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# CHANGES ON SOIL WETTABILITY,AGGRREGATE STABILITY AND ORGANIC MATTER CONTENT AFTER HEATING AND BURNED OF SUGARCANE RESIDUALS.

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## ABSTRACT

An experimental fire by using sugarcane residuals was conducted to study the effect of temperature on aggregate stability, water retention and organic matter content in soil samples from surface layers in two cases, the first under laboratory conditions, where temperature up to 300 $^0$Ċ and heat can be controlled and the secand under field conditions to study the changes in some soil physical properties during 4 month after fire. The obtained results showed that, there is no variation in cohesive forces resulting from temperature treatment during the 4 month following the fire. Heating programs in laboratory simulation have been used to control inputs of heat and to measure the influence of temperature on soil properties. Burned of sugarcane residuals have no clear effect on soil properties under study except soil wettability, organic matter content which were increased in burned soil compared with control. In the thermal treatment, at 200 $^0$C Sb,(stability of soil aggregate pretreatment in benzine), Se (stability of soil aggregate pretreatment in in alcohol) and Sw (stability of soil aggregate in water ),values are those of very stable aggregates. When the temperature raised to 300 $^0$C Sb and (Se-Sb) were decreased. The dry meanweight diameter (DMWD) is reduced by heating when the temperature reached 200 ºC and there is no detectable effect of heating on soil organic matter decrease until 200 ºC.

**Keywords**: Aggregate stability, Soil wettability, water retention, sugarcane residuals, fire.

## INTRODUCTION

In south Egypt, the burning of sugarcane residuals is a very common practice used for economic reasons and increasing soil organic matter. Influence of fires on the physical properties of soil have been reported in literature (Giovannini and Lucchesi 1983; Diaz-Fierros *et al.*, 1990) .De Bano *et al.* 1981; Giovannini *et al.* 1988, observed a decrease in aggregate stability of burnt soils. Nnevertheless, (Diaz-Fierros *et al*., 1990) observed an increase. Decreases in aggregate stability have often been explained as a result of the combustion of organic matter during burning (De Bano *et al.*, 1981, Soto *et al*., 1990). Aggregat stability is a dynamic property that change over time as do some other time-dependent parameters related to it, such as organic matter, (Utomo and Dexter, 1982).

In general water repellency, aggregates stability and organic matter are the most important parameters of soil that can be modified by fire. These properties are closely related to other important properties, such as water movement, water retantion. It is expected that fires increase soil erosion processes (De Bano *et al.*, 1981).

It is hard to summaries the effects produced by fire, because characteristics of soil and soil water conditions previous to fire, control the kind of effects of fire on soil properties (Wells *et al.*, 1979). The extension and depth of these effects depend also on the total energy released by the fire: fire intensity and fire residence time. Normally fire intensity can not be directly measure, and so fire temperature is often used. If soil fire is intense enough it will produce direct effects on soil physical properties but only in the top centimeters of mineral soil (Walker *et al.,* 1986). So there is no agreement about the basics aspects of the effects of fires on soil physical properties. In egypt there is lack information about, the effect of heating and burned sugarcane on soil properties.

It is very difficult to control fire intensity and fire residence time in situ due to of irregular fuel distribution and climatic conditions. Consequently, heating *programs* in laboratory simulation have been used to control inputs of heat and to measure the influence of temperature on soil properties (Gionannini *et al.,* 1988).

The aim of the present work to study the effects of burned sugarcane residuals and soil heating on soil structure, soil water relationships and organic matter content.

## MATERIALS AND METHODS

**Field experiment:**

An rexperimental fire on sugarcane residuals was conducted in a field after crop collection. Experimental fire was set up on March 2000 in the plots (15x5 m) of the experimental area. The day was characterized by the absence of wind and the soil moisture was 17%. Fire duration was not longer than ten minutes because of the low value of sugarcane residulas biomass. The experimental design of the area allow that one plot remained unburned serving as control.

