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Effect of Different Mulch Materials on Soil Temperature and Yield of Cauliflower.

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ABSTRACT :

Dynamic soil temperature and yield of Cauliflower (Brassica oleracea) gp. botrytis were studied using different mulching treatments evaluated under the local conditions of AL AIN - U.A.E. The treatments consisted of a control and three different mulch materials; Clear Polyethylene (PE), Black PE, and KURI-COAT (Latex mulch). The differences in soil temperature under the three types of mulch were not statistically significant; however, clear mulch treatment yield averaged 22.00 ton/ha followed by control treatment amounting to 20.1 tons/ha; KURI-COAT 19.9 ton/ha and black PE which gave 19.7 ton/ha.

Lower yield by black surface PE was attributed to the roughness of mulch which decreased heat transmission to the soil and to the loss of tensile strength due to prolong exposure to the sun and high temperature.

Additional key words : Mulch, Cauliflower, Clear (PE), Black (PE), KURI-COAT (Latex mulch), Soil temperature and yield.

INTRODUCTION

Plastic mulch is globally used in the production of fresh vegetables. Plastic mulches increase soil temperature, decrease nutrients leaching, increase soil Nitrogen mineralization and alter soil moisture (Wien and Minotti, 1988). The response of vegetable crops to mulch materials for earliness of tomato was reported by (Bhella, 1988; West and Pierce, 1988); better fruit quality (Wien and Minotti, 1987) and for higher yield by (Al-Masoum, 1982; Wien and Minotti, 1987; and Decoteau, 1988).

The mentioned responses above are attributed to increase in soil temperature (Taber, 1983; Hassan and Hussain, 1986; and Bonanno and Lament Jr. 1987); better and consistent use of soil moisture (Van Derwenken and Wilcox-lee, 1988; Bhella, 1988)and fertilizers (Bhella, 1988 and Wien and Minotti 1987).

The mulch preference is based on the effect of these materials on soil temperature. Clear PE is preferred for winter production, because of its ability in transmitting more solar energy, and balck PE in absorbing more heat (Hassan and Hussain, 1986). A white or aluminium coated mulch is preferred for summer production due to their ability in reducing soil temperature (Al-Masoum, 1982).

However, latex spray mulch is preferred because it increases soil temperature, reduces the rate of moisture loss, prevents soil erosion and reduces the stress on emerging seedlings or transplanted crops (Audette and pole, 1987).

The purpose of this experiment was to study the effect of mulch materials for their ability to modify soil

temperature and to increase yield of Cauliflower (Brassica oleracea) gp. botrytis.

MATERIALS AND METHODS

Cauliflower plants cv. "Snowball" * were started in Mid October, and transplanted to the field in mid-December, 1988 for early winter production.

The experiment was conducted at the Agricultural Education and Training Center at AL-OHA - U.A.E. (Latitude 24° 15⁻, Longitude 55° 45⁻ and Altitude 301.6 m above sea level). The plants were transplanted in rows 100 cm apart and spaced 50 cm between plants within the row in sandy soil (Typic pssaments) of pH 7.6.

Adequate organic and inorganic fertilizers and water were added according to cultural practices used in the district. Three different mulch materials were used; Black Polyethylene (PE), Clear PE (Kangaroo Plastics, DUBAI) and Latex mulch (KURI-COAT (Kurita Industry Co. Ltd., Japan). The plastic sheets were 1 m in width and 100 microns thickness.

Resistant bulbs (ER - 186; Yokogawa Hokushin Elect. Co. Ltd. Japan) with hand held data logger (MES - 801; KOITO Industries Ltd. Japan) and Platinum resistance sensor (PT - 100) with Data computing recorder (IPC - 1112; IIO Electric Co. Ltd. Japan) were used to record the soil temperture. Hourly soil temperature were measured with 12 thermocouples inserted at depth of 10 cms under plastic mulches, KURI-COAT

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* Commercial names are used for identification purposes only and do not imply any endorsement.

and control plots. Hourly values of air temperature were also recorded. 100 plants were taken from each treatment in order to determine the yield.

Yield of Cauliflower heads was determined as ton/ha at the end of the experiment. Mulch treatments were arranged in a randomized complete block design with 3 replications. Results of the experiment were analyzed using MSTAT computer software on an IBM-AT computer. Soil temperature values of the different treatments were fitted in linear regression models.

