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EFFECT OF DIFFERENT MULCHING TYPES ON SOIL TEMPERATURE AND CUCUMPER PRODUCTION UNDER LIBYAN CONDITIONS*

A. El- Shaikh[1] and T. Fouda[2]

ABSTRACT

The experiments of this study were carried out to investigate the effect of organic mulch (wheat straw), plastic mulches (black, transparent and yellow polyethylene) and bare soil (as a control) on soil temperature, germination ratio, plant growth, weed percent, water use efficiency and cucumber yield under drip irrigation system. The results showed that soil temperature increased by using plastic mulches. The highest soil temperature was obtained with transparent polyethylene which permits early germination, flowering and harvesting. Also, the average yield increased by 67, 109, 129, and 124 % with straw, black, transparent and yellow mulch respectively compared with the control.

Moreover, mulching treatments led to saving in irrigation water for all mulching types compared with the control treatment. The water use efficiency was 6.22, 7.76, 8.51, 8.34, and 2.32 kg/m^3 under straw, black, transparent, yellow and bare soil treatments respectively.

INTRODUCTION

Mulch is used for many different functions and may be composed of many different materials. The main benefit of mulching is to raise the soil temperature in seedbed zone, which promotes faster crop yield and earlier harvest.

Djigma et al. (1986) found that the black polyethylene mulch yielded 3.3 times higher than soil without mulch in eggplant and 2.3 times in tomato, when grown during the relatively cool season sown in September and harvested in January. In a trial carried out during the hot season, the use of plastic mulch had an adverse effect on vegetables and decreased their yields significantly

[1] Lec. of Agric.Eng, Faculty of Agric, Suez Canal University
[2] Assoc. Prof. Agric. Eng. Faculty of Agric., Tanta University.
* This work was carried out during 2004 in ElGeran High Inst. of Agric., Libya.

Sajjapongese et al. (1989) revealed that tomato yield increased by 67.5% when the crop mulched with black plastic and by 15% when rice straw used as a mulch. **Loy and Wells (1990)** reported that black plastic mulch made the harvest earlier by 7-14 days, while clear plastic may advance the harvest date by 21 days.

Toshio (1991) reported that the difference in soil temperature between mulched and bare soil in early May reached 7ºC in case of transparent film and 5ºC in case of black film.. This increase in soil temperature diminished later as the canopy of carrot leaves began to cover the mulch. In addition, black polyethylene film gives effective weed control by cutting down solar radiation by more than 90 %. William (1991) stated that there are three primary non-degradable mulch types used commercially in the production of vegetable crops: black, clear, and white (or white-on-black). Black plastic is the most popular one because it retards weed growth and warms the soil in the spring. The results showed that the mulch made the harvest earlier in addition to reducing soil water loss. Douglas and Sanders (2001) stated that the advantages of using plastic mulches are: increasing soil temperature from 4 to 5 ºC under black mulch, 5 to 8 ºC with infrared transmitting mulch (clear green), or 8 to 10 ºC at a 5 cm depth under clear mulch, reducing soil compaction, reducing evaporation, reducing weed problems, earlier crops and increasing growth. Lekasi (2001) used polyethylene and banana residues as mulches and organic inputs for cabbage production. Surface mulching with banana residues was not effective in weed suppression or moisture conservation but increased earthworm population densities. Plastic mulching, on the other hand, increased cabbage yields by 14.9 t.ha-1 over the un-weeded treatment and improved soil moisture status. Taber (2002) stated that the infrared plastic produced slightly higher maximum soil temperature compared with clear plastic. Therefore, the infrared film accumulated more heat compared with the clear one.

The objective of this study was to investigate the effect of different mulching types on soil temperature, germination ratio, plant growth, water use efficiency and cucumber production under Libyan conditions.

MATERIALS AND METHODS

The experimental work of this study was conducted at Ganzor. Algefarh province at The Great Socialist Peoples Libyan Arab Gamahiriya through the period from March to June 2004. The experiments were designed in a randomized complete blocks with three replicates to evaluate the different mulching types.

The soil of the experimental site was classified as a sandy soil (2.14% clay, 8.50% silt and 89.36% sand) with bulk density of 1.81 $g.cm^{-3}$. The site was then divided to plots, each plot had the dimension of 4.0×1.0×0.2 m with one row per plot, and each row will receive 12 seeds. Cucumber (*Cucumis sativus*) of Beta-alpha F1 variety was used with four seeds per one bed.

Four mulching types were used: the organic mulch (wheat straw), plastic mulches (black, transparent and yellow polyethylene with 100 microns thickens) and bare soil (uncovered soil) as control.

The cucumber seeds were planted manually by punching holes in the plastic and placing the seed in the soil through the holes. Super phosphate (1000 kg/ha), potassium sulfate (500 kg/ha) and organic fertilizer (50 m^3/ha) were applied during soil preparation. After planting, ammonium sulfate (16 kg/ha), urea (16 kg/ha) and potassium sulfate (40 kg/ha) were weekly added with water irrigation for two months. The soil set was irrigated using drip irrigation system in which the dripping line was placed about 10 cm from the center of the seedbed.

