mulch increasing wheat yield are soil and water conservation, improved soil physical and chemical properties, and enhanced soil biological activity (Tumulhairwe and Gumbs, 1983; Tindall *et al*., 1991; Deng *et al*., 2006; Ramakrishna *et al*., 2006).

However, the application of plastic film and straw mulch are restricted, since the widespread use of non-degradable plastic film mulch over many years may damage the sustainability of the soil, and straw mulch did not always lead to high yield because of allelochemical effect on crop growth and lower soil surface temperature (Mao, 1998; Rahman *et al*., 2005). In recent years some studies were conducted on the effect of concrete mulch in controlling evaporation and upward movement of $Na^+$ and other salts (Li, 2001; Mao and Tian, 1997). However there is no detailed report comparing the effect of plastic film, straw and concrete mulch on winter wheat growth in saline area.

This research was aimed at determining the effect of different mulch on the growing of winter wheat under slightly saline water irrigation.

## MATERIALS AND METHODS

### Field site description

The experiment was conducted at Nanpi Ecological Experimental Station (38°06′ N, 116°40′ E, elevation 8 m), Institute of Genetics and Developmental Biology, Chinese Academy of Sciences during two consecutive years of 2002~2003 and 2003~2004. This region is located in a medium temperate, semiarid and sub humid climatic area with long-term annual mean air temperature of 12.4 °C, annual mean precipitation of 537 mm with about 80% of the precipitation occuring between June and September. Precipitation during the winter wheat growing stage was 237 mm and 141 mm for the years of 2002~2003 and 2003~2004. The tested soil was a desalinized loam with a bulk density of 1.4 g/cm$^2$, soil salt content of 2~3 g/L. The groundwater has EC level of 3.28 dS/m and pH of 7.38. The organic matter, available N, available P, available K content were 1.18%, 36 mg/kg, 9.2 mg/kg, 157 mg/kg respectively.

### Experiment design and management

Four treatments were setup: (1) no mulching (CK); (2) mulching with 3 cm long pieces of dried corn straw by 15 mg/ha (straw); (3) mulching with concrete slab between the rows, which was 3 m long, 12 cm wide and 3 cm thick and the concrete was a mix of one part Portland cement and three parts sand (concrete); (4) mulching with 0.6 mm thick, white clear plastic film (film). All the mulches were applied after sowing. Whole plots were 3 m long and 2.2 m wide and separated by a 180 cm deep and 0.3 cm thick plastic wall. Each treatment was arranged in a randomized complete block design with three replicates.

The land was irrigated at rate of 675 m$^3$/ha before land preparation and then tilled deeply with fertilizer at rate of 150 kg/ha urea, 750 kg/ha calcium superphosphate in 2002 and 225 kg/ha urea, 375 kg/ha ammonium phosphate in 2003. Winter wheat variety “9204” was sown at rate of 315 kg/ha on 24 Oct. in 2002 and 21 Oct. in 2003 respectively. Irrigation was applied one time at turning green stage in 2003 and two times at shooting stage and heading stage in 2004 at rate of 600 m$^3$/ha each time in both years, and 150 kg/ha urea was tilled with the irrigation in 2003. Crop rotation was wheat-maize for both years.

### Sampling and measurement

One access tube was installed in each plot to determine soil water contents by neutron attenuation method. Determinations were made to a depth of 100 cm at 20 cm increments on 8 Nov., 8 Dec., 21 Jan., 20 Feb., 22 Mar., 1 Apr. and 11 Jun. during 2003~2004. Soil samples were taken from 0- to 5-, 5- to 10-, 10- to 20-, 20- to 40-, 40- to 60-, 60- to 80-, 80- to 100-cm depth to measure soluble cations and anions by titration methods (US Salinity Lab Staff, 1954) before harvest in 2003. Soil temperature of the top 15 cm layer at 5 cm intervals was measured by using geothermometer in 2003~2004. The soil temperature was observed at 8:00, 14:00 and 18:00 every day during the growing stage and the hourly temperature in a typical sunny and cloudy day was measured on 17 Feb. and 20 Feb.

