Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 55(2) (2017), 371 –384 **http://annagricmoshj.com**

Effectiveness of mulch treatments on soil properties and maize growth

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Abstract

A field experiment was conducted along two successive seasons of summer 2015 and 2016 at Giza Agricultural Experimental Station of the Agricultural Research Center (ARC), Giza, Egypt. Treatments included four mulching: (1) bare soil (un-mulched) as control (BS) (2) black plastic (BP) (3) rice straw (RS) at a rate of 4.8 Mg ha^{-1} (4) maize straw (MS) at a rate of 4.8 Mg ha^{-1}. Temperature, moisture content, physical properties of soil and maize productivity were significantly affected by the different mulch treatments compared to BS. The highest values of temperature, moisture content, total porosity, saturated hydraulic conductivity of soil and maize productivity, as well as, lowest values of bulk density and penetration resistance were obtained under BP. The RS and MS treatments increased most studied characters. The RS and MS decreased soil temperature. There were no significant differences between RS and MS. The non-mulched treatment had the lowest values of most studied characters except soil temperature where it was between BP and both of RS and MS. Temperature and moisture content of soil decrease as soil depth increase. Although RS or MS gave lower maize productivity than BP but they are inexpensive and available under Egyptian condition.

Keywords: mulch treatments; soil temperature; soil moisture content; soil physical properties; maize productivity

1. Introduction

Materials used to spread over soil surface to conserve soil and moisture are called mulches. Different types of materials like wheat straw, rice straw, plastic film, grass, wood, sand are used as mulches **(Khurshid *et al.*, 2006 and Seyfi and Rashidi 2007).** The use of plastic mulch in field crops such as maize, cotton, sugarcane, and rice is successfully used **(Kasirajan and Ngouajio 2012).** Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content **(Opara 1993, Hochmuth *et al.*, 2001 and Awodoyin and Ogunyemi 2005)**. Mulching can be done using organic or inorganic materials (**Kamal and Singh 2011). Dalorima, *et al*., (2014)** reported that mulching makes favorable condition for plant growth, and crop production. Mulching can control pests, conserve soil moisture, modulate the soil temperature, suppress weed, increase crop yield and improve crop quality **(Greer and Dole, 2003)**. Synthetic plastic mulches can promote plant growth and develop extensive roots and increase uptake of nutrients and increase soil water content **(Khurshid *et al.*, 2006).** Mulch provides a better soil environment, moderates soil temperature, increases soil porosity and water infiltration during intensive rain and controls runoff and erosion as well as suppresses weed growth **(Sarkar and Singh, 2007 and Glab and Kulig, 2008).** Straw mulching may conserve soil water and reduce the temperature due to the reduced soil disturbance and increased residue accumulation in soil **(Zhang *et al.*, 2009).** Straw mulches suppress soil temperature by preventing the radiant energy to contact soil directly **(Khan *et al*, 2000).** High soil temperatures was reported using plastic mulch **(Ramakrishna *et al.*, 2006). (Mbah *et al.*, 2010)** reported that plastic mulching (white, white black and black) increased soil temperature and water retention. **Javeed *et al.*, (2013)** reported that the mulches decreased bulk density in clay soil and increased porosity and the minimum root penetration resistance was observed in the black plastic mulches (1743.1 kPa) as well as with wheat straw mulches (1747.3 kPa). Polythene mulches have a positive effect on growth, yield and quality of maize **(Kulkarni *et al.*, 1998)**. Mulches conserve soil moisture and prevent erosion as well as increase soil fauna and flora activities, suppress weeds all of which lead to high crop yields **(Seyfi and Rashidi 2007 and Essien *et al.*, 2009).** Mulching adjusts soil temperature and moisture **(Acharya *et al.*, 2005)** and directly improves the grain yield of crops **(Ramalan and Nwokeocha 2000). Bhatt *et al.*, (2004)** reported that dry matter yield and grain yield of maize in wheat straw mulching plots were significantly higher (138% and 60.5%). **Javeed *et al.*, (2013)** observed that grain yield of maize increased by black plastic mulches. **Khurshid *et al.*, (2006)** reported that the mulch had positive effect on yield of maize and increased water contents in soil due to reduced evaporation. **Mbah *et al.*, (2010)** reported that the maize yield increased by 55 to 78 % in one season and 108 to 142 % in another season were observed in film mulch treatment relative to the control.

2. Materials and Methods

2.1. Site description

A field experiment was conducted in the two successive seasons of summer 2015 and 2016 on maize (*Zea mayes L. c. v*. single cross 10) at Giza Agricultural Experimental Station of the Agricultural Research Center (ARC), Egypt, lying between 30° 02- latitude and 31° 21- longitude. Its attitude is 30 meter above sea level. The aim was to evaluate the effect of four mulch treatments on temperature, moisture content, physical properties of soil and maize productivity. Main properties of soil are shown in Table 1 according to the methods described by **Page *et al.*, (1982)** and **Klute (1986)**.

2.2. Experimental design

The experimental treatments included four mulching treatments arranged in a randomized complete block design with three replicates as follows: (1) bare soil (un-mulched) as control (BS) (2) black plastic (BP) (3) rice straw (RS) at a rate of 4.8 Mg ha^{-1} (4) maize straw (MS) at a rate of 4.8 Mg ha^{-1}. The plot size was 9 x 6 m (54 m^2). Rice straw and maize straw were applied by hand, black plastic sheet was used to cover the soil area between crop rows Mulching treatments were imposed 25 days after sowing.

