The Libyan Journal of Agriculture: volume 8, 1979

Agrosil Influence on Soil Water Relationships of Calcareous Sandy Loam Soil

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ABSTRACT

The effect of addition of soil conditioner 'Agrosil' on moisture characteristics and water flow of calcareous sandy loam textured surface soil was investigated in this study. Agrosil was added to soil samples at three rates, namely, 0.1%, 0.2%, and 0.4% on weight basis. It was found that the addition of Agrosil did not effect the total pore space of soil, but had some effect on the pore size distribution. For example when Agrosil was added at 0.4% rate, the percent of pores less than 4 micron increased 19% compared to the untreated soil sample.

It was found that the moisture retained in the sample below 100 millibar tension was not affected by Agrosil treatment. At higher tension there was some effect on water retention. For example, there was 2%, 4%, and 8% increase in water retained at tension equal to 150 millibar for soil samples treated with 0.1%, 0.2%, and 0.4% Agrosil respectively (compared to untreated soil). At tension equal to 300 millibar this increase in water retention amounted to 1%, 8%, and 15% for the three Agrosil treatments respectively. This change in water retention was due to the change of the pore size distribution of treated soils. For the saturated hydraulic conductivity study, it was found that treatment of soil with Agrosil reduced the hydraulic conductivity (K) of soil. The reduction in K in the 0.4% Agrosil treatment was 50% while it amounted to 10%, and 17% for 0.1 and 0.2% Agrosil treatments respectively in comparison with the untreated soil. This is mainly due to the reduction in size of pores in treated soil.

In the vertical water infiltration study it was found that the data for both untreated and the treated soil fit the empirical equation, $y = Et^{0.5}$ where y is the accumulative infiltration in cm, (t) is time in min., and E is an empirical coefficient. The value of the coefficient E was affected by treatment of soil with Agrosil. (E) was equal to 1.89 for the untreated soil while it was 1.90, 1.87, and 1.52 for the 0.1%, 0.2%, and 0.4%, Agrosil treatments respectively. So the change occurred only for 0.4% addition where there was about 20% reduction in the accumulative infiltration compared to the untreated soil.

For the advance of wet front study it was found that the data fit the equation $X = Bt^{0.5}$, where X is the distance of advance of wet front, (t) is the time in minutes, and B is an empirical coefficient. The data indicate that the value of B was affected only in

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soil treated with 0.4% Agrosil, where there was 17% reduction in the rate of advance of wet front (compared to untreated soil).

INTRODUCTION

According to Russel (6), soil conditioners are generally materials which when added to soil improve its physical and chemical properties and make it more favourable for crop production. The soil conditioner 'Agrosil' is an amorphous silicate material of large specific surface area (1). It forms when dispersed with sufficient amount of water a mixture of silicate gel and silicate sols. Hempler (3) mentioned that Agrosil works as stabilizer for soil. Gebhardt (2) used the Agrosil to improve the physical and chemical properties of three different soils in Germany. Mounir (4) when treating the sandy loam soil of Libya with Agrosil obtained an increase in yield, and claimed that this is partially due to changes in aggregation and physical properties of soil. Sakr *et al.* (5) conducted an experiment to study the effect of Agrosil on growth of peas and yield, and obtained an increase in yield due to Agrosil application

The objective of this study was to investigate if treatment of sandy loam texture surface soil with Agrosil will have any effect on soil-water relationship; porosity and pore size distribution of that soil.

MATERIALS AND METHODS

The soil materials used in this study was taken from a surface horizon of a calcareous soil found in the Faculty of Agriculture Experimental Farm in Sidi El Mesri area. It is a sandy loam textured and contains 9% $CaCO_3$. Table 1 shows some of the characteristics of the soil layer used. After collecting the soil sample, it was air dried and sieved through a 2 mm sieve. Agrosil was added to the soil sample in three different rates, namely 0.1%, 0.2% and 0.4% on a weight basis. After the addition of Agrosil each soil sample was mixed for homogeniety, then wetted to field capacity and left covered for three weeks, then the soil sample was sieved again through a 2 mm sieve. The untreated soil sample was mixed at the same rate with distilled water and also was covered for a period of 3 weeks, then was dried and sieved.