Ten plants were randomly selected in each plot to examine plant height, leaf area index and above biomass dry matter on 2 Apr., 21 Apr., 2 May, and 27 May in 2003 and 19 Feb., 11 Apr., 27 Apr., and 21 May in 2004. Leaf area was measured by leaf width×length×0.75. Plant samples were oven dried at 105 °C for half hour and at 80 °C for another 36 h and then weighed for dry biomass. At final harvest, three rows of wheat in one meter in each plot were hand harvested, and grain yield and yield components were determined in both years. The winter wheat development stages were recorded, and also plant population including basic seedling, stem number before winter and max stems were counted by three rows of one meter during 2003~2004.

Leaf chlorophyll content was examined by Chlorophyll Meter SPAD-502 (Minolta Company) on 4 Apr., 3 May and 24 May during the years of 2002~2003, and on 19 Feb., 19 Mar., 8 Apr., 28 Apr., 2 May during the years of 2003~2004.

**Statistical analysis**

The data were subjected to statistical analysis by SPSS Ver. 11.0 and the means were tested using Duncan's Multiple Range Test at 5% level of significance.

RESULTS

**Soil conditions**

1. Soil moisture

Soil water content of all treatments was similar at the beginning of the growing stage and varied with time in response to mulch, until the irrigation was applied at turning green stage when the soil water content of all plots was similar again (Fig.1). At the early growing stage, soil water content of the plots with mulch was significantly greater than control and the order from high to low was: concrete, straw, film and control. However, with the growing of wheat population canopy, the effect of mulch on soil water content was decreasing. But soil moisture of concrete and straw mulch was still slightly higher than that of film and control, and there was no difference between film and control in the late stage.

2. Soil salinity level

Soil salinity level in mulch conditions was lower

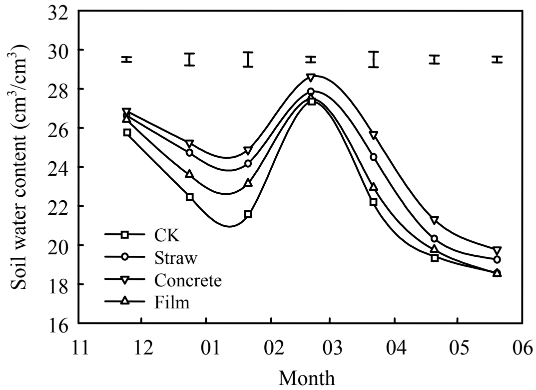



**Fig.1 Soil water content dynamics in surface layer (0~40) as affected by different mulching materials in the years of 2002~2003**

Vertical bars represent one standard error of the difference; CK corresponds to control treatment

as compared to control at the surface layer (0~20 cm); The concrete mulch had more significant effect on soil salinity level than straw and film mulch compared to control (Fig.2). To depth below 40 cm, the effect on salinity level among different mulch treatment was not significant.

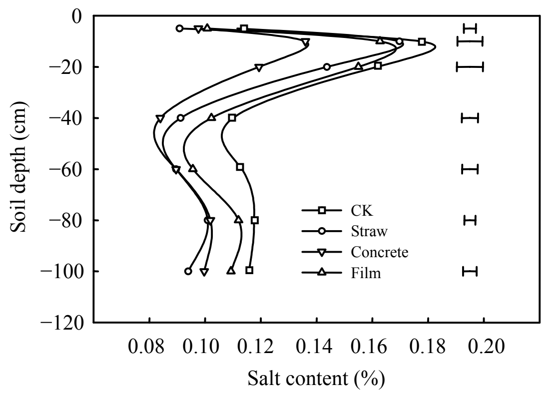



**Fig.2 Changes in salt content from 0 to 100 cm in a soil profile with different mulching materials in the years of 2003~2004**

Horizontal bars represent one standard error of the difference; CK corresponds to control treatment

3. Soil temperature

Effect of mulch treatment on soil temperature varied from treatments and time (Fig.3). In winter (from December to February), the film mulch treatment was more effective than concrete mulch treatment in increasing soil temperature, however the straw mulch treatment decreased the soil temperature compared to bare soil. At wheat turning green stage, due to the large fluctuation of soil temperature, the difference of each treatment became very significant and the sequence from great to small soil temperature was the same as that in winter stage. However, with the soil temperature increasing gradually at shooting stage, the effect of mulch treatment became less important and little difference due to treatment occurred. All the mulch treatments had reverse effect on soil temperature, with soil temperature of mulch treatment being lower than that of control. At filling stage, the effect of mulch was positive at first and then negative.