2.3. Data collection and determination of soil physical properties

Soil temperature was measured daily after two days from irrigation using K-thermocouple thermometer. Sensors were buried between plants at depths of 0, 5, 15 and 25cm. Soil moisture content was monitored by measuring gravimetrically (drying methods) at the same time of measuring soil temperature at the three studied layers *i.e*. (0-10), (10-20) and (20-30) throughout the period from 50 day till 104 day after sowing (DAS) at the stages of tasseling (VT), blister (R1), silking (R2), Milking (R3), Dough (R4) and Physiological maturity (R6) growth stage. The mean daily soil temperature and soil moisture content were calculated as the average of every growth stage. Bulk density was determined in undisturbed soil core samples. Total porosity was computed from according the following equation:

$TP= (1 - B_d/P_d) \times 100$

Where TP is total porosity, B_d is bulk density and P_d is particle density (2.65 g/cm^3). Penetration resistance was determined using a pocket penetrometer. Undisturbed soil samples were taken to determine saturated hydraulic conductivity by constant head methods.

2.5. Crop management

Maize seeds were planted into rows. Two seeds per hill spaced at 20 cm between hills and 70 cm between ridges. Two weeks after emergency plants were thinned to one plant/hill. All recommended agriculture practices were carried out. Nitrogen was applied at 220.8 kg N ha^{-1} as urea, (0.46 kg N kg^{-1}) added in 2 equal doses, before the first and second irrigation, Phosphorus fertilizer was applied at 32.5 kg P ha^{-1} in the form of ordinary calcium super phosphate (67.74 g P kg^{-1}) incorporated into the soil during land preparation and K was applied at 47.81 kg K ha^{-1} as potassium sulfate (0.398 kg K kg^{-1}) was given before the first irrigation.

At harvest grain and straw yields were determined. The weights of cobs and straw from the net plot of each treatment were determined in the field before taking subsamples for moisture determination. Grain and straw samples were dried at 60 C^o for 48 hours for moisture adjustment. Maize shelling percentage was determined. Grain yield was on basis of 12.5 % moisture content.

Table 1. Soil physical and chemical characteristics of the experimental site.

Soil depth (cm)		0 - 10	10-20	20 -30
Physical properties				
Particle size distribution %	Coarse sand	14.82	20.10	5.84
	Fine sand	27.70	26.47	27.98
	Silt	23.31	25.45	35.29
	Clay	34.17	27.98	30.89
Texture class*		Light clay	Light clay	Light clay
Bulk density (Mgm^{-3})		1.34	1.37	1.40
Total porosity (%)		47.15	46.78	43.40
Saturated hydraulic conductivity(cm/h)		2.89	2.09	1.35
Penetration resistance (MPa)		1.61	1.77	1.82
Chemical properties				
$CaCO_3$ (%)		4.45	3.01	1.25
Organic matter (%)		1.42	1.23	1.15
pH		7.93	7.87	7.95
EC (dSm^{-1})		2.52	2.31	1.75

*According to the International soil texture triangle.

3-Results and Discussion

3.1. Effect of mulch treatments on soil properties:

3.1.1. Soil temperature:

Data in Table 2 and illustrated in Fig. 1 show that the soil temperature was significantly affected under the different mulch treatments. Data also show that the soil temperature increased during growth stages and reached the highest values at R2 stage. Data show that soil temperature decreased by increasing soil depth. BP raised soil temperature substantially compared with the other mulch treatments (BS, RS and MS). The soil temperature of BP ranged from 37.33 ^{0}C for the soil surface at R2 stage to 24.30 ^{0}C in the 25 cm depth of soil at R6 stage. The BP treatment was superior in increasing soil temperature. The increment values, as average, were 1.24, 1.32, 1.46, 1.48, 1.23, and 1.25 ^{0}C as compare to BS for growth stages at VT, R1, R2, R3, R4, and R6, respectively.

Table 2. Effect of mulch treatments and soil depths on soil temperature (C^{o}) during different growth stages of maize.

Mulching treatments (M)	Soil depths(cm) (D)	Soil temperature (C^{o}) Growth stages					
		VT	R1	R2	R3	R4	R6
BS	0	30.32	32.60	34.80	33.27	30.15	28.50
	5	26.40	27.89	28.42	27.83	27.45	27.00
	15	24.45	25.52	26.77	25.05	24.22	24.02
	25	24.13	24.73	24.98	24.36	24.05	24.01
Mean		***26.33b***	***27.68ab***	***28.74ab***	***27.63ab***	***26.47b***	***25.88b***
BP	0	32.73	35.16	37.33	36.07	32.66	31.00
	5	27.99	29.60	30.74	29.48	28.76	28.30
	15	25.18	26.26	27.34	26.00	25.00	24.90
	25	24.38	24.99	25.39	24.89	24.40	24.30
Mean		***27.57a***	***29.00a***	***30.20a***	***29.11a***	***27.70a***	***27.13a***
RS	0	29.73	30.37	31.40	31.12	29.01	28.30
	5	25.48	26.89	27.43	27.11	26.23	26.20
	15	24.12	25.37	26.35	24.86	24.11	24.05
	25	24.00	24.57	24.76	24.09	23.80	23.90
Mean		***25.83b***	***26.80b***	***27.48b***	***26.79b***	***25.79b***	***25.61b***
MS	0	29.08	28.97	30.03	29.15	28.46	28.20
	5	25.15	26.27	26.55	26.57	25.78	25.70
	15	24.00	25.21	26.19	24.68	24.11	24.04
	25	23.88	24.45	24.60	24.02	23.75	23.80
Mean		***25.53b***	***26.22b***	***26.84b***	***26.11b***	***25.53b***	***25.44b***
Depth Mean	0	30.46a	31.77a	33.39	32.40a	30.07a	29.00a
	5	26.26b	27.66b	28.28	27.75b	27.06b	26.80b
	15	24.44c	25.59c	26.66	25.15c	24.36c	24.25c
	25	24.10c	24.69c	24.93	24.34c	24.00c	24.00c
L.S.D$_{0.05}$	M	*1.03*	*1.82*	*2.22*	*1.9*	*1.22*	*0.92*
	D	*1.02*	*1.81*	*2.21*	*1.89*	*1.22*	*0.91*
	M*D	*1.93*	*3.40*	*1.92*	*3.56*	*2.29*	*1.72*

VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological maturity

In general, polyethylene mulches increased the maximum and the minimum soil temperatures **(Ham *et al.*, 1993). Douglas and Sanders (2001)** stated that the advantages of using plastic mulches are: increasing soil temperature reducing soil compaction, decreasing evaporation, weed problems and giving earlier crops and increasing growth. **Moursy *et al.*, (2015)** reported that use of darker color mulches increase soil temperature, while lighter colors reflect more solar

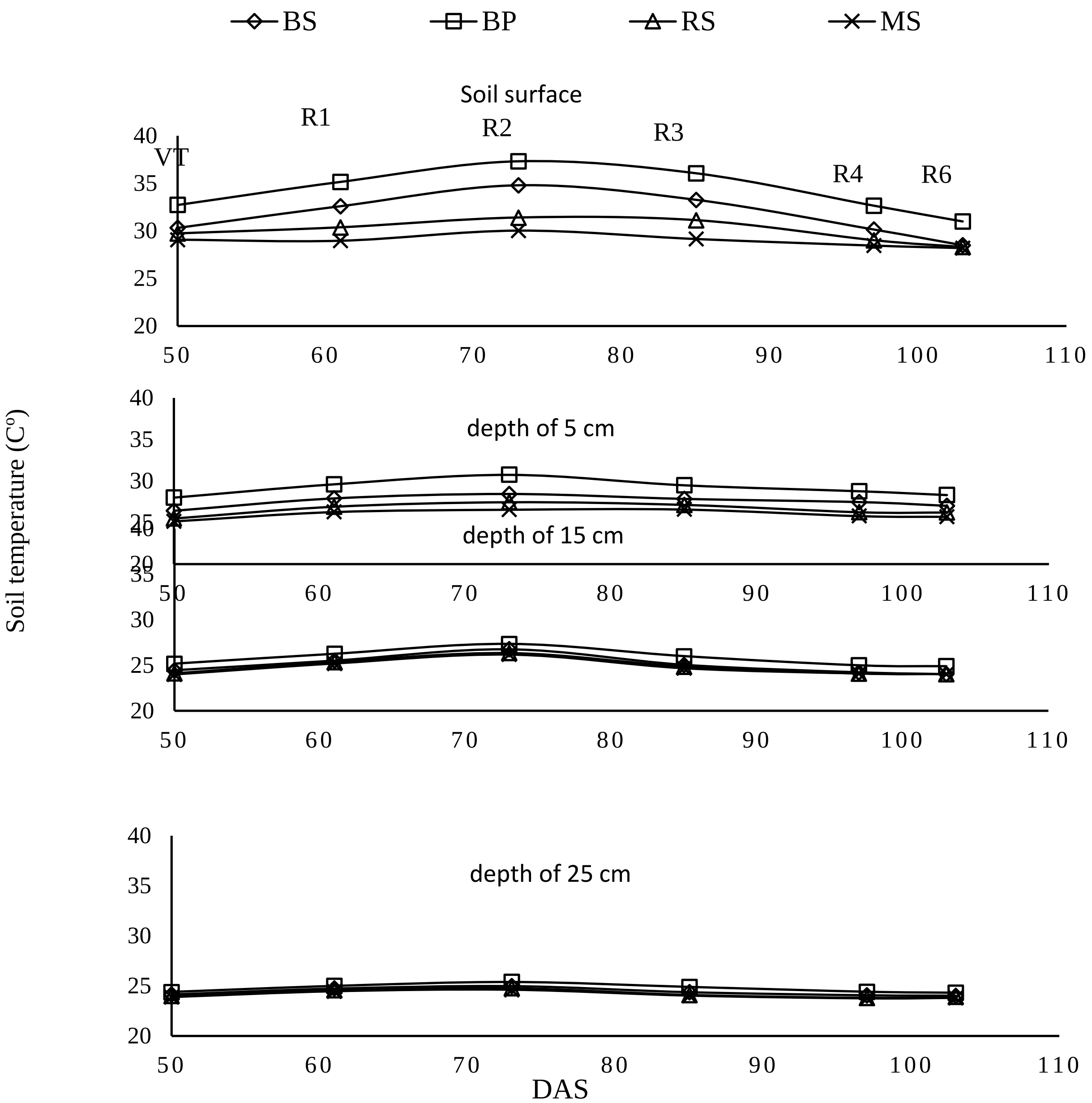


Fig. 1 Effect of mulch treatments on soil temperature for soil depth of surface, 5, 15 and 25 cm at different growth stages of maize plant.

VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological maturity

DAS: days after sowing

radiation and minimize changes in soil temperature besides increasing light irradiance. **(Decoteau *et al.*, 1990 and Mahmoudpour and Stapleton 1997).** The RS and MS treatments decreased soil temperature. The soil temperature of RS ranged from 31.40 C^0 for soil surface at R2 growth stage to 23.80 C^0 for soil depth of 25 cm at R4 growth stage. The soil temperature of MS ranged from 30.03 C^0 for soil surface of R2 growth stage to 23.75 C^0 for soil depth of 25 cm at R4 stage. Decreases were 0.50, 0.88, 1.26, 0.84, 0.68 and 0.27 C^0 for RS and 0.80, 1.46, 1.90, 1.52, 0.94 and 0.44 C^0 for MS at VT, R1, R2, R3, R4 and R6 stages, respectively. Several investigators reported that the soil temperature under straw mulching was lower than in non–mulched soils (**Sarkar *et al.*, 2007). Eruola *et al.*, (2012)** reported that soil mulching with grass decreased temperature at a depth of 15 cm. **(Khan *et al*, 2000)** found that the decreases in soil temperature under straw mulch**.**

