Soil Moisture Conservation by Kaolin, Rice Straw and Shale Applications

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Abstract: This work aims to study the effect of using soil conditioner (shale 10 Ton ⁄Fed), soil mulching (Rice straw) and plant foliar antitranspiration (kaolin 6%) on water conservation for soil and plant. A pot experiment was conducted during 2012 and 2013 summer seasons by using calcareous soil from Noubaria region. Soil moisture content was adjusted at field capacity during the experiment. The treatments used were control, kaolin(K), Rice straw(RS), shale(S) as a single treatments and, kaolin with Rice straw(K+RS), kaolin with shale(K+S), shale with Rice straw(S+RS) as a double treatments, finally, kaolin with Rice straw and shale (K+RS +S)as a triple treatment.Corn as indicator plant was harvested after 90 days from planting. Soil evaporation, soil moisture retention and plant transpiration was controlled by using Rice straw,shale and kaolin, respectively as a commercial and economical materials. Results showed that shale treatment (S) led to a significant increase in W.H.C%, F.C%, W.P% and A.W % than kaolin (K), Rice straw (RS) and control treatments. Also, shale and Rice straw (S+RS) treatment showed a pronounced increase in all soil moisture constant studied than the other applied treatments (K+RS) and (K+S). Highest values for W.H.C%, F.C%, W.P % and A.W % were obtained by using (K+RS+S) treatment. Also, shale treatment was decrease water consumptive use (W.C.U) values from 7.18 L/pot for control treatment to 7.05 L/pot. Consequently, shale (S) increased water use efficiency (W.U.E) values more than kaolin (K) and Rice straw (RS) treatment from 1.22gm/L for control to 1.42gm/L due to high soil moisture retention of shale. Also data for (S+RS) treatment was more effective in increasing (W.U.E) values than (K+RS) and (K+S) treatments. Concerning the (K+RS+S) treatment a higher increase was obtained in W.U.E value and higher decrease in W.C.U was observed than all other experimental treatments used in this study. Whereas, the relative increase percentage of W.U.E over control for (K+RS+S) reached to 36.07%. These results showed an important use of kaolin, shale and Rice straw as a commercial and economical materials in controlling water for soil and plant.
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1. Introduction

In arid and semi-arid areas, where water is scarce and population growth is high, the success of sustained agriculture depends entirely on water availability therefore; great potential for improving water use efficiency must be done. This may be achieved by reduce runoff, soil evaporation, plant transpiration and drainage loss using antitranspiration materials, mulching methods and soil conditioners.

Surface mulch (mulch refers to a material placed on the soil surface) has a significant effect on reducing evaporation of water therefore it can decrease salt accumulation of water as well (**Al-Rawahy *et al.,* 2011 and Leila *et al*.,2014).**

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.(**Yun-min *et al*., 2005, Balwinder-Singh *etal.*, 2011 and Adnan *etal*., 2012**).

Grass mulch is more useful in cultivation of Nagpur mandarin orchards (**Gaikwad, 2004**).Soil mulsh with Egyptian clover or weed residues gave the best vegetative growth and fruit quality of orange trees under To sakha conditions (**Abdel-Aziz *et al.,* 2010**).

Mulching by black polyethylene (BPE) and dry cut grass increased the percentage of soil moisture due to reducing evaporation water from soil surface.

Rice straw becomes a big problem to get rid of, so that the farmers oblige to burn the rice straw and this lead to environmental pollution; such straw can be used as mulch (**Lal and Stewart, 1995, Ti and Unger, 2001, Unger, 2001, Bu *et al.,* 2002, Sarkar, 2005, Xiying *et al.,* 2005,Berglund *et al.,* 2006 and Sadeghi *et al.,*2014).**

To reduce the transpiration rate,certain materials could be used called antitranspiration which were grouped into three categories, (1) film -forming types(which coat leaf surface with film that are impervious to water vapor), (2) reflecting materials (which reflect back a portion of the incident radition falling on the upper surface of the leaves) and (3) stomutal closing types, (**Prakoish *etal.*, 2000**) which affect the metabolic processes in leave tissues. The types 1and 2 of antitranspirations were found to be non-toxic and have a larger period of effectiveness than metabolic types (**Gawish, 1992**).