Soil and air temperatures were recorded after planting using copper-constantan thermocouples at certain depths of 0, 3, 5 and 7 cm. The germination ratio after 5, 7, 9, 11, and 13 days was calculated by enumerating the germinated seeds to the total number of sowed seeds. The progress in plant growth was determined by measuring the length of the plants after 25, 30, 35 and 40 days. In addition, flowering date was recorded by calculating the number of days from planting to starting of flower appearance. Moreover, crop yield was estimated as the amount of

yield per one hectare. Moreover, to determine the weed percent, images of the site for each treatment were acquired and analyzed qualitatively.

The water use efficiency (WUE) was determined according to **Awady et al. (1976)** by using the following formula:
WUE (kg/m^3) = Average yield (kg/ha.)/ Amount of applied water (m^3/ha).

RESULTS AND DISCUSSION

Effect of mulching on soil temperature

The obtained results demonstrated that all plastic films raised soil temperature substantially compared with bare soil (uncovered soil). During 24 hours, the behavior of temperature curves illustrated in Figs (1-4) indicated that the soil temperature decreased until 6:00 (morning) after which the soil temperature started to increase and reaches to its apex at noon (14:00). Then, the soil temperature decreased again during night and continued to decrease to its lowest value at 6:00 and so on.

In germination stage, Fig (1) showed that the soil temperature was affected by mulching types at soil surface (0 cm depth). The differences in maximum soil temperature between plastic mulch and bare soil were 3, 4 and 5 $^{\circ}C$ in case of black, yellow and transparent film respectively. Meanwhile in case of organic mulch (straw), the differences in maximum soil temperature was only 1 $^{\circ}C$ compared with bare soil.

Furthermore, the results showed that the soil temperature during daytime (from sunrise to sunset) decreased with increasing depth, while soil temperature increased with increasing depth at night. For instance, at time of 14:00, the soil temperatures were 30, 28, 26 and 25 $^{\circ}C$ at soil depths of 0, 3, 5 and 7 cm respectively. While at time 00:00 the soil temperatures were 20, 21, 22 and 23 $^{\circ}C$ for soil depths of 0, 3, 5 and 7 cm respectively under transparent film as shown in Fig. (1) and Table 1.

Table 1. Effect of different mulches on soil temperature at time 00:00 and 14:00 for soil depth of 0, 3, 5, 7 cm for germination stage.

Cover type	00:00				14:00			
	0	3	5	7	0	3	5	7
Bare soil (control)	17	18	18	19	25	24	23	21
Straw	18	18	19	20	26	24	23	22
Black	18	19	20	21	28	26	25	24
Yellow	19	20	21	22	29	28	27	25
Transparent	20	21	22	23	30	28	26	25

In the vegetative growth stage, presence of plastic mulches led to rising soil temperature compared with bare soil for all depths as shown in Fig. (2) and Table 2. For example, at time 14:00, the soil temperatures were 39, 37, 36 and 34 °C at soil depths of 0, 3, 5 and 7 cm respectively under black film. This indicated that the black film increased the soil temperature with 3, 2, 3, and 3 °C for 0, 3, 5, 7 cm soil depth respectively. Meanwhile at time 00:00, the soil temperatures were 24, 25, 25 and 26 °C at soil depth of 0, 3, 5 and 7 cm. respectively indicating that the black film increased the soil temperature with 1, 2, 1, 2 °C at these depths.

Table 2. Effect of different mulches on soil temperature at time 00:00 and 14:00 for soil depth of 0, 3, 5, 7 cm for growth stage.

Cover type	00:00				14:00			
	0	3	5	7	0	3	5	7
Bare soil (control)	23	23	24	24	36	35	33	31
Straw	24	24	25	25	35	34	30	29
Black	24	25	25	26	39	37	36	34
Yellow	25	26	26	27	39	38	37	34
Transparent	26	27	27	27	39	39	38	36

In flowering stage, the same effect of soil mulch could be inferred from Fig.(3) and Table 3. It is revealed that the transparent mulch gave the highest difference in the maximum soil temperature compared with bare

soil for all depths. For example, at time 14:00, the soil temperatures were 35, 32, 30 and 29 °C for soil depths of 0, 3, 5 and 7 cm respectively. While at time 00:00, the soil temperatures were 21, 22, 23 and 24°C at soil depth of 0, 3, 5 and 7 cm. respectively under transparent film.

Table 3. Effect of different mulches on soil temperature at time 00:00 and 14:00 for soil depth of 0, 3, 5, 7 cm for flowering stage.

Cover type	00:00				14:00			
	0	3	5	7	0	3	5	7
Bare soil (control)	17	18	19	20	33	29	28	27
Straw	18	19	20	21	32	27	26	25
Black	20	21	22	23	34	31	30	29
Yellow	20	20	21	22	33	30	29	28
Transparent	21	22	23	24	35	32	30	29

In the harvesting and yielding stage, the soil temperatures at time 14:00 were 31, 28, 26 and 25 °C at soil depths of 0, 3, 5 and 7 cm respectively. While at time 00:00, the soil temperatures were 20, 21, 22 and 22 °C at soil depth of 0, 3, 5 and 7 cm respectively under organic mulch as shown in Fig.(4) and Table 4.

Table 4. Effect of different mulches on soil temperature at time 00:00 and 14:00 for soil depth of 0, 3, 5, 7 cm for harvesting stage.