Changing trend of hourly temperature during a day was different between sunny and cloudy day (Fig.4). On sunny day, the soil temperature of each treatment from 7:00 to 14:00 was similar, but after

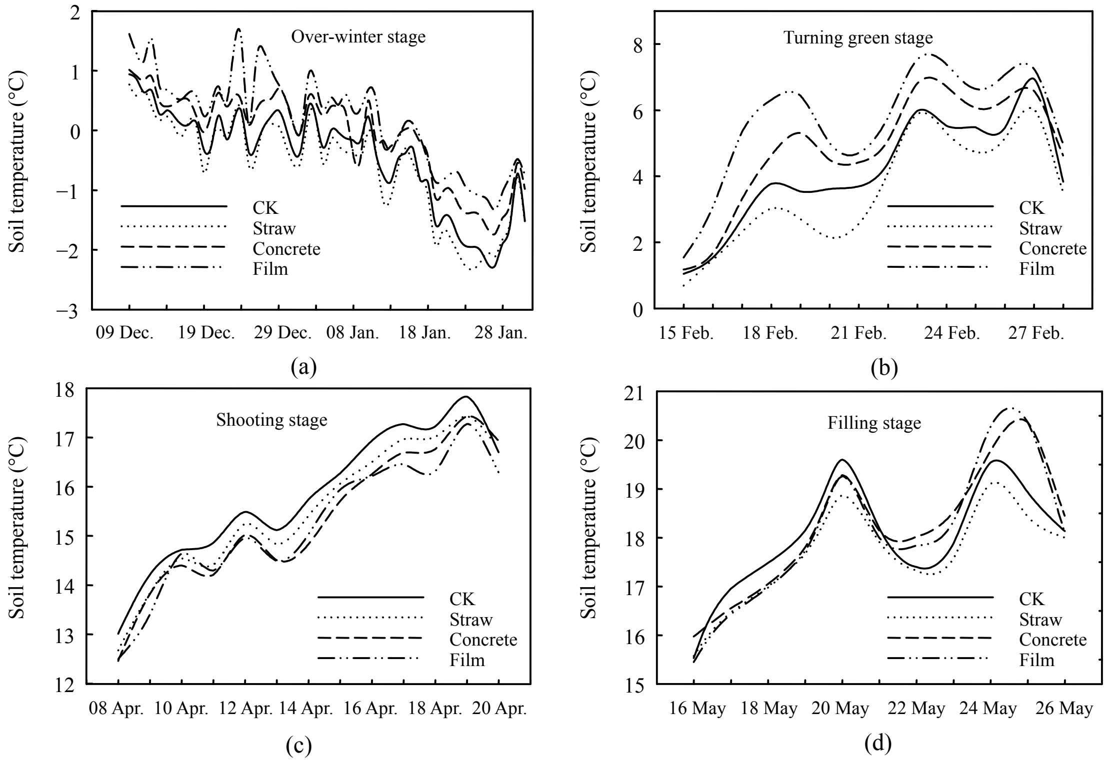



**Fig.3 Average daytime temperature of the soil profile from 0 to 20 cm with different mulching materials in different stage. (a) Over-winter stage; (b) Turning green stage; (c) Shooting stage; (d) Filling stage**
CK corresponds to control treatment

