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S. M. Gomaa[1] , E. M. Khalifa[2] , M. K. El-Nemr[3]

يحوى أبحاث المؤتمر الثالث عشر
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ABSTRACT

Mulch is one of the most benefitical things which can minimize the needs for watering and modify soil environment for plants which will result in crop productivity increasement. An experiment was achieved to explain the effect of mulching on water regime and cucumber crop productivity under sandy soil conditions using drip irrigation. GR type of emitters was used at 10 m of water operating head. experiment was carried out in Wahet El-Nagah Farm, Khatatba Village, Menoufia Governorate, during the summer season of 2005. The present study included: Two types of mulch, rice straw (R) and white plastic (P) were used in comparing with open air conditions (O) and four ratios (70, 80, 90, and 100%) of crop irrigation requirement for both types of mulch and non-mulch treatments.The results showed that:-

- Increasing applied water from 70 to 100% led to increase productivity by 8%, 24%, and 29 % for rice straw, plastic, and no mulch treatments respectively.
-Crop production increased by increasing amount of applied water.The maximum value of crop production was (6.74 Mg / fed) under rice straw with 100% of water requirement.
- The maximum value of water use efficiency was 6.45 kg / m^3 under rice straw with 70 % of water requirement.
-The results revealed that after irrigation rice straw had kept the temperature of soil in good range with its ability on aerating and warming soil contrary to plastic which kept values of temperature higher than suitable ranges.
- The average losses values of soil moisture content were 2.15, 3.275 and 3.825% for rice straw, no mulch and white plastic, respectively.

INTRODUCTION

The beneficial effect of mulches includes earlier production and reduces insects and diseases problem **Hassan et.al,1992** mentioned

[1] Prof. Ag. Eng., Dept of Ag. Eng., Faculty of Ag, Kafr El-Sheikh, Tanta Univ.
2Assoc. Prof. Ag. Eng., Dept of Ag. Eng., Faculty of Ag, Kafr El-Sheikh, Tanta Univ.
[3] Assistant lecturer, Dept of Ag. Eng., Faculty of Ag, Kafr El-Sheikh, Tanta Univ.

that the suitable maximum range for growth of cucumber plants is between 28-30°C.That may explain the bad effect of plastic mulch on plant components because it kept the soil temperature over 31 for long period of the day.**Mohamed,1982** pointed out that ,the high soil tempertaure has a great effect on growth of roots and its ability on water and nutrients suction which some times may lead to plants wilting. **Tiwari et al., (2003)** indicated that ,Use of different types of mulches have been found to conserve moisture, control weeds , moderate soil temperature , and increase in yield in different types of vegetables. **Tiwari et al., (1998)** pointed out that , Drip irrigation is the most effective way to supply water and nutrients to the plant and not only saves water but also increases yield of fruits and vegetables crops. **Sivanappan and padmakumari (1980)** compared drip and furrow irrigation systems and found that about one-third to one-fifth of the normal quantity of water was sufficient for drip irrigated vegetables crops compared to those under surface irrigation. Cucumber crop production in Egypt in summer season of year 2003 recorded an average 8.46 Mg/fed. **Kirda et al. (1999)** indicated that deficit (or regulated deficit) irrigation is one way of maximizing water use efficiency (WUE) for higher yields per unit of irrigation water applied. His study results showed that cotton, maize, wheat, sunflower, sugar beet and potato are well suited to deficit irrigation practices, with reduced actual evapotranspiration. He concluded also with a 25 percent deficit, WUE was 1.2 times that achieved under normal irrigation practices. Plastic mulch has many types (White, black, white on black...etc) and considered as a good material for mulching but it has a great initial cost in addition to the costs of removing it at the end of the season. That we should search for cheap alternatives that gives same advantages of plastic. **Olson (1995)** pointed out that the white upper surface plastic mulch reflects the sun's energy and does not become heated. He added that, Drip irrigation is compatible with mulching, because the grower can maintain optimum moisture under the mulch. **Sanders (2001)** indicated that Muskmelons, tomatoes, peppers, cucumbers, squash, eggplant, watermelons and okra are vegetable crops that have shown significant increases in earliness, yield, and fruit quality when grown on plastic mulch. He also showed that soil temperature will be increased from 8 to 10 °F under clear mulch. **Clatterbuck (2003)** revealed that organic mulch moderates the

temperature of the root zone. Mulch provides an insulation effect, keeping the soil warmer during the winter and cooler during the summer.Rice straw is an organic production which acts an environmental problem in Egypt at last few years resulted from the harm way of its disposition (burning) because of the difficulties of using it as a commercial product for normal farmers. So there must be easy solves and usage for that cheap product.