Cover type	00:00				14:00			
	0	3	5	7	0	3	5	7
Bare soil (control)	21	22	23	23	32	30	28	27
Straw	20	21	22	22	31	28	26	25
Black	23	24	24	25	33	32	30	28
Yellow	23	26	27	27	34	33	30	29
Transparent	24	25	26	26	35	33	31	30

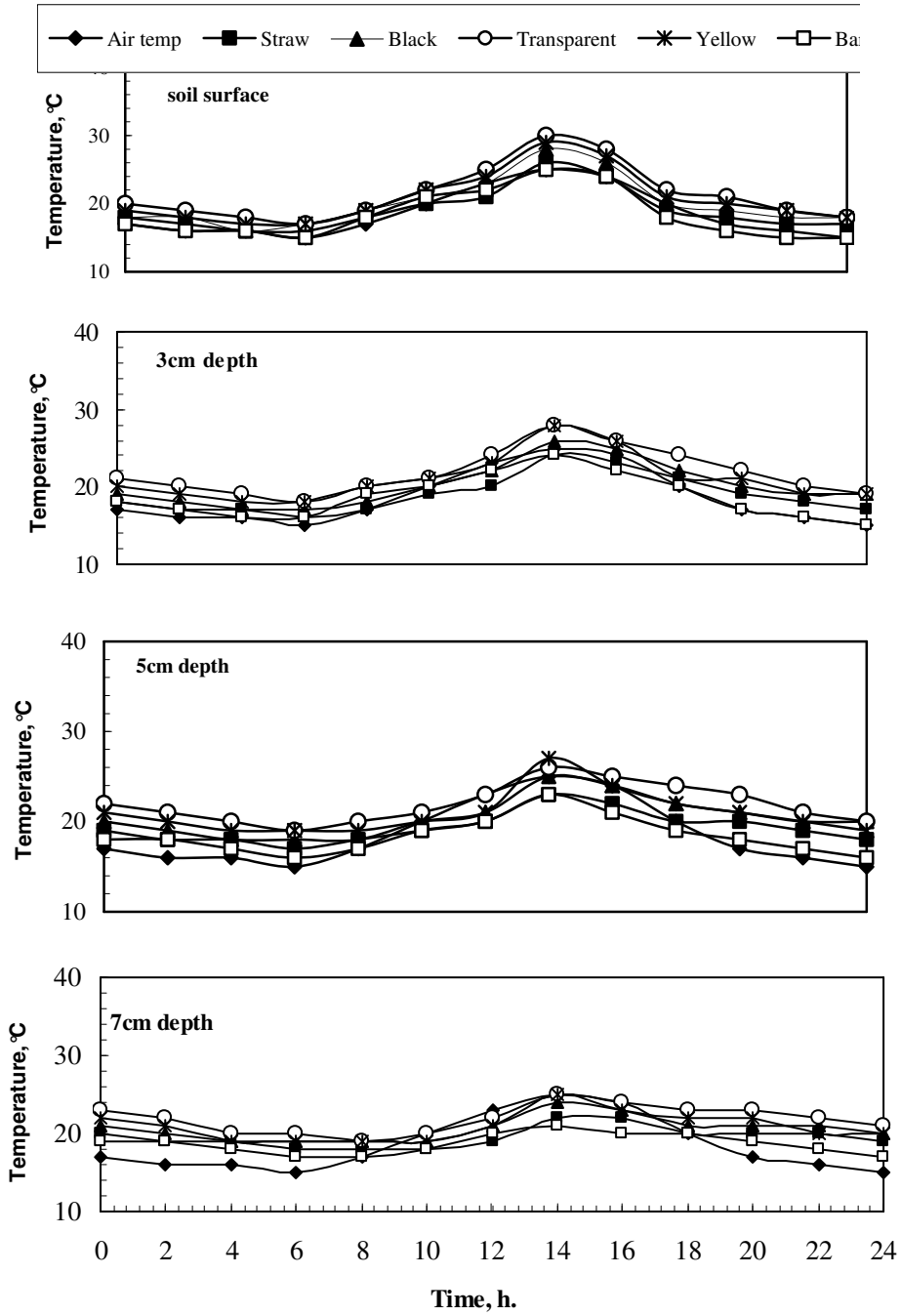

Fig 1: Diurnal fluctuations in soil temperature at depths of 0, 3, 5 and 7cm under different mulching types at germination stage.