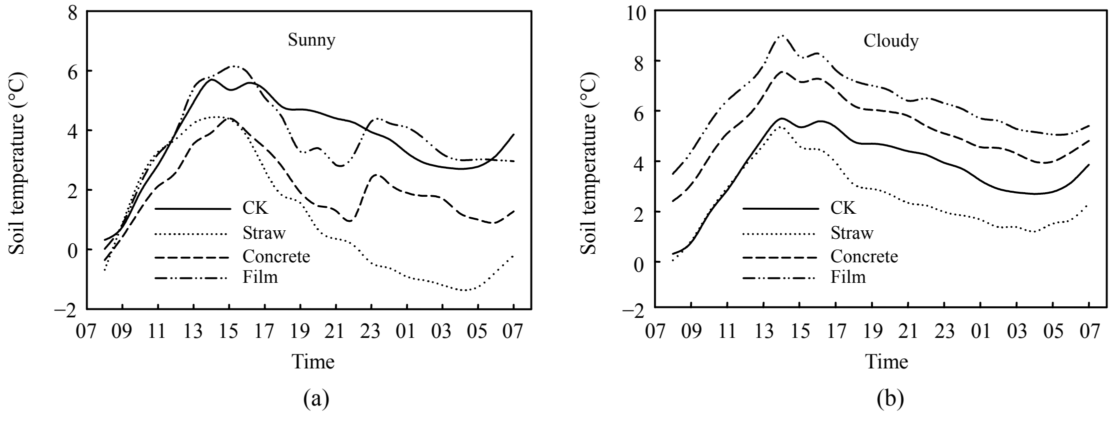



**Fig.4 Hourly temperature average from 0 to 20 cm soil profile as affected by different mulching materials on the typical sunny and cloudy day at turning green stage. (a) Sunny; (b) Cloudy**
CK corresponds to control treatment

14:00, the soil temperature of all treatments began to decrease, and the difference among the treatments was significant while concrete had similar variation trend with plastic film mulch, as control and straw mulch also did. After 14:00, straw had the lowest temperature among the four treatments while the temperature in the control and plastic film mulch was higher. However during cloudy day, the temperature among all the treatments was significantly different, except between control and straw mulch from 7:00 to 14:00 and the temperature in plastic film mulch and concrete mulch was higher than that in control and straw mulch.

**Plant growth**

1. Development stage

Wheat reached seedling emergence about 8 d and 4 d earlier for film and concrete mulch treatment, but 1 d later for straw mulch treatment compared to control (Table 1). And wheat reached turning green, shooting, heading and ripening stages about 1 to 2 d earlier for film and concrete mulch treatment and 1 to 2 d later for straw mulch treatment in 2002~2003. Similar result was found in 2003~2004.

2. Yield and yield components

Grain yield, spikes per unit area and weight per kernel in straw and concrete mulch treatments were significantly higher than those in control and straw mulch treatments in both years (Table 2). However, there was no significant difference in kernels per spike among the four treatments. Spikes per unit area in film mulch treatment were significantly greater than those in concrete mulch treatment for 2002~2003, but the results were not similar for year 2003~2004. However, the differences between the two treatments were not significant. Tiller's initiation of winter wheat occupies a long period which is divided into two stages, before winter and in the next spring. The tillers before winter are called winter-stems (main stem included) and the tillers initiation peaked in the next spring which was max-stems (main stem included). The basic seedling was similar in all the treatment before tiller initiation (Table 3). However, the tillers varied due to different mulch materials and the film was the most favorable for the winter tillers development, and the next was concrete mulch compared to the control which was similar to straw mulch before winter. Significant difference in number of

**Table 1 Developing stage of winter wheat as affected by different mulching materials in the years of 2002~2003 and 2003~2004 respectively**

| Treatment | Seeding | Seedling | Turning green | Shooting | Heading | Ripening |
|---|---|---|---|---|---|---|
| 2002~2003 | | | | | | |
| CK | 24 Oct. | 18 Nov. | 24 Feb. | 11 Apr. | 1 May | 7 Jun. |
| Straw | 24 Oct. | 19 Nov. | 25 Feb. | 11 Apr. | 3 May | 8 Jun. |
| Concrete | 24 Oct. | 14 Nov. | 23 Feb. | 9 Apr. | 29 Apr. | 6 Jun. |
| Film | 24 Oct. | 10 Nov. | 22 Feb. | 9 Apr. | 30 Apr. | 6 Jun. |
| 2003~2004 | | | | | | |
| CK | 21 Oct. | 11 Nov. | 17 Feb. | 4 Apr. | 23 Apr. | 6 Jun. |
| Straw | 21 Oct. | 13 Nov. | 18 Feb. | 5 Apr. | 24 Apr. | 8 Jun. |
| Concrete | 21 Oct. | 8 Nov. | 17 Feb. | 3 Apr. | 20 Apr. | 15 Jun. |
| Film | 21 Oct. | 4 Nov. | 16 Feb. | 3 Apr. | 21 Apr. | 6 Jun. |