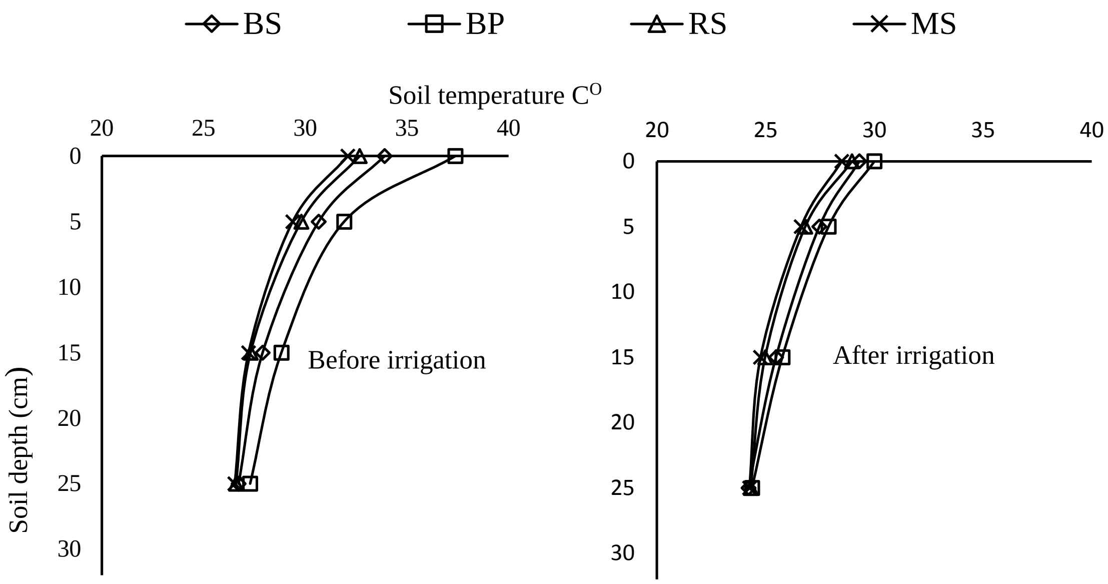


Fig. 2 Effect of mulch treatments on soil temperature before and after irrigation as average from 50 to 103 days after sowing.
VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological maturity

Several investigators reported that mulching improved soil structure, decreased wind and water erosion, and decreases soil warming in summer months as well as decreased fluctuations of soil temperature, resulting in an increase of crop yields **(Duppong *et al.*, 2004, Farrukh and Safdar 2004, Giordani *et al.*, 2004, Ramakrishna *et al.*, 2006 and Chakraborty *et al.*, 2008). Horton *et al.*, (1996) and Pramanik *et al.*, (2015**) reported that soil temperatures were reduced under rice straw. Mulching reduces the solar energy reaching the soil thereby reducing the magnitude of temperature increases in warm conditions **(Horton *et al.*, 1996 and Pramanik *et al.*, 2015).** Organic mulches decrease maximum and increase minimum soil temperature **(Teasdale and Mohler 1993).**

Soil temperature (averages from 50 to 104 days after sowing) before and after irrigation values are illustrated in Fig. 2. The high soil moisture content after irrigation reduced the variation between mulching treatments on soil temperature. The effect of mulching treatments on the soil temperature was more pronounced before irrigation when the soil is drier. This may be due to the high heat capacity of water reducing the fluctuation in soil temperature. The highest temperatures were on the soil surface. Soil temperature decreased with soil depth.

3.1.2. Soil moisture content.

Data in Table 3 and Fig. 3 show that mulching increased soil moisture. The highest contents were under BP and the lowest were under BS treatment. The moisture content decrease with soil depth. The increment percentages for BP at depth of 0-10 cm were 35, 35, 71, 50, 47 and 66 % for VT, R1, R2, R3, R4 and R6 growth stage, respectively as compared to BS whereas, at depth 0f 10-20 cm recorded 26, 24, 27, 32, 41 and 40 % and 17, 21, 20, 29, 24 and 23 for the depth of 20-30 cm for VT, R1, R2, R3, R4 and R6 growth stage respectively. These results are in agreement with those obtained by **Kosterna (2006), Hamouz *et al.*, (2007), Cholakov and Nacheva (2009) and Majkowska (2010)** who reported that mulching affected thermal and humidity conditions.

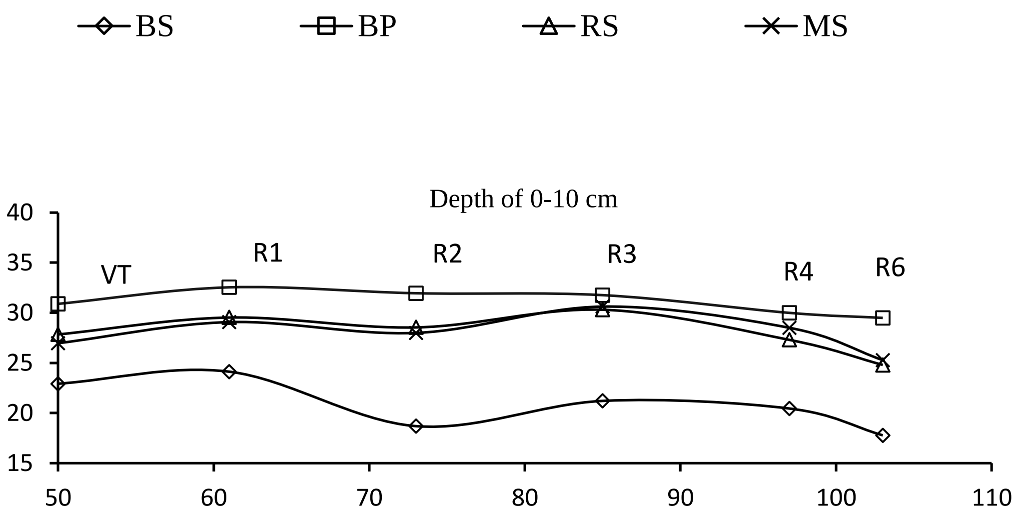
Data also show that the soil moisture content increased under RS or MS as compare with BS treatments. There were no significant differences between RS and MS in soil moisture content. Corresponding average increases due to RS at the depth of 0-10 cm were 21, 22, 53, 43, 34 and 40 % while, the MS treatment recorded 18, 20, 50, 44, 39 and 42 % for VT, R1, R2, R3, R4 and R6 growth stage, respectively. **Sinkevičienė *et al.*, (2009)** reported that the soil moisture under straw mulch was higher by 3.0 - 4.5 %. The favorable effect of straw mulch on the reduction of water losses from the soil in potato cultivation was reported by **Kar and Kumar (2007)**.