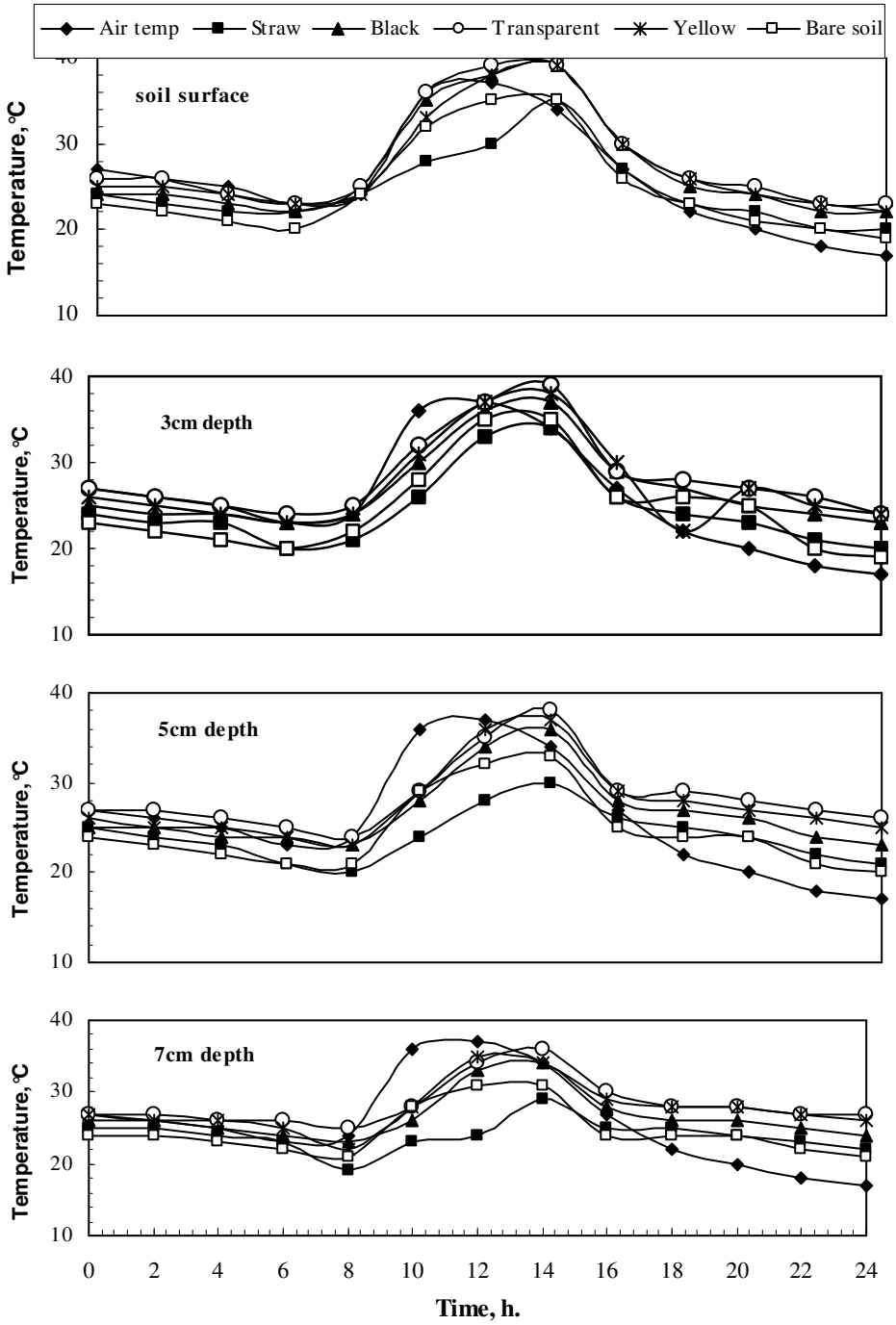

Fig 2: Diurnal fluctuations in soil temperature at depths of 0, 3, 5 and 7cm under different mulching types at growth stage.