RESULTS AND DISCUSSION

Soil temperature :

The maximum daily temperature during the period of the experiment ranged between 20 - 30°C while that of the minimum temperature ranged between 12.5 - 15°C (Fig. 1a and b).

Significant linear correlations existed among mean daily soil temperatures and time (days) in the different treatments (Table 1 and Fig. 2). In addition, the differences among correlations were also significant. This difference was specially between KURI-COAT mulch and control and black mulch and control. The rate of drop in soil temperature was faster in the control treatment, followed by KURI-COAT mulch, clear and finally black (Fig 1a and b).

Table 1 : A list of the different linear regression models of mean daily soil temperature and (days) in the different treatments.

Treatment	Slope	Intercept	r^2	F-Value
Control	- 0.079	24.36	0.79	410.28
Clear PE	- 0.108	26.03	0.83	519.81
Black PE	- 0.176	25.36	0.77	336.50
Kuri-Coat	- 0.194	24.86	0.75	312.26

The maximum temperature recorded at 10 cm deep in the various treatments were clear PE mulch: 25.13 ^{o}C $\pm$ 4.2 ^{o}C; black PE 24.9 $\pm$ 7.4 ^{o}C; KURI-KOAT 23.8 $\pm$ 5.5 ^{o}C and control plots 23.57 $\pm$ 8.8 ^{o}C (Fig. 1). However, the minimum temperature reached by clear mulch was 18.13 $\pm$ 3.1 ^{o}C followed by 18.37 $\pm$ 6.1 ^{o}C for black, 17.57 $\pm$ 8.2 ^{o}C for KURI-COAT and 17.47 $\pm$ 5.7 ^{o}C by non mulched treatment. These findings are partially in agreement with those of (Takatori et. al. 1964).

It is assumed that hot dry air passes through a moist bare soil causing some of the water in the soil to evaporate. Latent heat needed for evaporation is removed from the air, so that air is cooled; consequently, soil temperature drops. Black mulch acts as an efficient black body absorber and radiator. Black plastics absorb most ultraviolet, visible and infrared radiations and retards absorbed energy as thermal energy. Much of the solar energy absorbed by black plastics is