CK corresponds to control treatment

**Table 2 Yield and yield composition as affected by different mulching materials in the years of 2002~2003 and 2003~2004 respectively**

| Treatment | Spikes ($m^{-2}$) | Kernels per spike | Weight per kernel (mg) | Yield (kg/ha) | Treatment | Spikes ($m^{-2}$) | Kernels per spike | Weight per kernel (mg) | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| 2002~2003 | | | | | 2003~2004 | | | | |
| CK | $407\pm24^a$ | $33.3\pm1.6^a$ | $37.6\pm0.5^a$ | $4066\pm172^a$ | CK | $531\pm1^a$ | $33.9\pm0.2^a$ | $42.2\pm0.1^a$ | $7246\pm50^a$ |
| Straw | $397\pm3^a$ | $33.5\pm0.5^a$ | $37.4\pm0.6^a$ | $4072\pm127^a$ | Straw | $554\pm2^b$ | $33.6\pm0.3^a$ | $42.9\pm0.9^a$ | $7146\pm50^a$ |
| Concrete | $453\pm11^b$ | $31.6\pm0.3^a$ | $38.1\pm0.2^b$ | $4563\pm157^b$ | Concrete | $672\pm2^c$ | $33.8\pm0.1^a$ | $44.6\pm1.0^b$ | $7546\pm50^b$ |
| Film | $461\pm7^b$ | $33.0\pm0.5^a$ | $39.1\pm0.3^b$ | $4904\pm92^b$ | Film | $700\pm5^d$ | $33.4\pm0.4^a$ | $45.1\pm0.9^b$ | $7796\pm30^b$ |

Means within columns followed by the different letters are significantly different at $P$=0.05. CK corresponds to control treatment

**Table 3 Three population indexes of winter wheat as affected by different materials in the years of 2003~2004**

| Treatment | Seedling ($m^{-2}$) | Winter stems ($m^{-2}$) | Max stems ($m^{-2}$) |
|---|---|---|---|
| CK | 665±1[a] | 712±15[a] | 1517±20[b] |
| Straw | 664±1[a] | 682±1[a] | 1317±3[a] |
| Concrete | 668±0[a] | 716±7[b] | 1674±26[c] |
| Film | 657±5[a] | 748±11[c] | 2081±72[d] |

Means within columns followed by the different letters are significantly different at *P*=0.05. CK corresponds to control treatment

max stems occurred among each of the treatments and the maximum number was achieved in film mulch followed by concrete, control and straw mulch.

3. Plant height

The plant height of film mulch and concrete mulch was significantly greater than that of straw mulch and control at most stages in both years (Fig.5). But the plant height of all the treatment except film mulch was similar at the end of the growing stage of 2003~2004. The difference between film mulch and concrete mulch or the difference between straw mulch and control were not significant.

4. Leaf area index

Leaf area was gradually increased until the middle of May and then decreased during both years. At early growing stage, the leaf area index in plastic film mulch was greater than that in straw mulch and