An experiment was carried out on cucumber crop aiming to study:

1- Water use efficiency by using mulch to reduce the amount of applied water.
2- Difference between two types of mulch acting the organic and inorganic mulches compared to open air conditions and their effect on a responsive crop to whether water regime or mulch.
3- Effect of mulch type on both soil temperature and the ability of keeping moisture in the root zone.

MATERIALS AND METHODS

An experiment was carried out in the successive summer season 2004 /2005 in Wahet El-Nagah Farm, Khatatba Village, Menoufia Governorate. Cucumber crop (***F_1 Faris***) was used in the present study and planted in 22/7/2005 with 3 seeds per pore (50 cm spacing) and 5 cm depth then thinned to two plants/pore after germination under sandy soil conditions as shown in Table 1. The soil and water chemical analysis showed that, soil pH was 7.85, electric conductivity of water was 0.8 $ds.m^{-1}$ while SAR value was 2.55. In this case the irrigation water can be used with out any expected problems for salinity or infiltration (**FAO, 1985**). Chisel plow five shares was used to prepare the soil and erase residues of previous crop (***zea maize***) and weeds. Wooden piece 10.3 m length loaded with two men was used to facilitate the soil surface and the area slope was 1:1. 20, 75 and 100 kg/fed of N, P and K fertilizer were added during plowing operation before planting. Also, about of 40 kg/fed of sulfur were added to control alkalinity of soil.

Table (1): Some physical properties of the Experiment soil.

Soil depth, cm	Particle size distribution, %			Texture	F.C. %	W.P, %
	Sand	Silt	Clay			
0-15	89.69	0.47	9.84	Sandy	9.8	4.8
15-30	89.71	0.47	9.82	Sandy	10.2	5
30-45	88.54	3.21	8.25	Sandy	10.9	5.1

Irrigation Network:

Irrigation operation interval was 48 hours using drip irrigation system.

Built–in emitter (GR) was used for its wide spread usage and suitable costs. The laterals were 2 m spacing and 30 m length as shown in Fig. 1 .The distance between emitters along the lateral line was 50 cm. The mean value of emitter discharge was 4.41 l/h at 10 m operating pressure head.

Variables:

The present research included on the following variables:-

- Two types of mulch (Rice straw and white plastic) in addition to open air condition. The thickness of rice straw mulching was two inches to prevent over mulching, and avoid light mulch effect. white plastic was used because it is preferred to other dark types in hot time periods of the year .
- Four quantities of crop water requirement; 70% (A_1), 80% (A_2), 90% (A_3), and 100% (A_4).

The experimental area was designed as a split plot design and the plot area was 60 x 24 m. Mulch type was main plot and the applied water was sub plot. Means comparison test was performed to test the difference between treatments productivity values

Irrigation requirements

Climatic data were collected from Sadat meteo station for the year 2004. Reference Evapotranspiration (ET_o) was calculated using CROPWAT computer program. The resulted values of (ET_o) were 6.9, 6.3, 5.3, 4.2 mm/day for the months July, August, September, and

October respectively. The water requirement was calculated as follows: -

Gross irrigation requirements was calculated by using the following equation ***(FAO, 1980)***.

$$IR_g = \frac{IR_n}{E_a} \quad \text{..... 1}$$

$$IR_n = ET_{crop} + Lr \quad \text{..... 2}$$

$$ET_{crop} = K_c.K_r.ET_o \quad \text{..... 3}$$

Where:

IR_g = gross irrigation requirements, mm/day,

E_a = irrigation system efficiency (assumed 80%, ***Habib 1992***).

IR_n = net irrigation requirements (mm/day).

Lr = leaching requirements mm/day.(neglected because of the good mentioned water properties)

ET_{crop} = crop water requirements (mm/day)..

K_c = crop factor according to ***Allen et al. 1998***, (0.6,1,and 0.75 for the first , second, and last third of growing season, respectively)

K_r = Reduction factor (space between plants * space between laterals / 0.85 or 1 which is least refer to ***Habib 1992***.The value (one) was taken.