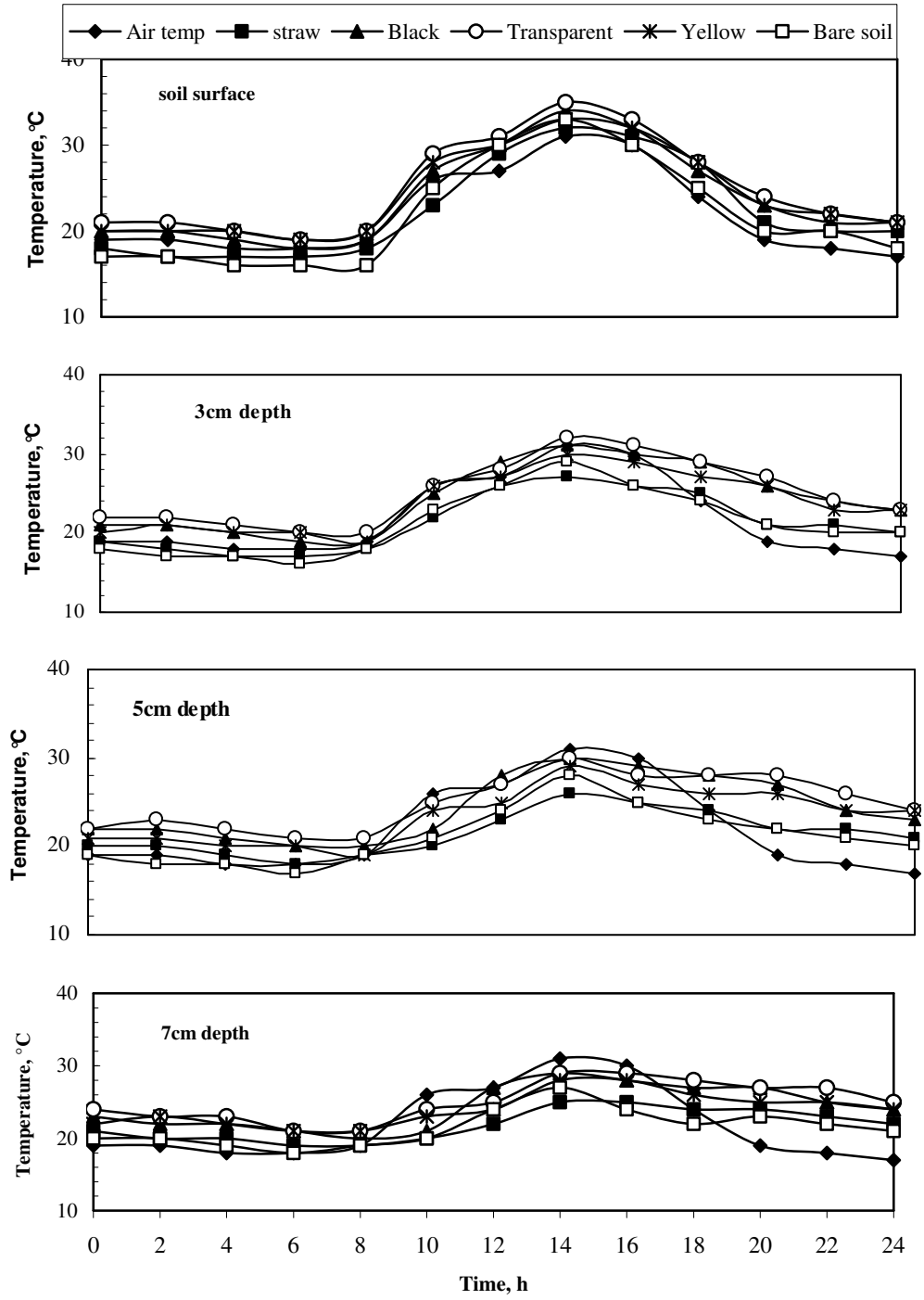

Fig 3: Diurnal fluctuations in soil temperature at depths of 0, 3, 5 and 7cm under different mulching types at flowering stage.