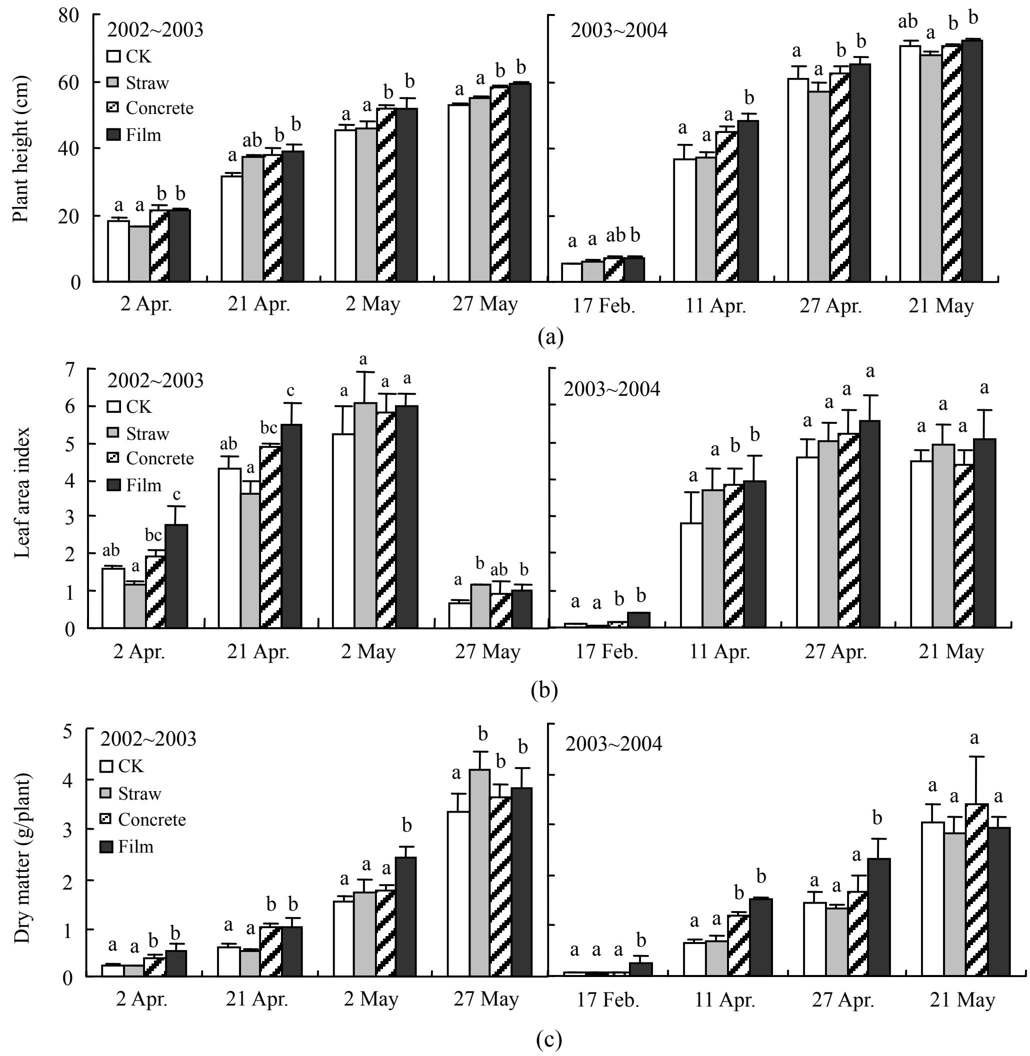



**Fig.5 Plant height (a), leaf area index (b) and dry matter (c) above ground over time as affected by different mulching materials in the years of 2002~2003 and 2003~2004 respectively**

Means followed by a different letter are significantly different within the treatments at the 0.05 probability level. Vertical bars represent one standard error of the difference among 3 replicates; CK corresponds to control treatment control in both years, but that in concrete mulch was only greater than straw mulch in the years 2002~2003 and was significantly greater than control and straw in the years 2003~2004 (Fig.5). There was no significant difference between either film and concrete or concrete and control in the early stage in both years. However at the late growing stage, the leaf area index in straw and control became greater than concrete and plastic film in both years and it was significantly greater in 2002~2003.

5. Dry matter accumulation

Dry matter accumulation in film mulch and concrete mulch was significantly greater than that in straw mulch and control for most of the time at the early growing stage of both years (Fig.5). But at the late growing stage, the difference among control, straw mulch and concrete mulch was decreasing, and at last there was no difference among the treatments (2003~2004), even the straw mulch was greater than the other treatments (2002~2003).