For the pore size distribution and the moisture energy relationship study soil samples were packed in metal cylinders 7.6 cm in diameter and 6.5 cm in height, placed on the porous plate inside the pressure chamber. The packing bulk density was 1.45 gm/cm^3 for all the treatments. An outflow volume measurement system was connected to the porous plate. A system for control of the gas phase pressure in the pressure chamber was achieved by using pressure regulators and mercury manometers to measure the exact pressure applied on soil samples in the pressure chambers. The soil

Table 1 Characteristics of the soil used in this study.

Depth 0–30 cm	$CaCO_3$ %	pH soil paste	EC in mmhos/cm at 25 C (1:1 extract)	Mechanical composition Sand %	Silt %	Clay %	Texture	Bulk density gm/cm^3	True density gm/cm^3	Cation exchange capacity meq/100 g soil
Surface soil of the experimental farm at Sidi Misri	9.5	7.8	0.55	71.5	12.4	16.1	Sandy loam	1.45	2.61	6.9

samples on the porous plates were saturated by soaking in water and was allowed to stand for a week before pressure was applied on the soil. Then different pressure increments were applied and the outflow water was recorded until equilibrium was attained. This equilibrium was reached when the flow of water stopped for a given applied pressure increment.

For the saturated hydraulic conductivity study, samples were packed in plexiglass tubes 25 cm long and 6 cm in diameter at a bulk density equal 1.45 gm/cm^3. To obtain uniform packing the tubes were divided into 5 cm sections and equal masses of soil were packed in equal volumes in the plexiglass tubes. The soil columns were saturated with distilled deaerated water, left saturated for a one week period, then connected to a flow meter with constant head device to control the hydraulic head applied. The hydraulic gradients applied to the soil columns which range between 0–6 and the velocity of flow was measured at each hydraulics gradient.

For vertical infiltration, soil tubes 100 cm long and 6 cm in diameter were packed with soil at a bulk density equal to 1.45 gm/cm^3. A 3 cm head of water was maintained constant on soil surface and both the accumulated infiltration and the advance of the wetting front were measured as a function of lapsed time.

RESULTS AND DISCUSSION

Figure 1 shows the relationship between soil moisture content and soil tension for untreated soil and soil treated with different amounts of Agrosil. The data indicate that at zero tension the moisture content was approximately the same for untreated soil.