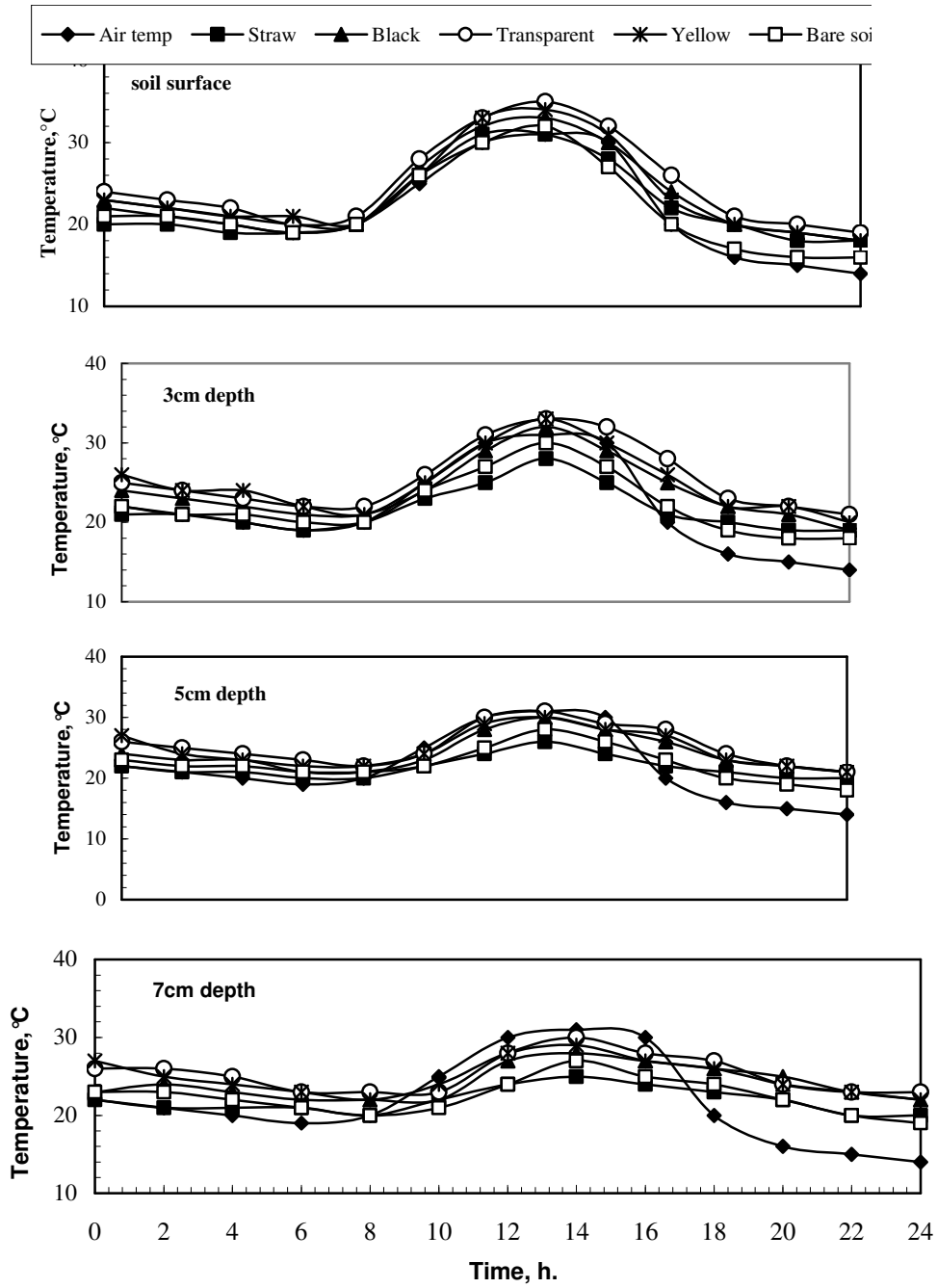

Fig 4: Diurnal fluctuations in soil temperature at depths of 0, 3, 5 and 7cm under different mulching types at harvesting stage.

Effect of mulching types on growing cycle of cucumber

The experimental results showed that the germination ratio is very sensitive to mulching material. As depicted in Fig.(5), the high value of germination ratio was obtained with transparent and yellow polyethylene mulch which is elucidated to that the plastic mulch increased the soil temperature in the root zone. On the contrary, the lower value of germination ratio in case of straw mulching was due to its capability to suppress any increase in soil temperature. In addition to their effect on germination ratio, the tested mulches led to early germination of cucumber seeds with 0, 2, 6, and 6 days using straw, black, yellow and transparent mulch respectively compared with uncovered soil.

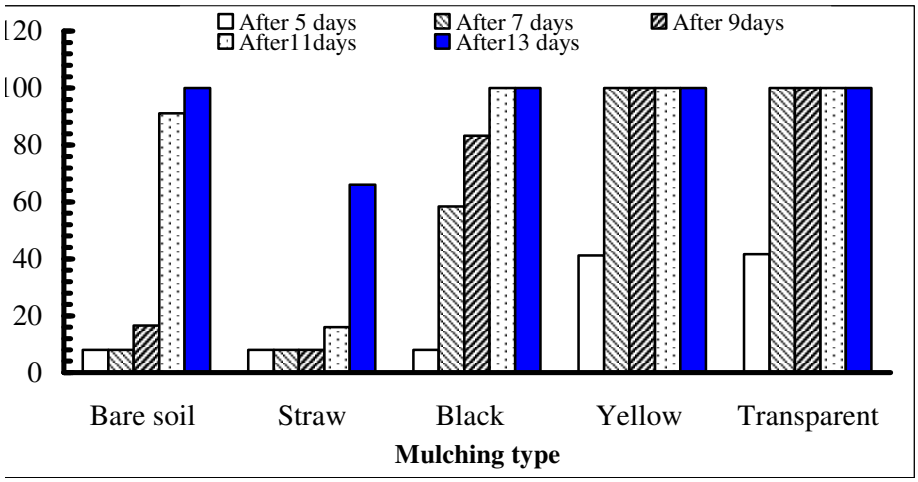

Fig. 5: Effect of mulching types on germination ratio.

It was found that the practice of mulching in spit of its type shortened the growth period. Fig. (6) showed the plant length increased with time after planting to reach to its highest values after 40 days from planting. After 40 days, the average length of the plants was 15.9, 12.3, 25.3, 35, and 36 cm for uncovered soil, straw, black, yellow and transparent mulch respectively. The increase in plant growth under plastic mulch could be referred to accumulation of carbon dioxide under plastic which created chimney effect and then resulting in abundant CO_2 for the actively growing leaves.

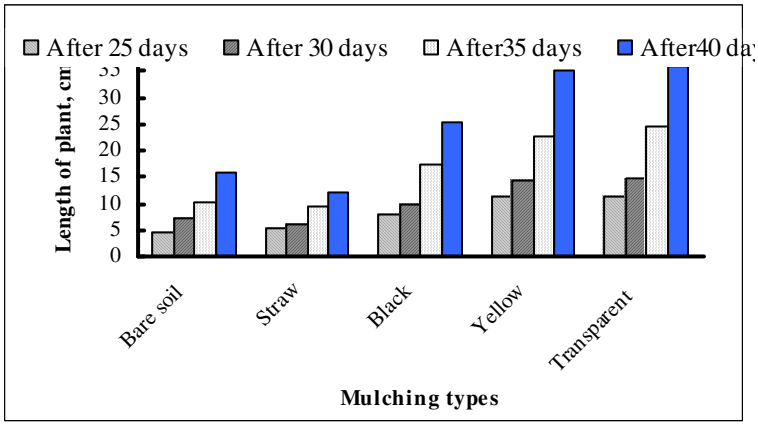

Fig.6: Effect of mulching types on plant growing

The stimulation of germination and growth led to accelerate flowering. Generally, flowering date was recorded by calculating the number of days from planting to starting of flower appearance. Fig (7) showed that the flowering date was 46, 48, 42, 40 and 39 days for uncovered soil, straw, black, yellow and transparent mulch respectively. This result indicated that the plastic mulch led to accelerate flowering with 6 and 7 days in case of yellow and transparent mulch. On the contrary, straw treatment retarded flowering with 2 days compared with uncovered soil and this delay in flowering date is due to its effect in decreasing soil temperature.