ET_o = reference evapotranspiration (mm/day) which was calculated depending on climatic data.

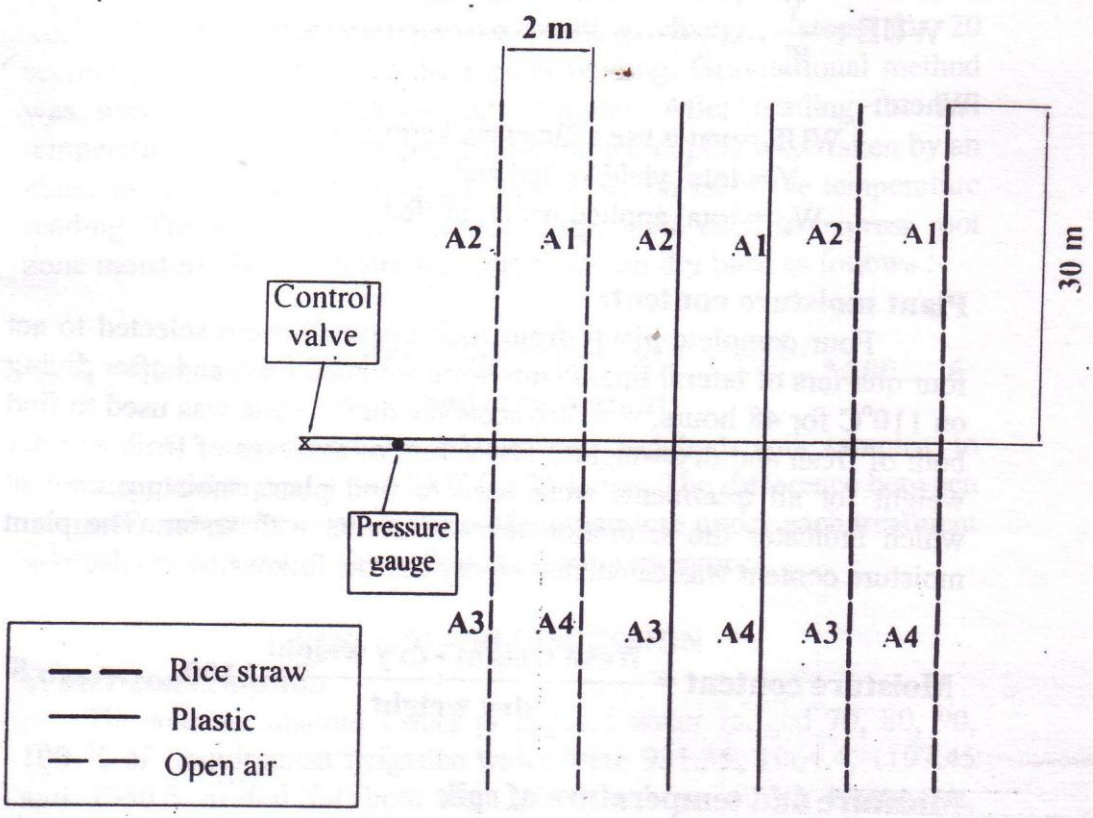

Figure.1: Schematic diagram for experimental area.

Productivity:

Four replicates from each treatment were taken to find the crop productivity along lateral. Fruits were weighed on 10 gm accuracy scale .The replicate was taken to act all the fruits in one meter length. The average of replicates were calculated and considered to act 2 m^2 in area. The productivity average of this area was doubled (multiplied in 2100) to act the productivity of feddan*.

Water use efficiency:

Water use efficiency has been used to describe the relationship between cucumber crop production and the total amount of water used. It was determined by applying the following equation (*Jensen, 1983*):

* One feddan = 4200 m^2

$$WUE = \frac{Y}{W_a} \quad \text{..... 4}$$

Where:-

WUE =water use efficiency, kg/m^3;

Y = total yield kg/fed and

W_a = total applied water, m^3/fed.