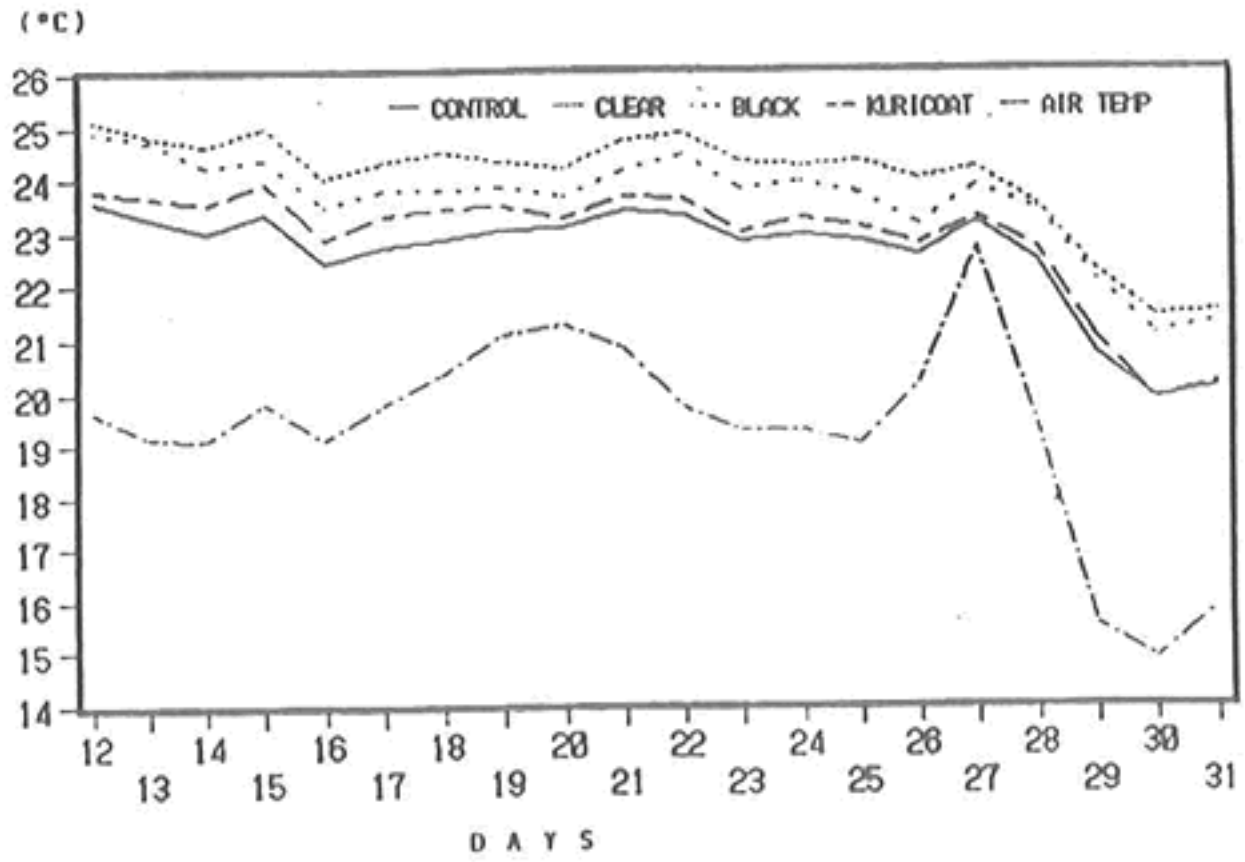

Fig. 1a: Average daily Soil temperature (Dec. 1988) at 10 Cm deep and air temp.