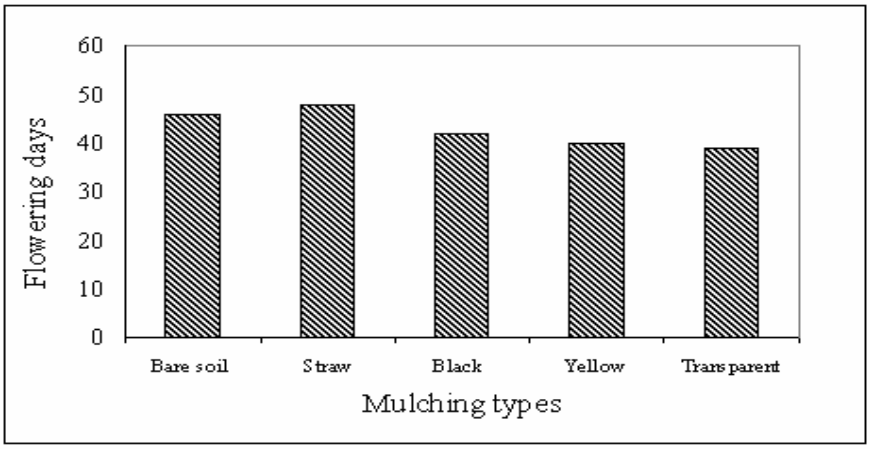

Fig. 7: Effect of mulching types on flowering date.

The results showed that the weed percent was affected by mulching types. Fig.(8) depicted the average weed percent for different treatments. The maximum reduction in weed percent of 98% was observed under black film while the minimum reduction was 9% under transparent film. The black film greatly inhibited light penetration to the soil; therefore, weed seedling cannot survive under the mulch.

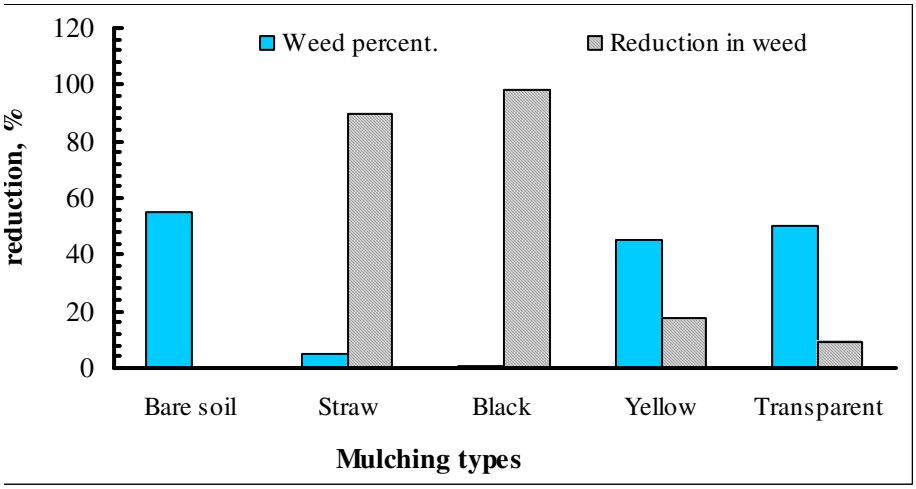

Fig. 8: Effect of mulching types on weed percent.

Effect of mulching on crop yield and WUE

In relation to the effect of mulching types on the cucumber yield, the results showed that the cucumber yield values were 5.57, 9.34, 11.65, 12.52 and 12.77 ton/ha. under soil bare, straw, black, yellow and transparent respectively as showing in Fig. (9). With plastic mulch, the high soil temperature in the planting bed will promote faster crop growing and early yield.

Finally, Fig (10) illustrated that the values of water use efficiency was 2.32, 6.22,7.76, 8.34 and 8.51 kg/m^3 under uncovered soil, straw, black, yellow and transparent mulch respectively.

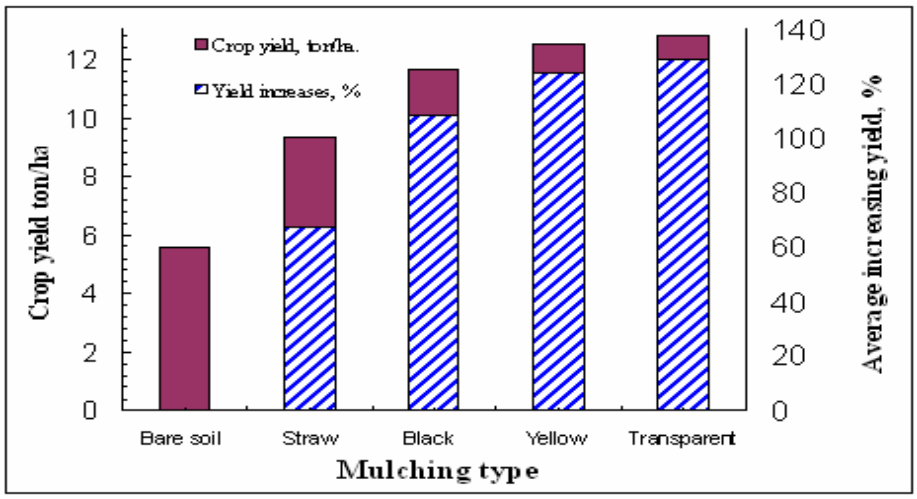

Fig. 9: Effect of mulching types on crop yield and average increase in yield.