Table 3. Effect of mulching treatments and soil depths on soil moisture content (%) during different growth stages of maize.

Mulching treatments M	Soil depths (cm) (D)	Soil moisture content (%) During growth stages					
		VT	**R1**	**R2**	**R3**	**R4**	**R6**
BS	**0-10**	22.93	24.14	18.69	21.21	20.45	17.77
	10-20	26.84	28.06	26.75	25.66	22.10	21.50
	20-30	28.80	29.07	28.95	26.86	26.04	25.90
Mean		***26.19c***	***27.09c***	***24.80b***	***24.58c***	***22.86c***	***21.72c***
BP	**0-10**	30.90	32.55	31.96	31.77	30.00	29.50
	10-20	33.89	34.72	33.93	33.75	31.25	30.11
	20-30	33.74	35.12	34.71	34.66	32.37	31.87
Mean		***32.84a***	***34.13a***	***33.53a***	***33.39a***	***31.21a***	***30.49a***
RS	**0-10**	27.85	29.54	28.55	30.32	27.31	24.81
	10-20	29.77	30.77	31.26	30.34	28.31	26.76
	20-30	32.33	32.83	31.87	31.74	29.79	28.15
Mean		***29.98b***	***31.05b***	***30.56a***	***30.80ab***	***28.47b***	***26.57b***
MS	**0-10**	26.97	29.08	28.00	30.63	28.51	25.28
	10-20	29.44	31.10	30.55	29.77	28.52	26.22
	20-30	32.01	32.15	31.45	31.04	29.05	28.01
Mean		***29.47b***	***30.78b***	***30.00a***	***30.48b***	***28.69b***	***26.50b***
Depth Mean	**0-10**	27.16c	28.83b	26.80b	28.48b	26.57b	24.34b
	10-20	29.99b	31.16a	30.62a	29.88ab	27.54ab	26.15ab
	20-30	31.72a	32.29a	31.75a	31.07a	29.31a	28.48a
$L.S.D_{0.05}$	M	***1.64***	***1.37***	***3.76***	***2.68***	***2.18***	***2.72***
	D	***1.42***	***1.18***	***3.25***	***2.32***	***1.19***	***2.36***
	M*D	***2.52***	***2.11***	***5.8***	***4.13***	***3.36***	***10.61***

VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological maturity

Fig. 3 shows variation of moisture content between mulch treatments with soil depth. The soil moisture content decreased in the period from R1 to R2 with time and reached the lowest values at R2 (73 days after sowing) and turned to increases from R2 to R3 for all treatments. It may be due to the R2 had high air temperature and consequently high evaporation rate. **Olasantan (1999)** found that the use of straw mulch prevents water evaporation and helps maintain a constant soil temperature. This was confirmed in studies by **Kęsik and Maskalaniec (2005)** in which mulch with rye straw was used effectively as an insulator and protected the soil from overheating. Studies by **Shangning and Unger (2001), Włodek *et al.*, (2003), Dahiya *et al.*, (2007), Pabin *et al.*, (2007) and Sinkevičienė *et al.*, (2009)** showed that the application of mulch increased soil water retention.