A reflective spray was found to decrease leaf temperature by increasing leaf reflectance and to reduce transpiration rate in many plant species grown at high solar radiation levels (**Nakane and Uehara, 1996**). Early studies demonstrated that kaolin improved water status and yield of apple while it did not reduce carbon assimilation (Glenn ***et al.,*** **2003** and **Abd el-Kader *et al.,* 2006).** Under subtropical conditions like Egypt**,** using antitranspiration may reduce transpiration rate from the plant, consequently, the amount of used water and improved the water use efficiency (**Makus, 1997 and Singh *et al.,* 1999).**

Wallace and Terrey 1998 defined soil conditioner as any substances- natural or manufactured that has the abilities to improve the physical properties and water conservation of soil, which emphasis on the soil ability to grow plants, soil conditioners enhance the quality of soil for many of its functions. Application of shale led to an increase in the soil moisture retention (**Abdel-Aziz *et al.,* 1990 and Mohamed, 1990**).

Nawar, 2002 found that the retained moisture of maize plant values increased by 152.4% and 175.3 % in sandy and calcareous soils, respectively after application of soil conditioners.

The present study was outlined to study the effect of some factors on soil moisture retention and water conservation by using corn plants as: (i) soil mulching by Rice Straw (ii) soil conditioning by shale (iii) use antitranspiration kaolin as a commercial and economic materials in calcareous soil.

2. Material and Methods:

The current investigation aims to study the effect of soil mulching, soil conditioning and antitranspiration on soil water conservation. Field experiment was conducted during 2012 and 2013 summer seasons in Agriculture College of al-azhar university, Cairo. Plastic pots have a diameter 30 cm were filled with 8kg.of air-dried soil collected from Nobaria region. Chemical and physical properties of the soil used were determined according to **Black 1965; Tables 1 and 2.** Five seed of zea maize (Giza 3) were planted in each pot then thinned to one plant. Climate of the studied area during the growth period were obtained from the meteorological department, Ministry of agriculture which shown in **Table 3.** Recommended doses of fertilizers were applied for maize production.

2.1. Soil treatments:

Eight soil treatments were applied as follows: control, kaolin; **K** (6%) was spread on the corn leaves every 15 days for two month as antitranspiration, rice straw **(RS)** as soil mulching, shale; **S**(10 Ton ⁄Fed) as soil conditioner, kaolin and rice straw (**K+RS**) as fifth treatment, kaolin and shale (**K+S**) as sixth treatment. shale and rice straw(**S+RS**) as seventh treatment, finally, kaolin,rice straw and shale (**K+RS+S**). Kaolin analysis used was SiO_2 56.0, TiO_2 1.3, Al_2O_3 30.0, Fe_2O_3 0.9, MgO 0.05,CaO 0.1, Na_2O 0.07, K_2O 0.03 and L.O.I 11.0 % while shale analysis used was clay 81.88, silt 3.30, fine sand 13.73, coarse sand 1.09, bulk density 1.50 gm ⁄cm^3 and EC 2.8 dSm^{-1}.

Table 1: Chemical Analysis of the Soil Used:

Particle size distribution (%)				Textural class	O.M %	$CaCO_3$ (%)	E.C	pH Soil paste	C.E.C	Soluble ions meq l^{-1}							
										Cations				Anions			
Course sand	Fine sand	Silt	Clay							Ca	Mg	Na	K	CO_3	HCO3	Cl	SO_4
12.19	39.61	19.77	28.43	Sandy clay loam	0.18	19.66	2.99	7.96	29.49	8.93	3.81	20.31	2.90	---	6.11	19.63	14.03

C.E.C: meq/100gm E.C: dSm^{-1} (Soil paste extract)

Table 2: Some Physical Properties of the Soil Used:

W.H.C %	F.C %	W.P %	A.W %	Bulk density gm/cm^3	Total porosity %	Pore size distribution%			Hydraulic conductivity h / cm
						Micropores <30µ	Mesopores 30-100µ	Macropores >100µ	
43.0	33.40	19.83	13.57	1.43	46.04	19.01	12.02	15.01	9.66

W.H.C:Water holding capacity F.C:Field capacity W.P: Wilting point A.W: Available water

Table 3: The Meteorological Data during Growth Period:

Meteorological Parameter	Month			
	May	June	July	August
Average Maximum Temp. (^oC)	35.40	35.31	35.09	34.99
Average Minimum Temp. (^oC)	24.31	24.20	24.03	23.96
Average Relative Humidity (%)	52.19	52.13	51.36	51.11
Average Sunshine (hr.)	12.30	11.95	11.81	11.56
Average Wind Speed (m/sec.)	2.03	1.95	1.81	1.79

Soil moisture content was adjusted gravimetrically at field capacity during the experiment and the loss in pot weights represented the amount of water lost and W.C.U and W.U.E were calculated for different treatments. The corn plants were harvested after 90 days from planting. Experimental layout was a randomized complete block design replicated three times.

3. Results and Discussion:

3.1. Effect on Soil Moisture Retention:

Soil moisture retention characteristics is very important because it doesn't only give the total amount of water held by the soil, but also its pattern release. This information is important for the proper planning of irrigation regions, particularly in arid and semiarid zones, where the amount of water is very limited. Data in **Table 4** showed that soil moisture retention was significantly affected by the shale (10 Ton /Fed) as soil conditioning, rice straw as soil mulching, kaolin as foliar antitranspiration and their interactions in sandy clay loam soil.

Shale (S) treatment showed a significant increase in W.H.C,F.C,W.P and A.W % than control, rice straw (RS) and kaolin(K) as single treatments. The highest A.W values(18%) were recorded for shale while for rice straw, kaolin and control were 17.92 %, 16.07 % and 14.66 %, respectively.

Concerning to double treatments used in this study; Shale and rice straw treatment, **(S+RS)** showed an pronounced increase in all soil moisture constant studied than the other applied treatments; **(K+RS)** and (**K+S); Table 4.**

A.W values was reached to 18.71 % for(S+**RS)** treatment, while for **(K+RS) and (K+S)** were 18.1% and 18.51%, respectively.

Generally, results in **Table 4** indicated that using of three materials kaolin, rice straw and shale **(K+RS+S)** as triple treatment led to highest value for W.H.C, F.C, W.P and A.W than all other investigated treatments. These values were 53%, 39.22%, 19.95 % and 19.27% for W.H.C, F.C, W.P and A.W, respectively compared with control (48.11 %, 33.55 %, 18.85% and 14.66%) for the same moisture constant respectively.

The relative increase percentages of W.H.C, F.C, W.P and A.W over control was illustrated in **Fig.1**$_{a,b,c,d}$. The highest values of relative increase percentages of A.W was clearly observed for (**S**) as a single treatment, (**S+RS**) as a double treatment and (**K+RS+S**) treatment; **Fig.1**$_{\mathbf{d}}$. These values were 22.85%, 27.63 % and 31.45 %, respectively. Finally, results show the enhancing role of mulching, conditioning and antitranspiration processes in reducing water loss from soil and plant. These results were agreement with those obtained by **El-Nady and Borhan, 2008.**

Table 4: Effect of Application Treatments on Soil Moisture Content of Sandy Clay Loam Soil:

Treatment	W.H.C %	F.C %	W.P %	A.W %
Control	48.11	33.51	18.85	14.66
K	48.75	34.96	18.89	16.07
RS	48.88	36.91	19.99	17.92
S	48.97	37.11	19.11	18.00
K+RS	49.78	37.19	19.18	18.01
K+S	50.63	37.80	19.29	18.51
S+RS	52.11	38.10	19.39	18.71
K+RS+S	53.00	39.22	19.95	19.27