Physical and chemical properties of studied soil are given in Table (1). The first sampling was taken from unburned plots as homogenous soil sample for the heating simulation program in laboratory conditions. The samples were taken from 0-5 cm depth.

Other samples were taken in both control and burned experimental plots, to study the change in soil properties during the 4 month. For each sampling time one sample of topsoil (0-5cm depth) in both control and burned plots were taken. Each sample was obtained from 5 sampling sites chosen at random.

**Table (1): Some Physical and chemical properties of the experimental Soil used in the study**

| Depth (cm) | Clay | Silt | Sand | Texture | $P^H$ 1:2.5 | EC $dSm^{-1}$ 1:5 | O.M | $CaCO_3$ | Total N | P | K | Ca | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Available | Soluble | | | |
| | % | | | | | | % | | ppm | | | | | |
| 0-5 | 36.6 | 52.5 | 7.9 | Loamy Clay | 8.04 | 0.32 | 1.58 | 3.27 | 197 | 27 | 43 | 200 | 480 | 80 |
| 5-10 | 33.2 | 51.4 | 15.4 | | 8.00 | 0.35 | 1.41 | 3.54 | 89 | 32 | 32 | 256 | 480 | 89 |
| 10-20 | 33.0 | 57.1 | 9.9 | | 7.89 | 0.35 | 0.94 | 3.60 | 78 | 32 | 32 | 259 | 406 | 93 |

A composite sample had been taken at four sampling periods: 1, 30, 60 and 120 days after fire. The sample was air dried and a part was sieved through 2 mm and divided into five equal subsamples, which were used in simulation program.

**Laboratory simulation program:**

Four of the five subsamples collected were introduced for 30 minutes in an oven at 50, 100, 200 and 300 $^{0}$Ċ respectively, the fifth subsample was taken as a control**.**

All samples were tested for aggregate size distribution, drop test, water drop penetration time, field capacity and permanent wilting point.

**Aggregate stability**

The aggregate size distribution was measured carefully sieving the sample following (Baruah and Barthakur, 1997**)** with automatic sieving device (Ro-Tap Shaker model 59986-62) for 5 minutes. Sieves used were 5.0, 2.0, 1.0, 0.5, 0.2 and 0.1 mm. Results are expressed as dry meanweight diameter (DMWD). This test was done with samples coming from both the control and the experimental plot. Measurements were carried in three replicate samples from plots and in four replicates for laboratory simulation.

Aggregate stability was measured by water sieving using dry aggregates <2mm immersed quickly in water (Sw).Two pretreatment of samples in alcohol (Se) and in benzine (Sb) and the results are expressed as percentage of resistant aggregates, which is the sum of the mass fraction remaining on each sieve after sieves.

**Water drop impact**

Water drop impact test (WDI) water drops fall on an aggregate and the stability at the moment impact is measured. For each sample, twenty dry aggregates of between 4 and 5mm were selected and placed in automatic sieving device, (Ro-Tap Shaker model 59986-62) 100 drops (100 µml distelled water with from 0.5 m height) were allowed to fall on each aggregate. Results are expressed as percentage of unbroken aggregates from total aggregate used.

**Wettability Measurement on Agregates**

The wettability was assessed with the water drop penetration time into the soil (WDPT). De-ionized water drops (0.1mL) were deposited with a micro-syringe on the surface of individual air dry aggregates (4-5 mm diam.) and the time required for the drop to pentrate the aggregate was recorded. Fifty replicates were made by the method of (Letey, 1969). Water repellency is classified by (De Bano *et al*., 1981) as: lower than 6 seconds, wettable; between 6 and 60 sec. Slightly water repellent; between 60 and 600sec.moderately water repellent; and over 600 sec., extremely water repellent.

**Water retention**

Field capacity (FC) and wilting point (WP) were measured following the procedure of (Kemper and Roseneau, 1986), as percent of soil water content at 0.03 and –1.5 Mpa water potential respectively, (using 15 bar ceramic plate extractor device Model A-140). Three replicates were made on soil fraction 2 mm in diameter.