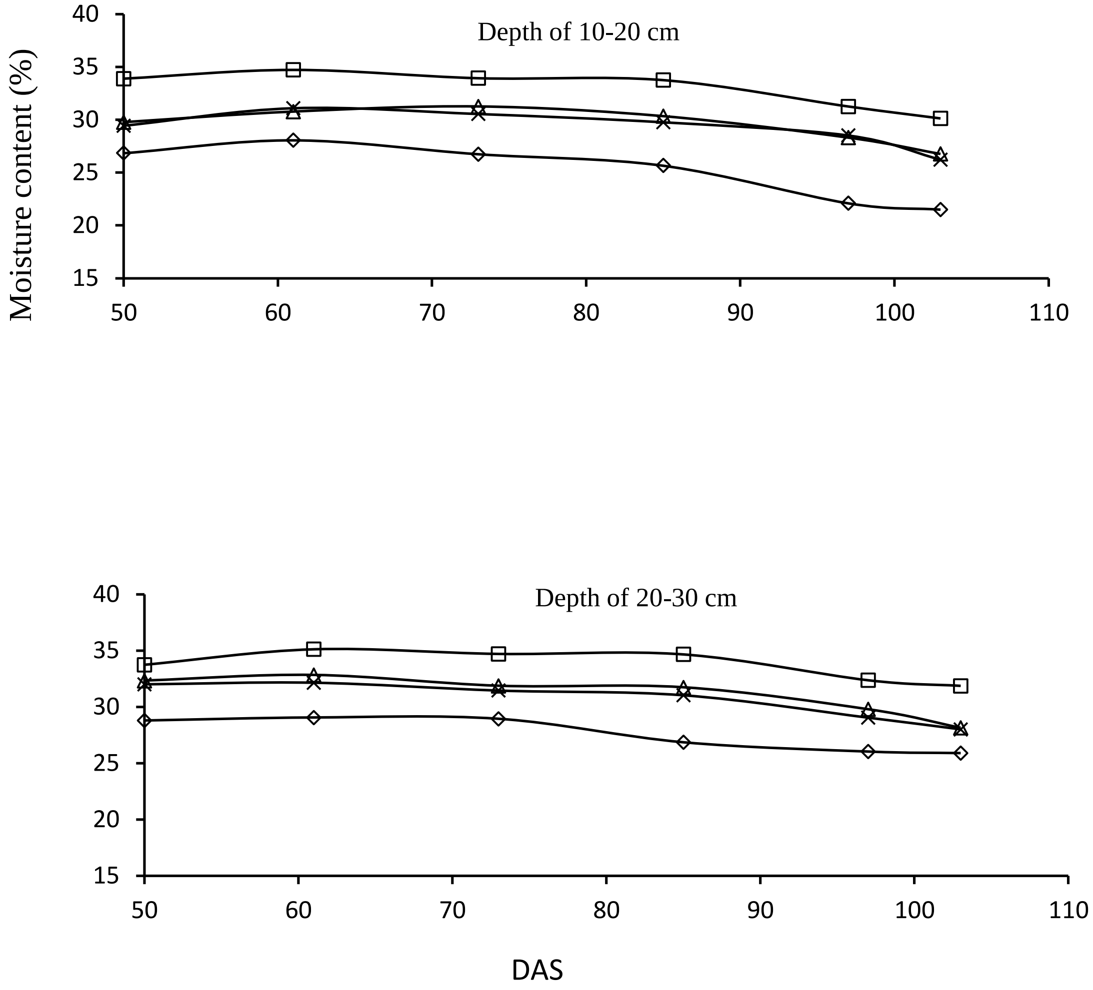


Fig. (3) Effect of mulch treatments on soil moisture content for soil depth layer of (0-10), (10-20) and (20-30) cm at different growth stages of maize

VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological stage

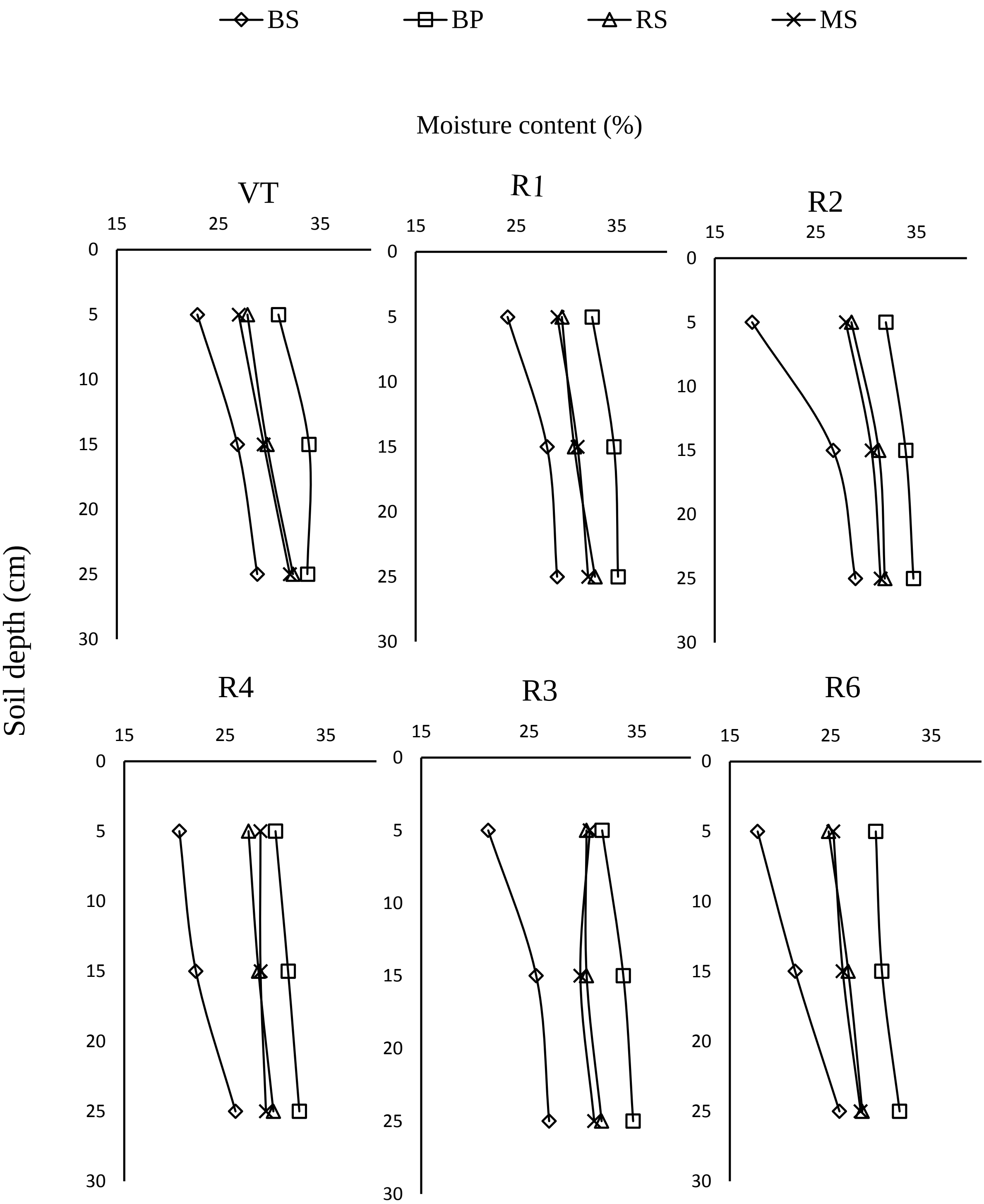


Fig. (4) Effect of mulch treatments on soil moisture content at different growth stages of maize plant.
VT: Tasseling stage R1: Blister stage R2: silking stage R3: milking stage R4: Dough stage R5: Physiological maturity