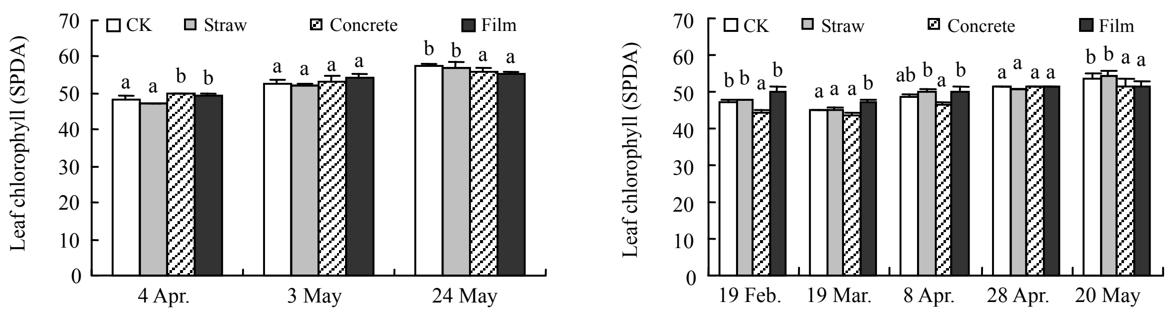
6. Leaf chlorophyll content

Leaf chlorophyll content in plastic film and concrete was slightly greater than that in straw mulch and control in 2002~2003 and that in plastic film was greater than the other treatments in 2003~2004 in the early stage (Fig.6). But with increase in age, the leaf chlorophyll content in straw and control was becoming higher than that in film and concrete in both years.

## DISCUSSION

Various kind of field mulches have been used (Bu *et al*., 2002; Unger, 2001; Tejedor *et al*., 2002; Li, 2003) like (1) chemical mulch (plastic film, pitch, water conservation agent, membrane agent, etc.), (2) physical mulch (sand, pebble, paper pellets, cloth, turf, etc.), (3) biological mulch (straw, crop residue, grass, growing green fertilizer, etc.). In addition to most popular mulch material used (i.e., plastic film and straw), pebble has also been reported in literature to conserve moisture in the semi-arid region of China for thousands of years (Li *et al*., 2000a). Concrete mulch has similar physical characteristics as that of pebble and it is more favorable for field production, because it can be easily removed when not used in comparison to pebble. Concrete mulch does not pollute the soil and it can be sustainably used for many years. Therefore concrete mulch is a safe and low cost method in agricultural production.

The environmental factors which are affected by mulch include soil temperature, soil moisture, soil salinity level, nutrients and soil texture (Li *et al*., 2000b). The initial response of application of mulch is the change of soil temperature which varies with the type and quantity of mulch material, also application time and site. Our result indicates the soil temperature in plastic film and concrete mulch was higher than those in bare soil during most growing stages, which is consistent with results of numerous studies that showed use of mulch increases soil temperature (Unger, 1975; Li and Lan, 1995). But the soil temperature in mulch treatment was lower than that in control at shooting stage and late filling stage, which was likely due to the two times of irrigation. However the soil temperature in straw mulch applied area was lower than that in control, which is in agreement with results obtained earlier (Wicks *et al*., 1994; Gao and




(a) (b)

**Fig.6 Leaf chlorophyll content over time as affected by different mulching materials in the years of 2002~2003 (a) and 2003~2004 (b) respectively**

Means followed by a different letter are significantly different within the treatments at the 0.05 probability level; Vertical bars represent one standard error of the difference among 3 replicates; CK corresponds to control treatment

Zhao, 1995; Buerkert *et al*., 2000). The lower soil temperature with straw mulch may be caused by the combined effects of changes in albedo and surface roughness, increased plant cover, and higher water content at the soil surface (Buerkert *et al*., 2000). Excessive amount of straw may lead to low soil temperature (Chen *et al*., 2002). However, Dong and Qian (2002) argued the soil temperature with straw mulch decreased in the day and was conserved at night; Chen *et al*.(2002) and Fan *et al*.(2003) reported that soil temperature with straw mulch increased in winter and decreased in the spring.

The mulch layer on the field surface can weaken the intensity of turbulent exchange between the atmosphere and soil water, which cause soil moisture to be prevented from evaporating, and thus reduce ineffective water consumption (Dong and Qian, 2002). However the mulch treatment usually promotes plant growth associated with higher plant transpiration and greater soil water loss (Li and Lan, 1995). Therefore the soil surface mulch can alter water distribution between soil evaporation and plant transpiration (Huang *et al*., 2005). In addition mulch can change the soil water distribution from deep layer to surface layer. Our experiments showed that the moisture in mulch treated top soil was greater in comparison to bare soil during early stage, and this difference reduced when the crop exhibits certain canopy (Tolk *et al*., 1999; Todd *et al*., 1991). Unger and Jones (1981) found that shading by the plant canopy substitutes for the beneficial effect of growing season mulch. Concrete mulch is more effective in conserving soil water than the other two materials: straw and plastic film. It seems that straw is better than plastic film in soil water conservation, but it sacrifices soil temperature and wheat growth. On the other hand, plastic film increases soil temperature the most but consumes too much soil water. Compared to straw and plastic film, concrete mulch is more favorable either in conserving soil moisture or increasing soil temperature.