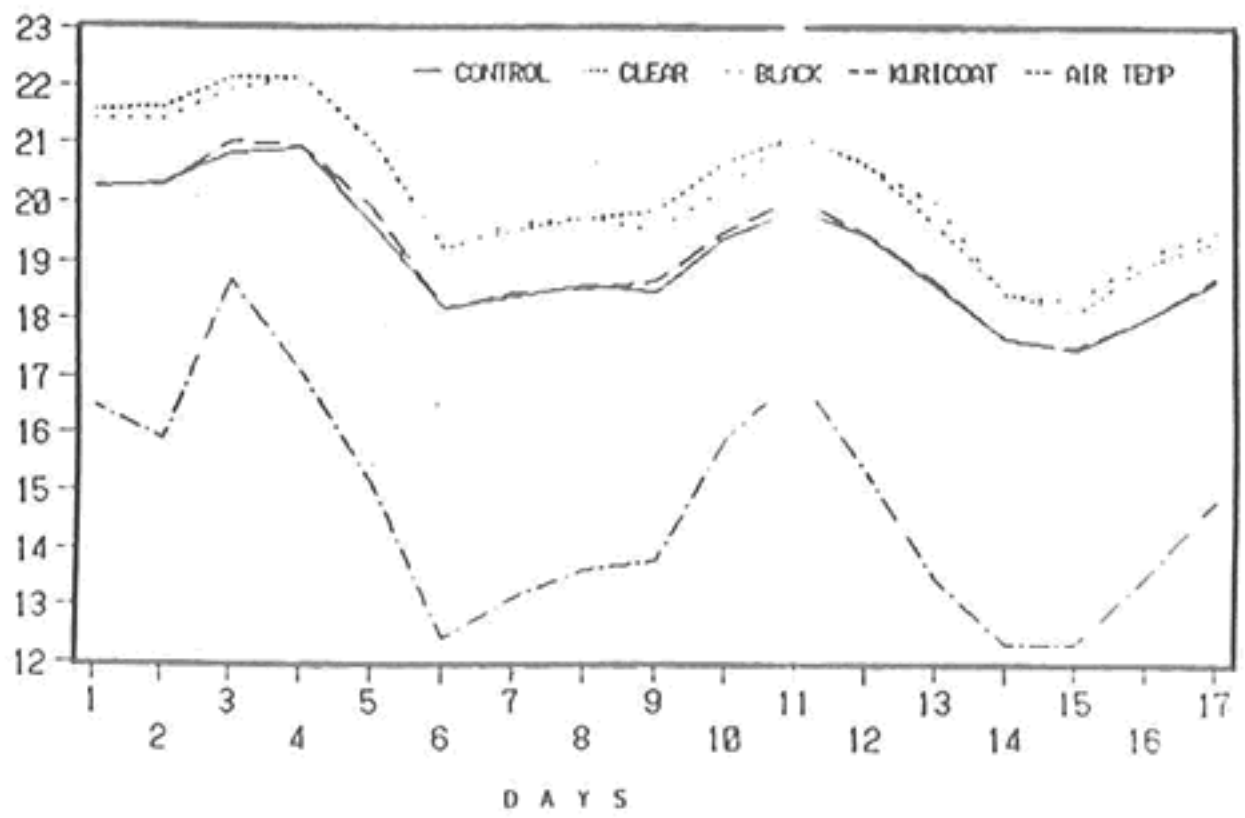

Fig. 1b: Average in Soil temperature (Jan. 1989) at 10 Cm deep and average air temperature

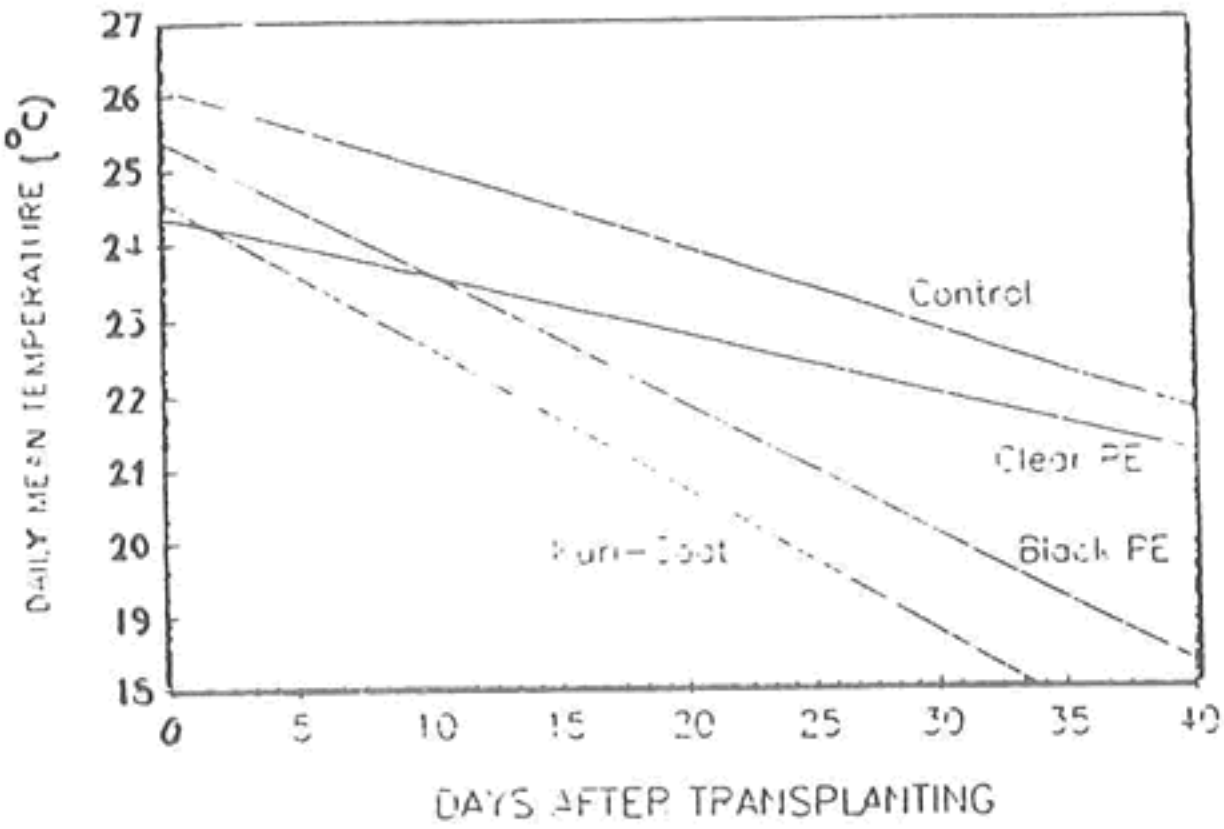

Figure 2. Linear regression models of soil temperature variation over time for the different treatments.