Plant moisture content:

Four complete plants from each treatment were selected to act four quarters of lateral line. Plants were weighed fresh and after drying on 110°C for 48 hours. A 0.001 accuracy digital scale was used to find both of fresh and dry weights. The values of averages of fresh and dry weight for all treatments were used to find plants moisture content which indicates the saturation level of plants with water. The plant moisture content was calculated on dry base as follows

$$\text{Moisture content} = \frac{\text{fresh weight - dry weight}}{\text{dry weight}} * 100 \quad \text{..... 5}$$

Moisture and temperature of soil:

The benefits of mulching when applied in the field: increase in soil temperatures especially in early spring, reduced weed problems, moisture conservation, reduction of certain insect pests, higher crop yields and more efficient use of soil nutrients. Water is shed from the row area and excess water runs off the field thus reducing drowning and other excess soil water stresses. The effect of mulching type on soil temperature was studied in the present work. The optimal soil temperature for cucumber crop ranges between 18 to 30 °C according to **Hassan et al, 1992**. Both of soil moisture content and temperature for the root zone were measured vertically at the same time for four different times from irrigation (after irrigation directly, 3 hours, 6 hours, 9 hours) at soil depths [(0-5), (5-10), (10-15), (15-20), (20-25), (25-30) cm] from the soil surface. A digital thermometer (0.1°C accuracy) with stainless steel probe was used to measure the mentioned horizons temperature .A soil profile (45 cm depth , 30 cm width) was dug directly after irrigation under random emitters from the first , second ,and the last thirds of laterals and the averages of

readings were used to express the values of temperature for each treatment. When the thermometer reading change stops for 20 seconds, it is considered as the correct reading. Gravitational method was used to express the moisture content. After reading the soil temperature, soil samples from the mentioned depths were taken by an auger to find the sample moisture content which faces the temperature reading. The average of moisture readings were used to express root zone moisture. Soil moisture was calculated on dry base as follows :-

$$\text{Soil moisture} = \frac{\text{Soil wet weight} - \text{Soil dry weight}}{\text{Soil dry weight}} * 100 \ldots 6$$

Dry weight was found by taking wet weighed soil samples to laboratory and drying it on 105°C for 24 hours. The difference between the maximum and minimum value of temperature under each treatment was calculated to judge the ability of keeping moisture.

RESULTS AND DISCUSSION

Water consumption

The average amount values of applied water ranged 70, 80, 90, 100 % of requirement irrigation water were 931.35, 1064.4, 1197.45 and 1330.5 m^3/fed for both rice straw and no mulch treatments, respectively of irrigation requirement. These values were 1031.65, 1164.7, 1297.75, and 1430.8 m^3/fed for plastic treatments at the same previous conditions. It is clear that the values of applied water in case of plastic mulch were higher than amount of water in case of rice straw and no mulch treatment because the cucumber plant stayed along time under plastic treatments.

Soil temperature: -

Heat-absorbing mulch is used to warm the soil and give plants a head start. Also, mulches were developed to increase soil temperatures while suppressing weed growth. Figure 2 (a,b,c) show the behavior of soil temperature under the different soil covering conditions and also describes how it was affected by air temperature under the different ratios of applied water. The results showed that under all soil covering conditions the soil temperature followed the same trend of air temperature. In another meaning by increasing air temperature the soil temperature will be increased and vice versa. Plastic mulch showed

higher values of soil temperature than both rice straw and open conditions. Under rice straw the values of temperature was decreased by increasing the amount of water till 6 hours. at the 9th hour when the air temperature reaches the minimum value during that time period (25.2°C) the heat storage ability of water raises in helping to keep the soil temperature higher than air temperature .That will be clear in the temperature behavior which will be higher for the 100% percentage and decreased gradually by decreasing the amount of applied water. The same would happen with plastic mulch but under plastic mulch the values of temperature will always be over 31°C except when the air temperature reaches its minimum value after nine hours .That may mean plastic mulch will improve heating soil .Keeping the soil temperature always in ranges lower than air temperature during hot periods may mean good ability for rice straw to aerate soil. That will be clear by comparing soil temperature under open conditions and rice straw. When the air temperature reduces the soil temperature under rice straw was higher than it was under open conditions. That may mean Rice straw will share in soil warming beside water. The high soil temperatures recorded under the white plastic mulch may have affected plant development.

Soil moisture:

Figure 3 shows the ability of keeping soil moisture for both types of mulches compared to open air conditions .It was found that soil moisture loss will be decreased by decreasing amount of applied water .That may be due to increasing the water holding in soil by moisture decrease.