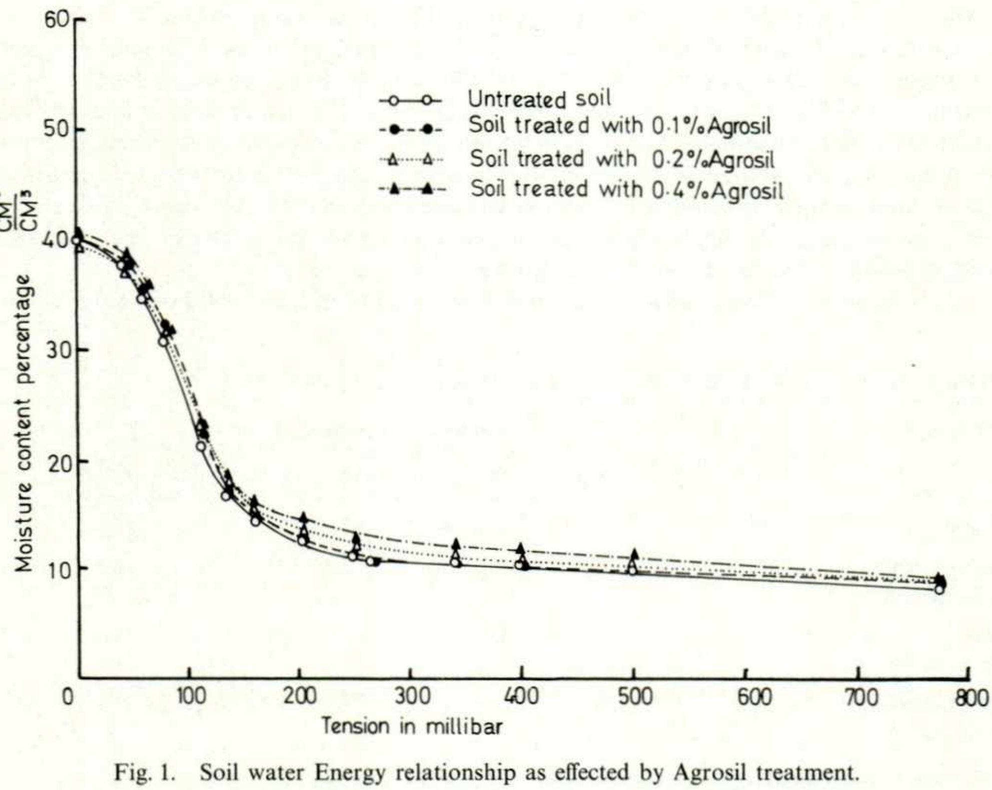

Fig. 1. Soil water Energy relationship as effected by Agrosil treatment.

This proves that the percent total pore space in the soil was not changed by the application of Agrosil. The moisture retained in untreated and treated soil was the same up to a tension equal to 100 millibar. However, at tension higher than 100 millibar there was a trend towards an increase in the percent water held in treated soil compared to untreated soil. For example at a tension equal to 150 millibar moisture percent on volume basis in the untreated soil was 15.7%, while it was 16%, 16.2% and in soils treated with 0.1%, 0.2% and 0.4% Agrosil respectively. At 300 millibar tension this percent retained moisture was 10.8%, 10.9%, 11.7% and 12.4% for the four treatments respectively. Generally the treatment of soil with Agrosil increased slightly the percent of retained moisture and the higher the amount of Agrosil added to soil the higher the increase of retained moisture at a tension higher than 100 millibar. The change of retained moisture is increased by about 15% in soil that contained 0.4% Agrosil compared to untreated soil at 300 millibar tension.

Table 2 shows the pore size distribution in untreated and treated soil samples. These data were obtained from curves relating water content and tension by using the equation,

$$r = \frac{2\sigma}{hLg}$$

where r is the upper limiting radius which can remain full of water when a tension of h cm of water is applied to the wet soil, σ is the surface tension coefficient, 1 is the density of water and g is the acceleration of gravity. The size distribution of the pores in the soil provides a specification of its structure, so if there was a change in soil structure due to Agrosil application it should be reflected in the pore size distribution of soil. The data show that the application of Agrosil affected to some extent the size and distribution of pores in soil. For example the volume of pores which have a size between 0–4 micron in diameter is 80 cm^3/1,000 cm^3 (volume of pores related to bulk volume of soil) or 8% in the untreated soil, while it was 8.7, 9, and 9.5% in soils treated with 0.1%, 0.2%, and 0.4% Agrosil respectively. There was about a 19% increase in the volume of pores falling in that size (0–4 micron) in soil treated with 0.4% Agrosil compared to the untreated soil. It could be concluded that the treatment of soil with Agrosil increased to some extent the amount of small size pores in the soil, and consequently affected the amount of moisture retained in soil.

It is recognized that in general the water flow rate through soil will be affected by the

Table 2 Pore* size distribution in soil treated with different amounts of Agrosil.

Treatment	Size range (Diameter in μ)									
	0–4	4–5	5–6	6–7.5	7.5–10	10–15	15–20	20–30	30–60	60–120
Untreated soil	8	1	0.7	0.5	0.6	1.7	3.2	9.3	11.4	3.6
Soil treated with 0.1% Agrosil	8.7	0.7	0.6	0.3	0.6	2.3	2.8	10.3	10.7	3.0
Soil treated with 0.2% Agrosil	9	1	0.4	0.5	0.8	2.1	2.4	9.2	10.6	3.5
Soil treated with 0.4% Agrisol	9.5	1	0.8	0.6	0.5	2.4	2.2	9.4	11.3	2.8

*(Volume of pores are expressed in percent of the bulk volume of soil).