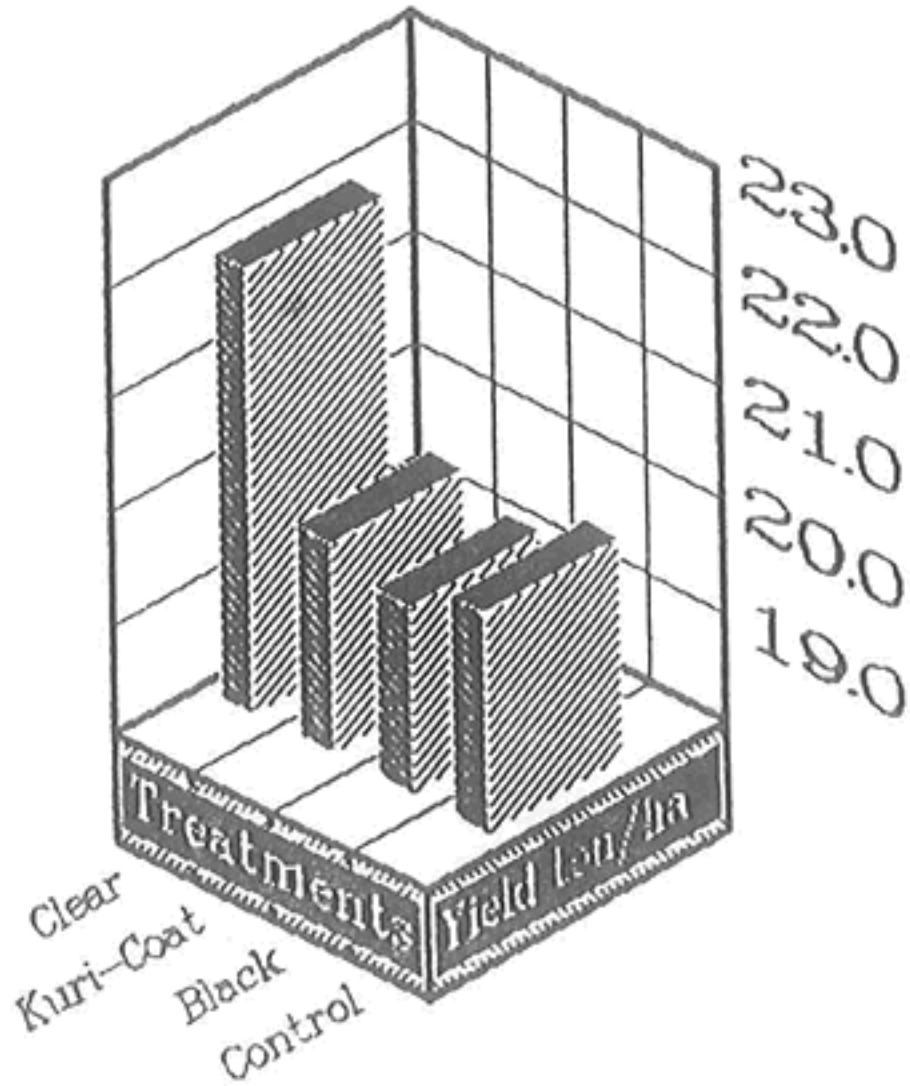

Fig. 3 : Effect of different mulch materials on yield of Cauliflower

lost to the atmosphere through radiation and wind currents. Loss of heat to the atmosphere can be minimized if there is a good contact between the mulch and the soil surface. It is also believed that over the time, black PE lose tensile strength when exposed to the sun and high temperature.

Clear mulch, by contrast, absorbs little solar radiation but transmits 85 - 90% radiant energy (Loy et al., 1989) depending on the thickness and degree of clarity of the PE. Most of the transmitted radiant energy is absorbed by soil particles. Thus, a big amount of heat is built up under the soil, then acts as a black body radiator.

Clear PE acts both as partial barrier to radiation heat loss and reduces convection heat loss, thus keeping soil temperature higher than the ambient or those obtained with black PE.

It is also assumed that latex mulch acts similar to clear PE. Audette and Pole, (1987) found that petroleum mulch and clear PE films at band widths of 6 inches or more increased soil temperature during the daylight hours to a depth of 6 inches and retained some soil heat during the night.