**Organic matter**

The organic matter content of soils was estimated from the organic carbon, determined by the wet-degestion method, Walkey and Black method; (Dewis and Frietas, 1970).

## RESULTS AND DISCUSSION

**Aggregate size**

Results from simulated soil heating in laboratory conditions indicate that aggregate size significantly decrease when temperature increases (Figure 1). Dry mean weight diameter (DMWD) decreases by 20 and 70% of its initial value when the sample is exposed to 200 and 300 $^0$C respectively. Nevertheless, in the field study the decreases in DMWD between the sample from control plot and burned plot 4 month after the fire is only 5% (Table 2) This could be attributed to increases in soil temperature create a higher fragility in larger aggregates under dry conditions, causing breakdown into smaller fragments.

The drop test (WDI) results 90% of aggregates between 4 and 5 mm in diameter are resistant to impact of 100-water drops.(Table 2 ). Only after the high temperature treatment in the simulated heating the significant reduction (27%) was obtained (Table 4). In surface sample exposed to fire in the field study, like DMWD, the WDI very low differences were found between the control and soil 4 month after fire (Table 2).

**Table (2): Effect of sugarcane burned on aggregate stability in 0-5 cm soil depth after 4 month of burned.**

| Treatment | DMWD | WDPT | WDI | Sw | Se | Sb |
|---|---|---|---|---|---|---|
| | | Sec | % | | | |
| Control | 2.08 | 24.1 | 89.6 | 59.3 | 61.1 | 68.2 |
| Burned | 1.98 | 11.3 | 91.2 | 62.4 | 58.7 | 62.5 |

**Aggregate stability**

The percentage of stable aggregates after a fast immersion in water, using samples previously treated with different polar liquids, provides information about the characteristics of the cementing agents. Where the high Sw values indicate the cementing agents are neither soluble in water (salts or soluble organic components) nor dispersible under large amounts of water (Rengasamy *et al.,* 1984). Alcohol pretreatment, which obliterates the slaking, allows the evaluation of cohesive forces. Values near zero in the Se-Sw differences indicate a high resistance to slaking (Giovannini and Lucchesi, 1983).

Results obtained from both laboratory simulation and in field conditions (figure 2 and Table 3) indicate there is no variation in cohesive forces resulting from heat treatment during the 4 month following the fire,

where the Sw and Se remain stable during the period measured. According to the aggregates formation theory, organic matter and mineral colloides act as a cementing agent of mineral grains. Positive correlation has been found between the percentage of stable aggregates and organic matter content (Tisdall and Oades, 1982; Chaney and Swift.1984; Chenu *et al.*,. 2000). According to Dinel *et al.,* 1991, the Se-Sb differences can be used to distinguish between the structure stabilizing agents. In our samples, there no difference was found except for sample heated over 100$^0$C (Table 4). This may be attributed to the contributing of organic compound to the coating the aggregates with hydrofuge layer which protects the aggregates even more during benzene pretreatment, (Ma'shun *et al.,* 1988).

**Table (3): Effect of field fire treatment on stable aggregates during the 4 month after sugarcane burned.**

| **Treatment** | | **1** | **30** | **60** | **120** |
|---|---|---|---|---|---|
| | | **%** | | | |
| Control | Sw | 60.1 | 58.9 | 58.9 | 59.3 |
| | Se | 62.3 | 59.8 | 60.1 | 61.1 |
| Burned | Sw | 57.3 | 59.0 | 60.9 | 62.4 |
| | Se | 62.1 | 62.4 | 61.2 | 58.7 |

Figure 4 shows the Sb values in burned plots are approximately equal that of control in the two samples after one and 30 days from fire. After 4 month the Sb of control was higher than that of burned one.

The thermal treatment produces important variations in Hydrophobicity. Where at 200 $^0$C the number of stable aggregates in benzene Sb, water Sw and alcohol Se are those of stable aggregates (Table 3), indicating a hydrophobicity increased. When the temperature is raised to 300 $^0$C it is followed a reduction in both Sb and (Se-Sb), and decreased of hydrophobicity.