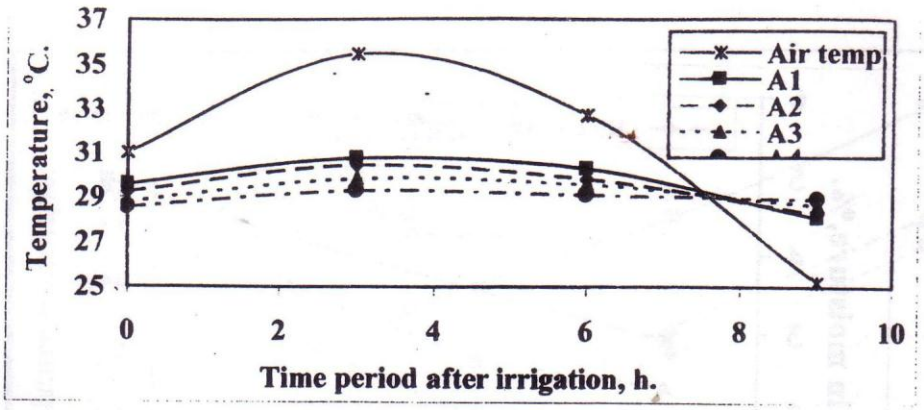

Fig. 2a :Effect of rice Straw on soil temperature after irrigation.

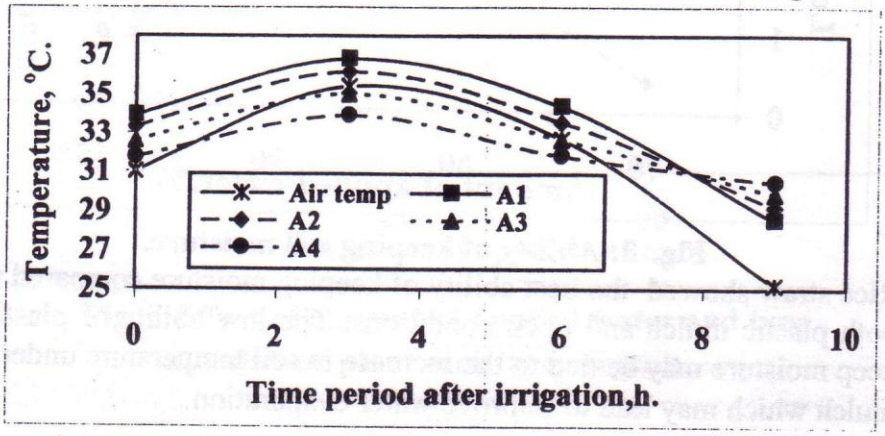

Fig.2b:Effect of plastic mulch on soil temperature.

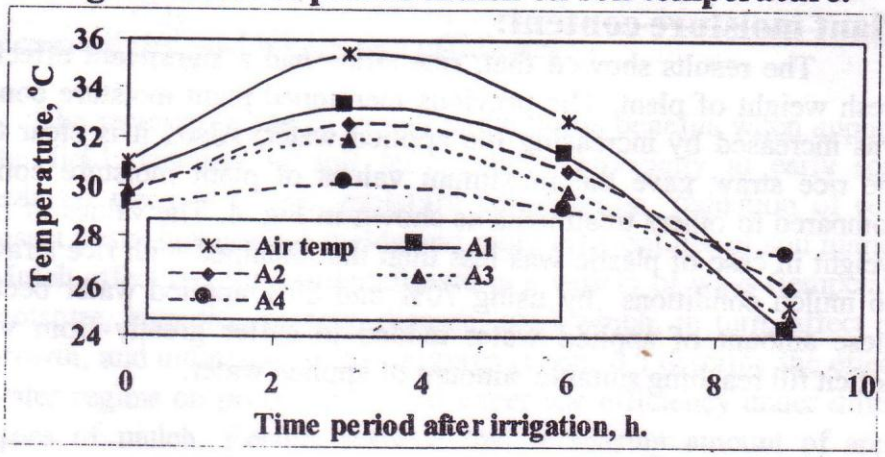

Fig. 2c:Soil temperature under open conditions.