Yield of Cauliflower :

Air and soil temperature have a great influence on growth of the plant. Clear mulch tends to increase soil temperature; thus, effect plant growth. Fig. 3 shows that the total yield for clear mulched plots gave 22 tons/ha, while the yield under black and KURI-COAT was 19 ton/ha. The control plants yielded 20 ton/ha. No significant difference was observed in the yield of all treatments.

It was observed that the yield under clear plots tended to outperform the black and KURI-COAT treatments although it is believed the black PE absorbs more heat and transmits it to the soil.

It is assumed that the roughness of the surface of the mulch has a great effect on the amount of heat absorbed. It is also affected by the degree of contact between film and soil which also depends on the roughness of the surface due to the fact that heat is transferred by convention and conduction. Indeed, black plastic absorbs short wave radiation, thus; the film temperature rises and heat flux from the film to the soil occurs, and leads to an increase in soil temperature. Roughness of the film causes heat flux from film to soil to be relatively low due to poor contact, thus soil temperature is lower than that of smooth-face surface. These findings are in agreement with those of Kamichika and Matsuda, (1981) and Decoteau et. al (1989).

It is assumed that the observed tend towards higher production under clear mulch is due to the fact that water has higher specific heat than any other material, thus maintaining warmer temperature for longer period of time than bare soil.

The yield is also related to the more consistant availability of soil moisture. The enhancement due to prolonged maintenance of soil moisture resulted in more friable soil under mulch than with bare soil. Mulching may mitigate some of the harmful effects of saline irrigation water by decreasing moisture stress or by reducing evaporation and increasing infiltration (Patten et. al, 1988).

Inada and Yamaki, (1971) reported that water drops which adhere to the lower surface of the mulch resulted in much less temperature in black PE than in clear PE under solar radiation. This is because the lower the transmission of film by pigmentation, the higher the temperature becomes by absorbing the radiation energy, Sheldrake, (1963) investigated the influence of mulching, and found an improvement of CO_2 level in the plant canopy which he explained the early and total crop yield increase. Carbon dioxide concentration in the canopy increased four-fold due to CO_2 build up under the continuous films which emitted through the planting holes. This was referred to as 'Chimney effect'. Sheldrake, (1963) who suggested that this is the major factor contributing to the increase in growth and yield.

CONCLUSION

It is well recognized that one of the contribution of mulches is modification of soil temperature and conservation of soil moisture by reducing the evaporation. Plastics will play an important part in this type of production in the country for early vegetable production, even though, the introduction of special mulches such as aluminium coated and bio-degradable types will face some difficulties. Studies should be continued on new types of plastic mulches such as coloured mulches (red PE specifically) that are reasonable in price and bio-or- photo degradable.

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مجلة الأمارات للعلوم الزراعية (١٩٩١) ، ٢ : ٦٧ - ٧٩

تأثير مختلف الأغطية البلاستيكية الأرضية على درجة حرارة التربة ونمو محصول القرنبيط .

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الخلاصة :

تم اجراء تجربة على محصول القرنبيط (الزهرة) Brassica Oleracea gp. botytis فى مزرعة كلية العلوم الزراعية التابعة لجامعة الإمارات العربية المتحدة في عام ١٩٨٨/١٩٨٩. وكان الهدف من التجربه هو دراسة تأثير مختلف أنواع الأغطية البلاستيكية الأرضية وكذلك البلاستيك السائل على معدل رفع درجة حرارة التربة وزيادة محصول القرنبيط .

وقد دلت النتائج على أن الأغطية البلاستيكية المختلفة لم يكن لها تأثير ذات دلاله معنوية على رفع درجة حرارة التربة .

كما دلت النتائج على عدم وجود اختلاف ذات دلاله معنوية بين البلاستيك الإسود والشفاف والسائل والمعامله غير المغطاه فى زيادة محصول القرنبيط حيث بلغ معدل الإنتاج تحت البلاستيك الإسود ١٩ر٧ طن / هكتار والشفاف ٢٢ر٠٠ طن / هكتار ، بزيادة قدرها حوالى ٥٪ مقارنة بالشاهد ، بينما بلغ انتاج القرنبيط باستخدام البلاستيك السائل ١٩ر٩ طن / هكتار .

كلمات مفتاحية : حرارة التربة ، الأغطية البلاستيكية ، القرنبيط ، معدلل الأنتاج .