**Water drop penetration time and hydrophobicity**

The thermic treatment (Figures 2 and 3) produce important variations: hydrophobicity increased at 200 $^0$C as the number of stable aggregates in water, pretreated with benzene, alcohol and WDPT the maximum values. This indicates the hydrophobicity increased without modification of the aliphatic compounds, which are responsible for aggregation. At 300 $^0$C, it is followed by reduction in both Sw, Sb, Se and hydrophobicity.

Looking the results of field experimental plots, the obtained results shows, the mean WDPT of the burned plots during the studied period ranged from 8.8 to 12.6 sec., while in the control plot, values are between 14 and 37 sec with a certain variation in time sampling. According to the time that a water drop to be adsorbed in the soil, the either soil from control and burned plots were moderately repellent to water because the WDPT index is longer than 6 sec., (Figure 6.) which is the threshold value for hydrophobicity, ( Krames, MacGhie and Posner, 1981).

**Table (4): Effect of artificial heating on stable aggregates differences between alcohol (Se), water (Sw) and benzene (Sb) treatments, available water capacity (AWC) and water drop impact (WDI)**

| Temperature | Se-Sw | Se-Sb | WDI | AWC |
|---|---|---|---|---|
| | | | % | |
| Control | 4.3 | 2.6 | 89.6 | 22.9 |
| 50 $^0$C | 2.4 | 1.9 | 84.5 | 20.1 |
| 100 $^0$C | 0.1 | -3.5 | 92.1 | 17.3 |
| 200 $^0$C | 0.3 | -17.3 | 85.4 | 18.6 |
| 300 $^0$C | 4.9 | -11.3 | 65.7 | 25.3 |

**Water retention**

Figure 5. Shows that laboratory heated samples at 300 $^o$C have lower values at field capacity (FC) by 12% than the control, however at the wilting point (WP) the reduction is more than 40%, this reduction in absolute value originates in increase in available water, calculated as the difference between FC-WP by 15%. The reduction in the water content at WP at high temperature must be attributed to microporosity reduction due to both partial organic matter destruction and to the collapse of the clay platelets.

Table 5. represents values of water retained from field experimental plots don't show conclusive results, although WP values are initially reduced in the burned plot, they rapidly recover during the measurement period till reach and even exceed the control plot values. More effects are clear from FC values after an initial reduction the burned plot shows a continuous progressive recovery.

**Table (5): Effect of field fire on soil water retention at field capacity (F.C) and wilting point (W.P)**

| Days after burning | F.C | | WP | |
|---|---|---|---|---|
| | cm$^3$ water /cm$^3$ soil | | | |
| | Control | Burned | Control | Burned |
| 1 | 0.32 | 0.32 | 0.15 | 0.15 |
| 30 | 0.40 | 0.36 | 0.22 | 0.18 |
| 60 | 0.45 | 0.37 | 0.20 | 0.19 |
| 120 | 0.40 | 0.36 | 0.18 | 0.19 |

**Organic matter content**

In the field, data in Table ( 6 ) shows, temporary increases (23%) in organic matter content after fire was explained, Ibanez et al., 1983.In an experiment similer to our study found O.M. increments after fire burning by 24%, as a results of ash addition and raises in microbial activity (Raison,1979; Rashid 1987). On the other hand the organic matter content in laboratory heating experment decreased by 18 and 54% at 200 and 300 $^o$C respectively, Figure7. Authors such as ( Nishita et al., 1970, Giovannini et al., 1988, Soto et al., 1990) did not observe appreciable changes in the organic matter content when soils were heated at temperature below 200 $^0$C. In high intensity fires O.M. decreases sharply above 550 $^{0}$C (Giovannini *et al.*, 1988) because total combustion occurs.