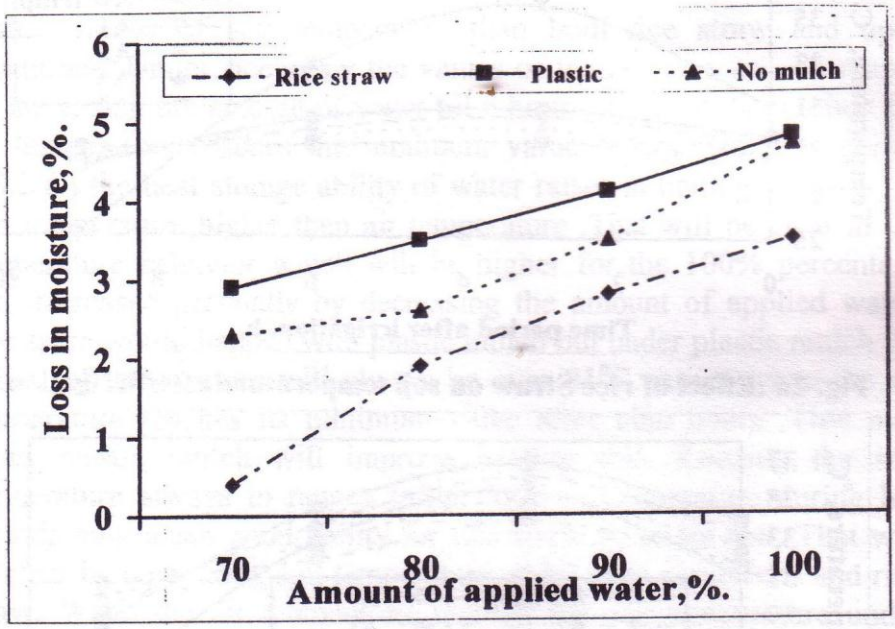

Fig. 3: Ability of keeping soil moisture.

Rice straw showed the best ability of keeping moisture compared with both plastic mulch and open conditions. The low ability of plastic to keep moisture may be due to the increase in soil temperature under that mulch which may lead to improve water evaporation.

Plant moisture content:

The results showed that, rice straw had a significant effect on fresh weight of plant. The previous mentioned plant moisture content was increased by increasing the applied water. Also,, it is clear that, the rice straw gave the maximum values of plant moisture content compared to others treatments as shown in Fig. 4. The values of fresh weight in case of plastic was less than that obtained with rice straw or no mulch conditions by using 70% and 80% applied water because these amount of applied water tended to suffer greatly from water deficit till reaching suitable amount of applied water.