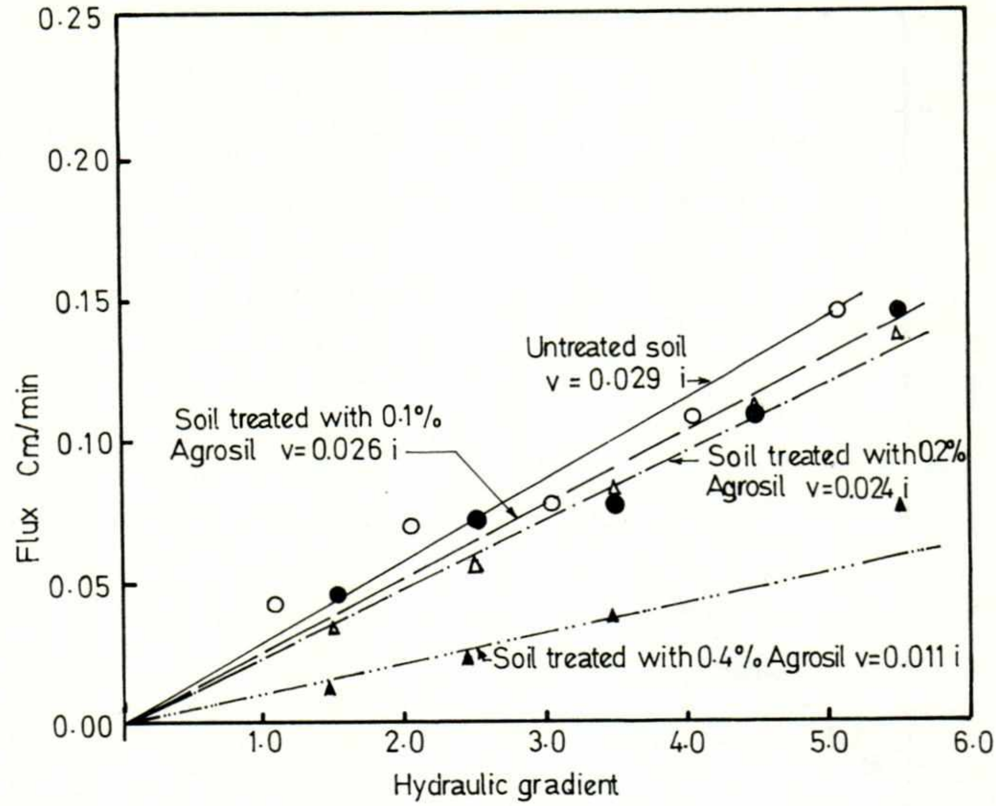

Fig. 2. Water Flux versus Hydraulic gradient was effected by Agrosil treatment.

porosity and with the size of pores through which fluid has to pass.

Figure 2 shows the relationship between water flux and hydraulic gradient for both treated and untreated soil. According to Darcy's law the volumetric water flux (v) in saturated porous media is directly proportional to the hydraulic gradient (i) and can be expressed by the equation:

$$V = ki$$

where K is the hydraulic conductivity taken as constant for a given porous media under iso-thermal condition. Results show that the relation between water flux and hydraulic gradient is linear which proves that Darcy's equation describes the flow in both untreated and treated soil. The saturated hydraulic conductivity of the untreated soil sample was equal to 0.029 cm/min, while it was 0.026 cm/min, 0.024 cm/min, and 0.011 cm/min respectively for soil samples treated with 0.1%, 0.2% and 0.4% Agrosil. This indicates that 0.1% addition of Agrosil changed saturated hydraulic conductivity slightly (about 10%) but the change was the highest in the 0.4% Agrosil treatment, where there was a reduction of more than 50% in the value of saturated hydraulic conductivity. This was mainly due to the reduction in pore size as was discussed earlier.