**Table (6): Organic matter content at different time from fire**

| Days after burned | 1 | 30 | 60 | 120 |
|---|---|---|---|---|
| **O.M.** | % | | | |
| Control | 1.58 | 1..58 | 1.60 | 1.62 |
| Burned | 1.94 | 1.85 | 1.62 | 1.65 |

## CONCLUSION

Controlling fire in field experimental for studing the effects on the physical properties of the soil is not easy because fire intensity and residence time are very difficult to measure accurately in the field conditions. Burned of sugarcane residual have no clear effect on the physical properties under study during the studied time except soil wettability that was increased in burned soil compared with the control. The low intensity fire did not affect the soil organic matter content after 4 month from fire. Laboratory simulation shows that (DMWD) is reduced by heating when the temperature reaches $^{o}$C200. The most important soil properties measured that are effected by heating in laboratory conditions are DMWD, WDPT, WDI, Sb and Sw.

The upper part of the soil layer in burned sugarcane residual showed an increase of organic matter content one day after fire. This increment of organic matter content tended to return to intial levels 4 months after the fire. In laboratory simulated heating, there is no detectable effect until 200 $^{0}$C, (18%) decreased, whereas at 300 $^{0}$C more decreases was shown (54%). From the results obtained it can be concluded that the beneficial effect of burned sugarcane residuals on certain soil properties and organic matter content. Howevere, under our climite which is dry the burned of sugarcane resdiuals could be increase the polution, as the results of carbon dioxide emission in atmosphere. More studies are needed in this field experiment about another effects could be influnced by burned .

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## التغيرات التى تحدث للتربة فى قابلية الابتلال, ثبات الحبيبات و المحتوى من المادة العضوية عند تعرضها للحرارة و حرق مخلفات قصب السكر.

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يعتبر حرق مخلفات قصب السكر من قش واجزاء جافة فى الارض الزراعية من العمليات المنتشرة فى جنوب مصر اعتقادا من الزراع ان هذه العملية من شانها تحسين صفات التربة. لقد اجرى هذا البحث لايجاد دراسة علمية موثقه للتاثيرات التى يمكن ان تحدثها هذه العملية على قابلية الابتلال, ثبات الحبيبات و المحتوى من الماده العضوية للتربة الزراعية .

اجريت تجربتان احداهما حقلية ابتداء من مارس عام 2000 و الاخرى معملية لدراسة تاثير حرق مخلفات قصب السكر و الحرارة على قابلية التربة للابتلال, ثبات الحبيبات و المحتوى من المادة العضوية حيث تم عمل الاتى: 1- حرق مخلفات قصب السكر من الاوراق و السيقان الجافة فى الحقل و التى استمر حرقها 10 دقائق تقريبا.مع متابعة التغيرات التى تحدث فى بعض الصفات الطبيعية للارض و المحتوى من الماده العضوية لفترة 1-30-60و120يوم من الحرق.

2-تعريض عينات من الطبقه السطحيه ماخوذه من نفس الحقل قبل الحرق فى المعمل لدرجات حراره 50-100- 200و 300م0 لمدة نصف ساعه.

**ويمكن تلخيص النتائج المتحصل عليها فيما يلى:**

- عدم تاثيرحرق مخلفات قصب السكر فى الحقل على ثبات حبيبات التربة المجمعه الجافة طوال فترة الدراسه و بالتالى انجراف التربة بالرياح.
- حرق مخلفات قصب السكر ادى لزيادة سرعة امتصاص التربه للماء ونقص مقاومة حبيبات التربه للهدم بواسطة الماء.
- زيادة مقدار الماء الميسر فى التربه ( الماء عند السعه الحقليه-الماء عند نقطة الذبول) المحروق بها المخلفات مقارنة بالكنترول.
- لم يؤثر تعرض التربة لدرجات حراره فى المعمل على ثبات حبيباتها الا عند الدرجات الاعلى من 200درجة مئويه.
- تعرض التربة لدرجات حراره 300 ادى الى زيادة الماء الميسر الذى يمكن للتربة ان تحتفظ به.
- زاد محتوى التربه من الماده العضويه بمقدار 34% بعد يوم من الحرق كما لم يحدث نقص كبير فى المحتوى من المادة العضويه الا عند تعريض التربه الى درجة 300درجه مئويه.