3.1.3. Soil bulk density

Data in Table 4 show that mulching decreased bulk density the decrease was more pronounced at the top soil layer (0-10 cm) than the other two deep layers. The lowest value of BD was on the surface 0-10 cm under BP followed by RS and MS while the highest BD was obtained with the BS. The decreases of the BP were 13.66, 7.80 and 7.73 % for the soil depth of 0-10, 10-20 and 20-30 cm, respectively. These findings are in accordance with those obtained by **(Mulmba and Lal 2008; Khan *et al.*, 2014; Parker 2015 and Joel *et al.*, 2015). (Mbah *et al.*, 2010)** reported that the bulk density decreased from 9, 4, and 17% for black / white, white and black plastic mulch, respectively compared to the un-mulched treatment. **Javeed *et al.*, (2013)** indicated that the maximum soil bulk density was recorded in the control treatment followed by the wheat straw mulch that was at par with those of grass mulch. Significantly minimum soil bulk density was noted in the black plastic mulch.

Table 4 .Effect of mulch treatments on soil physical properties

Mulch treatments	Bulk density ($Mgm^{-3)}$			Total porosity (%)			Saturated hydraulic conductivity (cm/h)			Penetration resistance (MPa)		
	soil depth (cm)											
M	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
BS	1.398	1.411	1.448	43.401	44.229	43.876	3.772	2.809	1.479	1.361	1.585	1.628
BP	1.207	1.301	1.336	51.134	48.577	48.217	6.589	4.768	2.321	0.945	1.275	1.491
RS	1.315	1.337	1.375	46.761	47.154	46.705	6.242	3.853	2.011	1.011	1.391	1.523
MS	1.318	1.339	1.373	46.640	47.075	46.783	5.972	3.765	1.878	1.065	1.423	1.545
L.S.D $_{0.05}$	***0.063***	***0.052***	***0.064***	***4.354***	***3.770***	***3.611***	***1.287***	***1.633***	***1.911***	***0.112***	***0.201***	***n.s***

3.1.4. Soil total porosity

Data in Table 4 show that the total porosity (TP) increased by mulching. The highest was by BP treatment. Average increases in the top soil layer (0-10 cm) were17.82, 7.74 and 7.46 % for BP, RS and MS, respectively and 9.89, 6.61and 6.43 %, respectively for the 10-20 cm depth layer while, the 20-30 cm depth layer recorded 9.89,6.45 and 6.63 %, respectively. These results are agree with those of **Glab and Kulig (2008)**. **Javeed *et al.*, (2013)** reported that the higher total soil porosity was obtained by black plastic mulch (0.46 m^3m^{-3}) followed by the wheat straw mulch treatment (0.45 m^3m^{-3}) that was at par with those of grass mulch treatment (0.45 m^3m^{-3}). The lowest porosity was noted in the non-mulched treatment (0.44 m^3m^{-3}). **Joel *et al.*, (2015)** demonstrated that the soil porosity varied significantly with maize residue mulch thickness (0, 5 and 10 cm).

3.1.5. Saturated hydraulic conductivity

As soil bulk density decreased the total pore space increased and consequently affected the hydraulic properties. Data in Table 4 reveal that the mulch increased the saturated hydraulic conductivity (Ksat). The increases were 74.67, 65.48 and 58.33 % for BP, RS and MS, respectively at 0-10 cm. and 69.71, 37.14 and 34.00 % at 10-20 cm while in the 20-30 cm depth the increases were 56.92, 35. 97 and 26.99 % for BP, RS and MS, respectively. The highest value was in BP and the lowest was in the BS. There was no significant difference between RS and MS. **Shah *et al.*, (2013) , Joel *et al.*, (2015) and Chiroma *et al.*, (2006)** revealed that wheat straw and farm manure mulch showed higher saturated hydraulic conductivity.

3.1.6. Soil penetration resistance

Soil penetration resistance (PR) are shown in Table 4. The results indicate that for all treatments the (PR) increased with depth increased. Significant differences in PR at the end of the trial were only found at 0-10 and 10-20cm depths. Mulching had lower values relative to bare soil. In the top soil layer (0-10 cm) the decreases were 30.57, 25.72 and 21.75 % for BP, RS and MS, respectively. Corresponding averages for the 10-20 cm layer were 19.56, 12.24 and 10.22 % respectively, and those of the 20-30 cm were 8.42, 6.45 and 5.1 %, respectively. These results stand in agreement with those reported by **Yaseen *et al.*, (2014), Javeed *et al.*, (2013) and Shah *et al.*, (2013).** Mulches improved the ecological environment of the soil and increased soil water content causing less soil penetration resistance and lower water contents soil become compact and hard **(Khurshid *et al.*, 2006). Pervaiz *et al.*, (2009) and Shah *et al.*, (2013)** observed decreased bulk density and soil strength under mulch.

3.2. Effect of mulch treatments on yield of maize crop

Data in Table 5 show that the mulch treatments had a significant effects on plant height and yield of cob, grain, straw and grain + straw of maize plants as compare to BS. The BP mulch treatment had a high growth performance and recorded the highest values whereas, the lowest was by BS treatment. The increases for BP were 6.7, 10.50, 14.42, 43.94 and 32.62 % for plant height, cob, grain, straw and grain + straw yield, respectively. **El-Nady and Borham (2008)** reported that plastic and rice straw mulches significantly increased grain yield of maize by 17.0 % and by 10.0, respectively.