K: Kaolin RS: Rice Straw S: Shale

3.2. Effect on W.U.E and W.C.U:

Water consumptive use (W.C.U) or crop water requirement refers to the amount of water that needs to be supplied, while crop evaportranspiration refers to the amount of water that is lost through evapotranspiration processes. Also, the irrigation water requirement includes additional water for leaching salts. The water use efficiency (W.U.E) represents the ratio between the dry matter produced by photosynthesis and the water consumed in evapotranspiration. It was calculated according to **Allen *et al.*, 1998.**

Water use efficiency can be increased by decreasing losses from water consumed.

Water consumptive use (W.C.U) and water use efficiency (W.U.E) of corn plants as affected by soil conditioning, soil mulching and foliar ant transpiration were recorded in **Table 5**.

Single treatments indicated that shale was successive over kaolin and rice straw treatments. Whereas, shale decreased the W.C.U value from 7.18 L / pot for control treatment to 7.05 L/pot. Consequently, shale increased the W.U.E values from 1.22 gm/L for control treatment to 1.42gm/L due to high moisture retention of shale. Regarding to kaolin treatment values of W.U.E reached to 1.29 gm/L due to the effect of spray kaolin in decrease leaf temperature by increasing leaf reflectance and to reduce transpiration rate in plants leaves grown at high solar radiation levels **(Nakano and Uehara, 1996).**

Rice straw becomes a big problem to get rid of, so that the farmer's oblige to burn it and this lead to the environmental pollution. Mulch management by rice straw as plant residues was employed to a benefit way for soil and water conservation. In this concern, data in **Table 5** referred that mulching rice straw increased W.U.E value to 1.40 gm/L compared to control treatment; 1.22 gm/L. These result in agreement with **El-Nady and Borhan, 2008.**