Salt damage is serious in spring, because of high evaporation induced by little precipitation, more wind, and high temperature and less canopy, when most crops are during the seedling stage and sensitive to salinity. Mulch can prevent soil salinity from flowing back to soil surface through reducing evaporation as the salt comes with water and goes with water (Zhang *et al*., 1996; Li and Lan, 1995; Li *et al*., 2000c; Tejedor *et al*., 2003). Fan *et al*.(1993) reported that the salinity level of the soil (0.44%) decreased to 0.07% after being mulched with straw for two years. Mao and Tian (1997) demonstrated that the concrete mulch has significant effect on decreasing salt content in maize and jujube fields. Our findings provide direct evidence that the three kinds of mulch material can decrease salt content in 0~40 cm depth of soil layer, in which the concrete is the more favorable than straw and plastic film mulch under saline water irrigation. The frequency of saline water irrigation can be increased under mulches practice; however it is impossible under conventional conditions, because it can lead to secondary salinisation and decrease crop yield (Li *et al*., 2004a). The main reason concrete treatment decreased the salinity level more significantly than the straw and film treatment may be that the concrete mulch as a thick cover separates the soil and atmosphere turbulence and reduces the water and salt movement much more than the other two treatments.

The growth and development of winter wheat was promoted by film and concrete mulch resulted from favorable soil moisture, temperature and salinity level, and delayed by straw mainly due to low soil temperature. The soil temperature is likely to be the critical environmental factor in promoting developmental stage and tillers initiation for winter wheat growth in this area. The other reason for reduced yield in straw mulch treatment was likely to be due to low N fertility that occurred when the soil was covered with much residue (Unger, 1986). While, multi-year studies showed a variable response to straw mulch with each growing season, ranging from 0% up to 70% yield increases (Tolk *et al*., 1999).

The higher grain yield in plastic film mulch and concrete mulch may be caused by promoting developmental stage, increasing dry matter accumulation in the early stage and optimizing dry matter distribution in the reproduction in the late stage. In the early stage, the plant height, and leaf area and dry matter accumulation was definitely higher in plastic film mulch and concrete mulch than in straw mulch and control. But in the late season, the differences of dry matter among the three mulch treatments were not significant and the leaf area index and leaf chlorophyll content of plastic film and concrete were lower in comparison to straw and control. This is likely due to the fact that plastic film mulch and concrete mulch treatments promoted vegetative growing in the early season and distributed more dry matter to reproductive organ and decreased the vegetative growth, which caused the lower leaf area and leaf chlorophyll content in the late season.

Film and concrete mulch treatments produced higher grain yield by increasing spikes per unit area and weight per kernel compared to control and straw mulch. However Li *et al*.(2004a) reported that there was no significant difference in yield components between plastic film mulch and non-mulch treatment, although there was increased yield in mulch treatment. Our results indicated that the difference of kernels per spike in all treatments was not significant. But Li and Lan (1995) and Niu *et al*.(1998) pointed out that kernels per spikes were increased due to plastic film mulch. Rahman *et al*.(2005) reported straw mulch treatments brought about significantly higher spikes per unit area and kernel weight per spike than no-mulch treatment, but not in kernel weight. Concrete and plastic film mulch has similar effect on the yield and yield components.

## CONCLUSION

Different mulch materials had different effect on soil conditions: concrete and straw mulch seems more favorable for conserving soil water; and plastic film is the best treatment for increasing soil temperature; concrete mulch decreases the soil surface salinity level more in comparison to the other two material mulches. However the straw mulch decreases wheat grain yield due to low temperature, although it conserve more soil water content. Straw mulch is not very fit for winter wheat production in this area. Concrete mulch has similar effect with plastic film mulch on promoting winter wheat development and growth. As a new mulch material, the concrete mulch has some advantage such as repeated use, without pollution and low cost, compared to plastic mulch, so we recommend that it can be used as a complementary material to plastic film.

## ACKNOWLEDGEMENT

The authors thank the technical assistance by Mrs. Xinyan Feng and Mr. Jinyu Guo. The thanks also go to Professor M. Ajmal Khan at University of Karachi for his constructive suggestion and language reviewing.

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