Table 5. Effect of mulch treatments on yield of maize crop.

Mulch treatments	Plant height	Yield (t ha^{-1})			
M	(cm)	Cob	Grain	Straw	Grain + straw
Bare soil	180	9.433	7.319	11.778	19.097
Black plastic	192	10.423	8.374	16.953	25.327
Rice straw	185	9.785	7.878	15.351	23.229
Maize straw	186	9.738	7.990	15.739	23.729
L.S.D 0.05	3.8	0.327	0.278	0.502	0.569

Lalitha *et al.*, (2010) found that plant growth and yield are positively affected by the plastic mulch due to the modification of soil microclimate. Mulching was beneficial for crop growth because of changes in soil environment through modifying soil temperature, decreasing evaporation, weed competition, compaction and erosion. **Xiukang and Yingying (2016)** stated that yield increased in response to plastic mulching. **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.

Growth and yield of maize plant increased by RS and MS treatments. There were no significant differences between RS and MS treatments. The increments percentages for RS were 2.8, 3.7, 7.6, 30.3 and 21.6 % for plant height, cob, grain, straw and grain + straw yield, respectively and for MS they were 3.3, 3.2, 9.2, 33.6 and 24.3 %, respectively. **Dalorima *et al.*, (2014)** reported that the effects of different mulching treatments on the growth performance of Okra *(Abelmoschus esculentus)* show that plant height, and bud count were high in polythene mulch, and low soil temperature was recorded in sawdust and sorghum straw mulch. **Khalifa and El-nemr (2011)** reported that the rice straw is inexpensive and available under Egyptian condition, insulates conserves moisture.

3.3. Effect of mulch treatments on NPK uptake of maize plant.

Data presented in Table 6 show that the mulching increased NPK uptake in grain and straw of maize plant. The BP gave highest NPK uptake. The increment percentages for BS were 40, 19, and 25 % in grain and 42, 58 and 39 % in straw for N, P and K, respectively. **Zagade (2004)** reported that total nitrogen, phosphorus and potassium were significantly higher under polythene mulch than no mulch treatment. Data also show that the NPK increased under RS and MS. There were no differences between RS and MS in NPK uptake. The increment percentages of RS in grain were 13, 15 and 5 % for N, P and K, respectively and for MS were 14, 13 and 8 %, respectively while, for straw were 19, 26 and 18 %, respectively for RS and 22, 39 and 20 %, respectively for MS. **Rajput *et al.*, (2014)** reported that NPK uptake by grain and straw of maize are influenced by mulching practices. **Acharya and Sharma (1994) and Muhammad *et al.*, (2009)** observed that mulched treatments showed greater total uptake of NPK. **Hundal *et al.*, (2000)** reported that uptake in tomato increased by mulching. **Khambal *et al.*, (2009)** revealed that the black mulch recorded highest uptake of N, P and K by okra plant. **(Kumar and Dey, 2011)** reported that application of mulch (hay mulch and black polyethylene mulch) enhanced the nutrient uptake of strawberry up to 179 % under drip irrigation and 84 % under surface irrigation**.** **Yaseen *et al.*, (2014)** reported that N, P and K uptake by grain and straw of maize increased by wheat straw mulch.

Table 6: Effect of mulch treatments on NPK uptake of maize plant.

Mulch treatments	uptake (t ha^{-1})					
	Grain			Straw		
M	N	P	K	N	P	K
Bare soil	227.31	26.12	90.08	290.54	32.93	204.95
Black plastic	318.17	30.98	112.74	412.69	52.02	286.01
Rice straw	256.83	29.94	94.80	344.37	41.46	242.05
Maize straw	259.71	29.55	96.92	353.60	45.65	245.04
L.S.D 0.05	12.04	1.94	6.71	23.92	4.89	21.9

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تأثير أغطية التربة على خواص الارض وانتاجية محصول الذرة الشامية

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أقيمت تجربة حقلية لموسمين صيفيين متعاقبين (2015 – 2016) بمحطة بحوث الجيزة مركز البحوث الزراعية، الجيزة ، مصر. واشتملت على اربعة انواع من أغطية التربة وهى 1–ارض مكشوفة (كنترول) 2 –غطاء بلاستيك اسود 3–غطاء قش الارز بمعدل 4,8 ميجا جم / فدان 4– غطاء قش الذرة بمعدل 4,8 ميجا جم / فدان. تأثرت درجة الحرارة ووالمحتوى الرطوبى والمسامية الكلية وخواص الأرض الطبيعية وانتاجية نبات الذرة تأثيرا معنويا باختلاف نوع غطاء التربة مقارنة بالأرض المكشوفة . وكانت أعلى قيم لدرجات حرارة التربة والمحتوى الرطوبى والمسامية الكلية و معامل التوصيل الهيدروليكى المشبع وانتاجية نبات الذرة وكذلك اقل قيم للكثافة الظاهرية و مقاومة التربة للإختراق فى المعاملة غطاء التربة بالبلاستيك الأسود. كما عملت المعاملتين قش الأرز و قش الذرة على زيادة معظم الصفات تحت الدراسة ولكن لم يكن هناك فرقا معنويا بين المعاملتين. ابدت معاملة الأرض المكشوفة اقل القيم لمعظم الصفات تحت الدراسة فيما عدا حرارة التربة حيث وقعت بين البلاستيك الأسود وقش الأرز أو قش الذرة. كما قلت حرارة التربة والمحتوى الرطوبى بزيادة العمق. وبالرغم من أن المعاملات قش الأرز وقش الذرة اعطت نتائج أقل من معاملة البلاستيك الأسود وإلا إنهما أقل تكلفة ومتاحين تحت ظروف الأراضى المصرية.