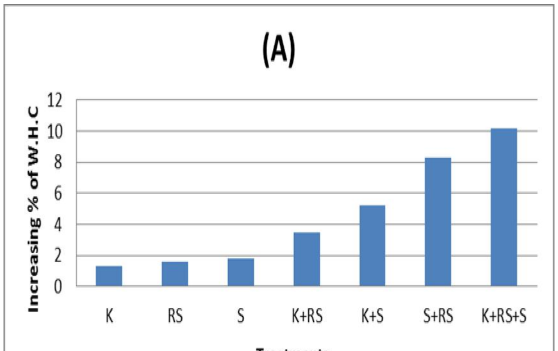

Fig 1_a: Relative Increase Percentages of W.H.C over control

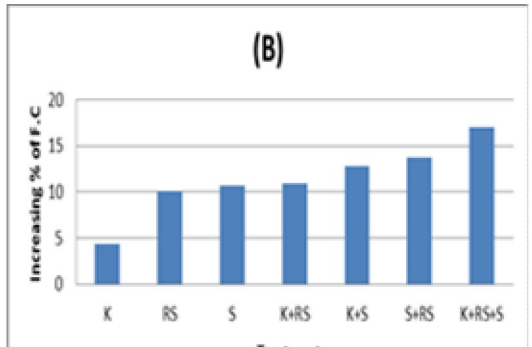

Fig 1_b: Relative Increase Percentages of F.C over control

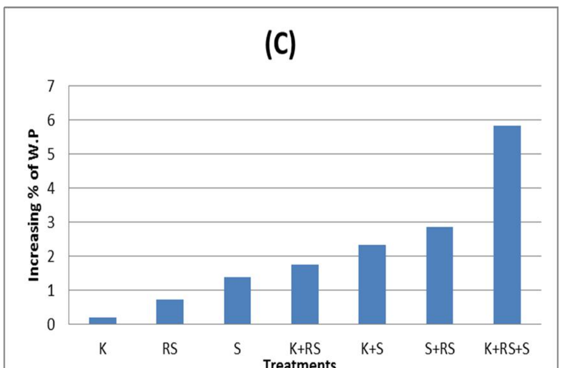

Fig 1_c: Relative Increase Percentages of W.P over control

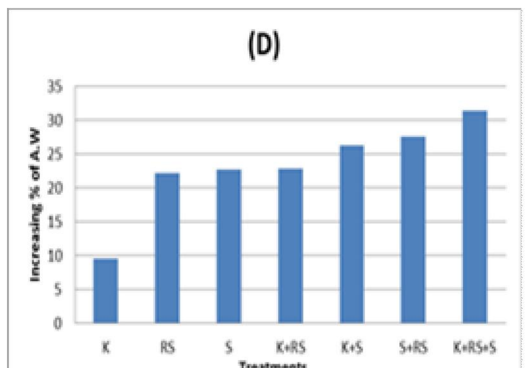

Fig 1_d: Relative Increase Percentages of A.W over control

Data also, showed that (**S+RS**) treatment was decreased W.C.U values from 7.18L/pot for control treatment to 6.70 L/pot. Also, the values of W.U.E for (**S+RS**) treatment were increased to 1.60 gm/L.

Data for (**S+RS**) treatment was more effective for increasing W.U.E values than (**K+RS**) and (**K+S**) treatments.

Concerning, the (**K+RS+S**) treatment, a higher increase was observed in W.U.E values and higher decreased in W.C.U values was obtained than all other experimental treatments used in this work. Whereas, W.C.U value reached to 6.59 L/pot and W.U.E value reached to 1.66 gm/L for control treatment, respectively.

Table 5:Effect of Experimental Treatments on Water Consumptive Use and Water Use Efficiency for Corn Plants:

Treatment	**W.C.U L/pot**	**W.U.E gm/L**
Control	7.18	1.22
K	7.14	1.29
RS	7.13	1.40
S	7.05	1.42
K+RS	6.88	1.45
K+S	6.58	1.50
S+RS	6.70	1.60
K+RS+S	6.59	1.66

Fig.2$_a$, illustrated the relative decrease percentage in W.C.U values over control for all treatments used. K+RS+S treatment has highest relative decrease percentage over control which reached to 8.22 %. While fig2$_b$ showed a relative increase percentage in W.U.E values over control treatment. (**K+RS+S**) treatment was more effective than the other treatments used for increasing W.U.E. relative percentage over control treatment (36.07%).

Finally, this study was confirmed to the important use of kaolin, Rice straw and shale (K+RS+S) in triple treatment as a commercial and economical materials in controlling water for soil and plant.

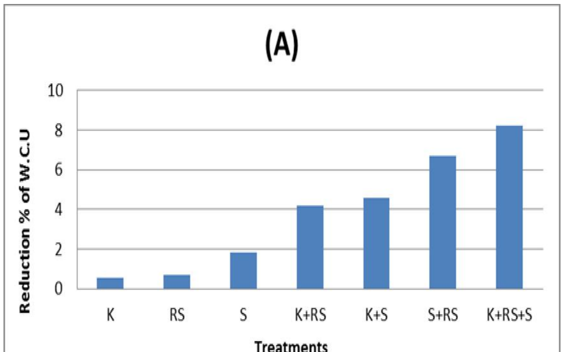

Fig 2$_a$: Relative Reduction Percentages of W.C.U over control

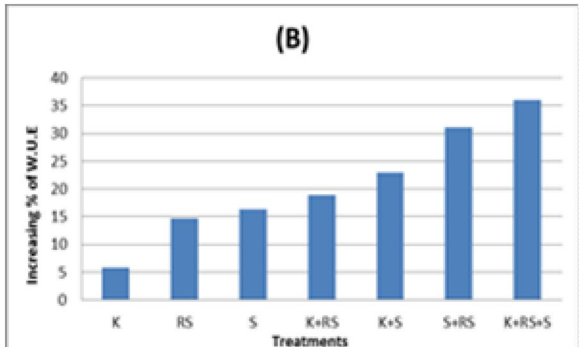

Fig 2$_b$: Relative Increase Percentages of W.U.E over control

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