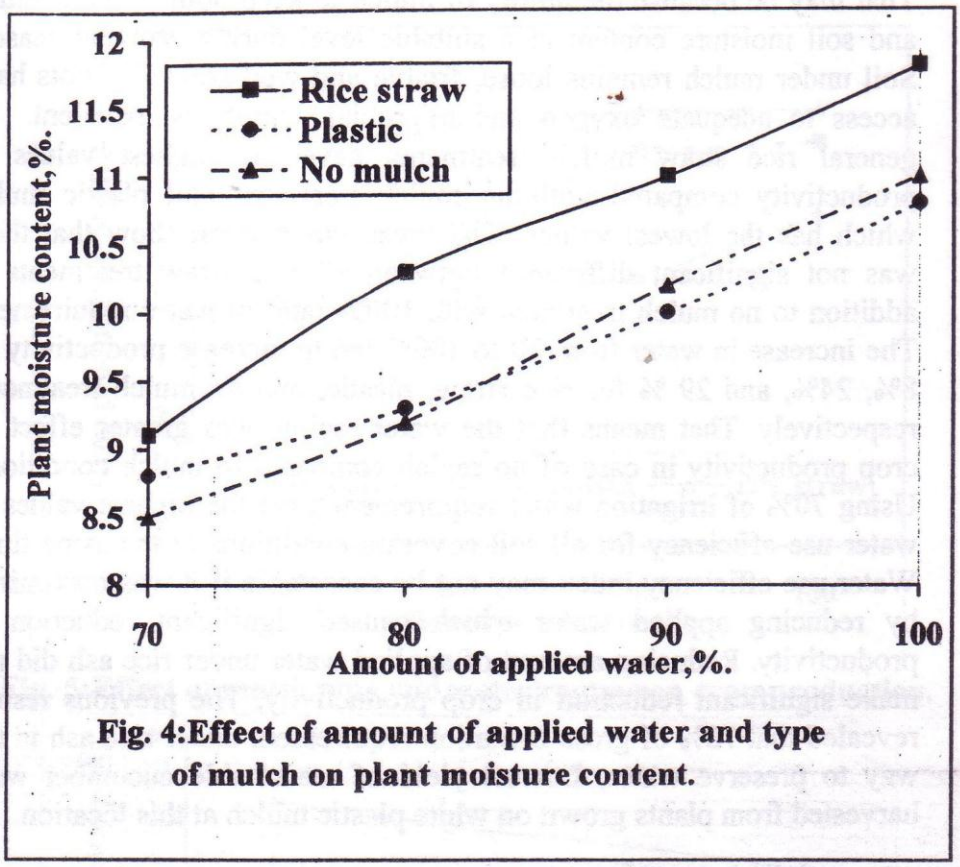

Fig. 4:Effect of amount of applied water and type of mulch on plant moisture content.

Productivity and water use efficiency: -

The increase in use of mulch is due to its benefits when applied in the field: increase in soil temperatures especially in early spring, reduced weed problems, moisture conservation, reduction of certain insect pests, higher crop yields and more efficient use of soil nutrients. Mulch affect the plant microclimate in a variety of ways (temperature, moisture, humidity, insects, disease, etc.) which, in turn, affect plant growth, and ultimately yield. Figures (6 and 6) describe the effect of water regime on productivity and water use efficiency under different types of mulch. Results showed that increasing amount of applied water leaded to increase crop productivity for all types of mulch. The highest value of crop productivity was 6.74 Mg/fed obtained under rice straw with 100% ratio of water requirement while the lowest value was 3.86 Mg/fed, under plastic mulch with 70% ratio water requirement.

That may be because the ability of mulch to keep both of temperature and soil moisture content at a suitable level during growing season. Soil under mulch remains loose, friable and well-aerated. Roots have access to adequate oxygen and microbial activity is excellent. In general rice straw mulch treatments gave the highest values of productivity compared with no mulch treatment and plastic mulch which has the lowest values. The mean comparison show that there was not significant difference between all rice straw treatments in addition to no mulch treatment with 100% ratio of water requirement. The increase in water from 70 to 100% led to increase productivity by 8%, 24%, and 29 % for rice straw, plastic, and no mulch treatments respectively. That means that the water regime was greater effect on crop productivity in case of no mulch compared to mulch conditions. Using 70% of irrigation water requirement gave the highest values of water use efficiency for all soil covering conditions at the same time. Water use efficiency index may not be acceptable if it was maximized by reducing applied water which caused significant reduction in productivity. Reducing amount of applied water under rice ash did not make significant reduction in crop productivity. The previous results revealed that 70% of gross irrigation requirement under rice ash in the way to preserve water. Lowest yield of marketable cucumber were harvested from plants grown on white plastic mulch at this location..

Figure 7 points out the effect of the average of soil temperature during 9 hours after irrigation and crop productivity .The Figure showed that in the range between 28.63°C to 29.41 the temperature incensement will lead to increase crop productivity .

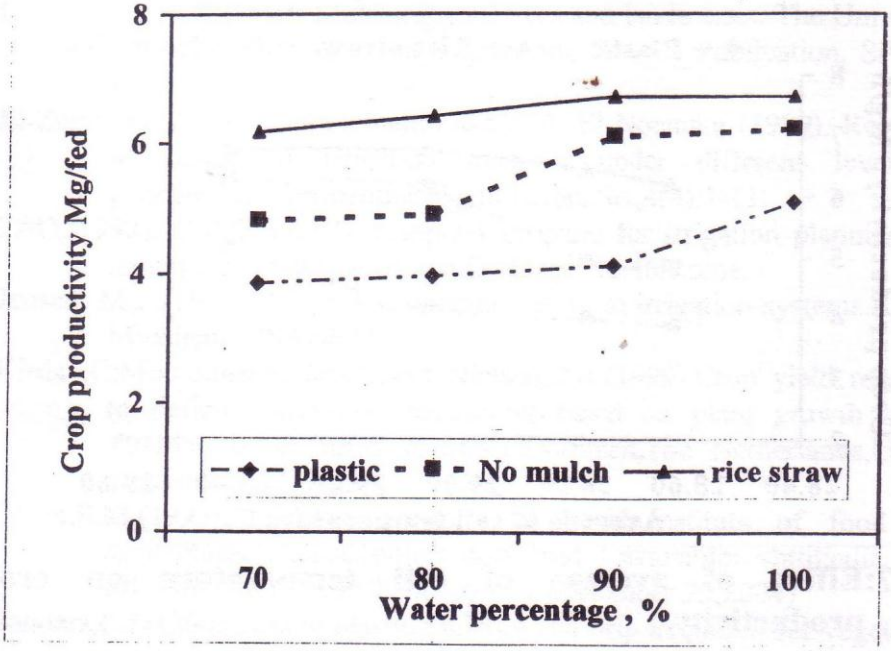

Fig. 5:Effect of mulch type and water regime on crop production.