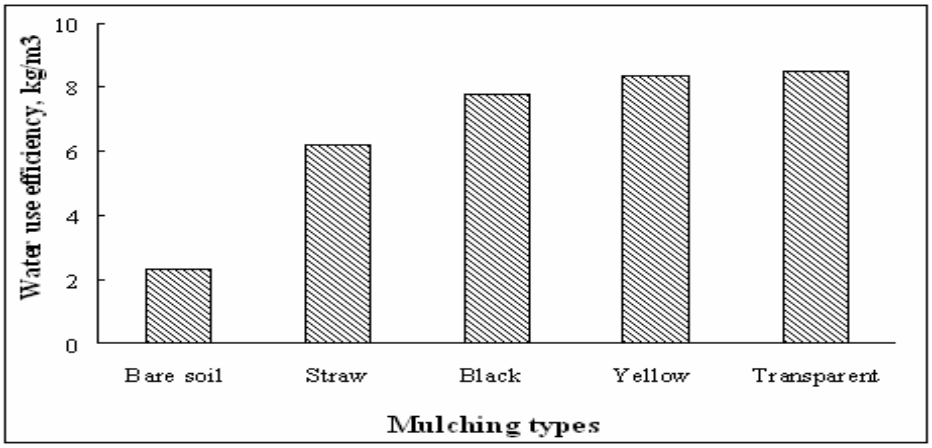

Fig 10: Effect of mulching types on water use efficiency (WUE), kg/m^3

CONCLUSION

This study was carried out as a comparative analysis to demonstrate the effect of organic mulch (wheat straw) and plastic mulches (black, transparent and yellow polyethylene) on soil temperature, germination ratio, plant growth, weed percent, water use efficiency and cucumber yield under drip irrigation system.

In general, the average soil temperature was greater than bare soil in case of using plastic mulch. Therefore, plastic mulches are recommended to

obtain high soil temperatures in the cold conditions; meanwhile, the organic mulches are better than plastic mulching in a hot climate due to its ability for reducing soil temperature.

The transparent polyethylene was highly promising technique for cucumber production because it increased soil temperature with about 7ºC, accelerated germination and flowering, and enhanced water use efficiency with about 8.51 kg/m^3 compared with the other tested covers. Cucumber yield was 67.6, 109, 124 and 129 % when the crop mulched with straw, black, yellow and transparent mulches. On the other hand, black polyethylene has advantage of reducing weed percent with about 98%.

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الملخص العربى

تأثير أنواع الأغطية على حرارة التربة وإنتاجية الخيار تحت الظروف الليبية

إسلام الشيخ[1] طارق فوده[2]

تنخفض درجة الحرارة في منطقة الجفارة بالجماهيرية الليبية في شهر مارس بشكل ملحوظ، هذا الإنخفاض يؤدي الي التأثير سلبا علي موعد ونسبة الإنبات لبعض محاصيل الخضر.

وقد أجرى هذا البحث بالمعهد العالي للتقنيات الزراعية- -الجفاره– ليبيا لدراسة تأثير أنواع مختلفة من الأغطية على درجة حرارة التربة، نسبة الإنبات، معدل نمو النبات، موعد التزهير، موعد الحصاد، كفاءة استخدام المياة، نسبة انتشار الحشائش وإنتاجية محصول الخيار.

تم إستخدام أنواع الأغطية التالية : غطاء عضوي (القش) وثلاث أغطية بلاستكية (أسود، شفاف ، أصفر) ومعاملة بدون غطاء للمقارنة. قيست درجة حرارة التربة على أربعة أعماق (السطح ، 3 ، 5 و7 سم) بالإضافة إلى درجة حرارة الهواء.

وكانت النتائج كالتالي:

ارتفعت درجة حرارة التربة علي الأعماق المختلفة مع استخدام الأغطية البلاستيكية بالمقارنة بالتربة المكشوفة وكانت أعلي قيم لدرجة حرارة التربة مع الغطاء الشفاف والذي أدي الي التبكير في الإنبات والتزهير للنباتات المزروعة تحت هذا الغطاء بالمقارنة بالنباتات المزروعة تحت الأغطية البلاستيكية الأخري.

أدى استخدام الأغطية إلى توفير كمية مياه الرى بالمقارنة بالتربة المكشوفة، حيث كانت كفاءة استخدام المياة (6.22، 7.67، 8.51، 8.34 و 3.42 كجم/متر مكعب) لكل من الغطاء العضوي، الأسود، الشفاف، الأصفر والتربة المكشوفة على التوالى.

أدى استخدام أغطية التربة إلى زيادة الإنتاج بمقدار 67، 109، 129، 124 % لكل من الغطاء العضوي، الغطاء الأسود، الغطاء الشفاف، الغطاء الأصفر بالمقارنة بالتربة المكشوفة.

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[1] مدرس الهندسة الزراعية – كلية الزراعة- جامعة قناة السويس

[2] أستاذ مساعد الهندسة الزراعية –كلية الزراعة- جامعة طنطا.