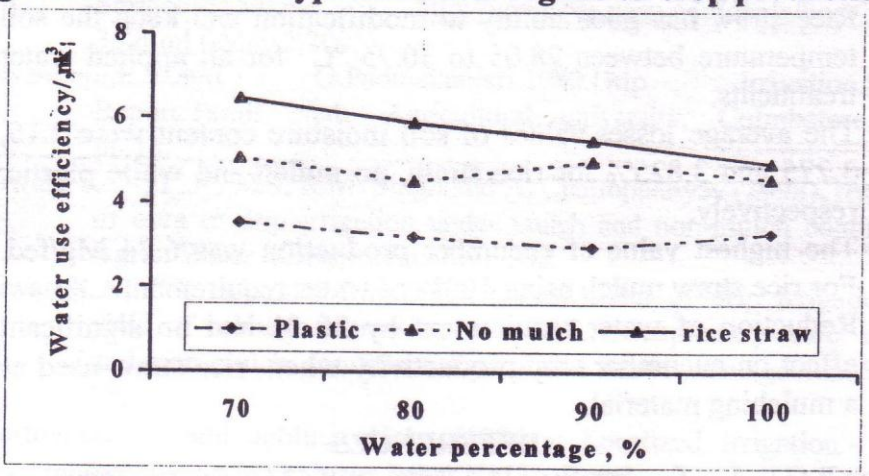

Fig. 6:Effect of mulch type and water regime on water use efficiency.

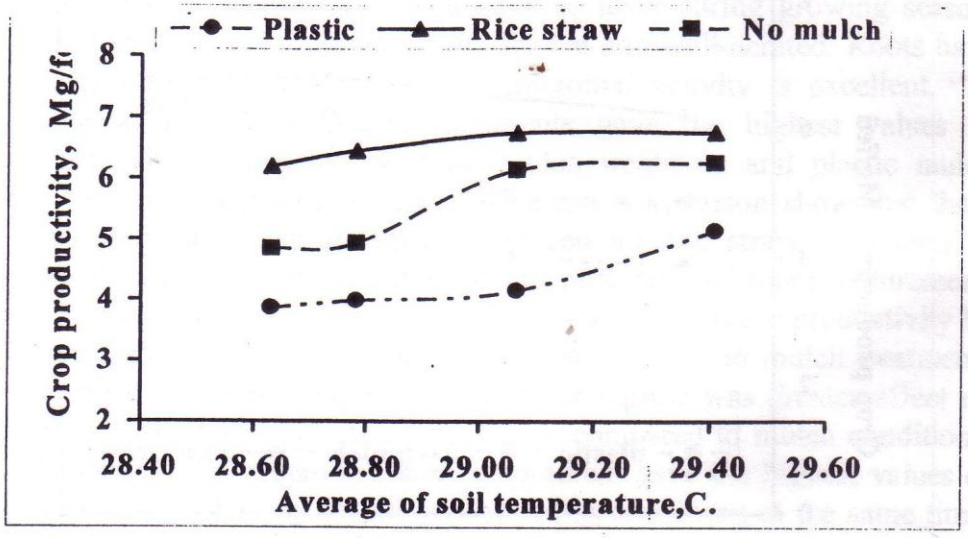

Fig.7:Effect of average of soil temperature on crop productivity.

Conclusion

1- Rice straw has good ability to modification and keep the soil temperature between 28.05 to 30.75 °C for all applied water treatments.

2- The average losses values of soil moisture content were 2.15, 3.275 and 3.825% for rice straw, no mulch and white plastic, respectively.

3- The highest value of cucumber production was 6.74 Mg/fed. For rice straw mulch using 100% of water requirement.

4- Reduction of water requirement by 30 % had no significant effect on cucumber crop productivity when rice straw used as a mulching material.

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