Figure 3 shows the relationship between cumulative infiltration and $(\text{time})^{1/2}$ in the vertical direction for both untreated and treated soil samples. In all cases the data fit

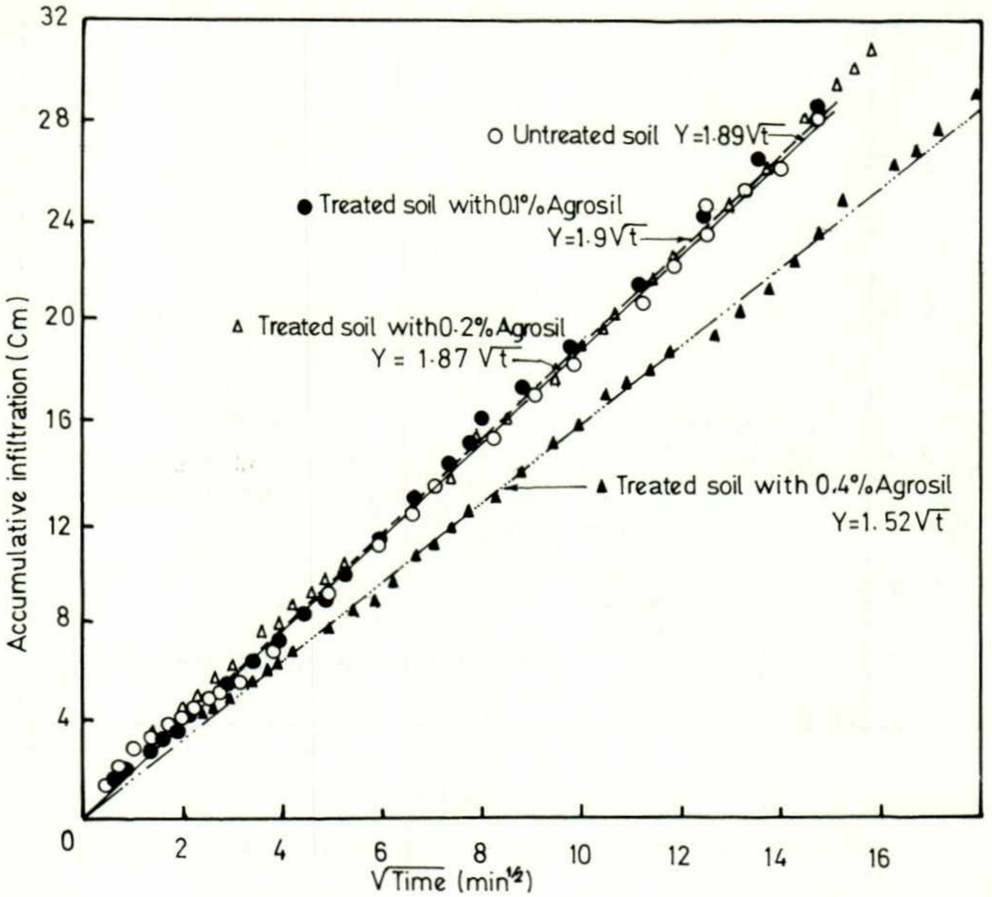

Fig. 3. Cumulative infiltration rate as effected by Agrosil treatment.

the empirical relationship

$$Y = Et^{0.5}$$

where Y is the cumulative infiltration in cm, t is the time in minutes, and E is an empirical coefficient. The value of E was equal to 1.89 for the untreated soil sample, while it was 1.90, 1.87, and 1.52 for soil samples treated with 0.1% 0.2% and 0.4% Agrosil respectively. It is noticed that only when Agrosil was added at 0.4% was there about a 20% reduction in the coefficient E.

Figure 4 shows the relationship between the advance of the wetting front and lapsed time for both untreated and treated soil. The data in both cases fit the equation of the type

$$X = Bt^{0.5}$$

where X is the distance of advance of the wetting front in cm, t is the time in minutes and B is an empirical constant. The value of B for untreated soil and soil treated with both 0.1% and 0.2% Agrosil is approximately the same. Only when Agrosil was added at 0.4% was there a 17% reduction in the value of B. It could be concluded that both the infiltration rate and the advance of wetting front were affected in the same direction

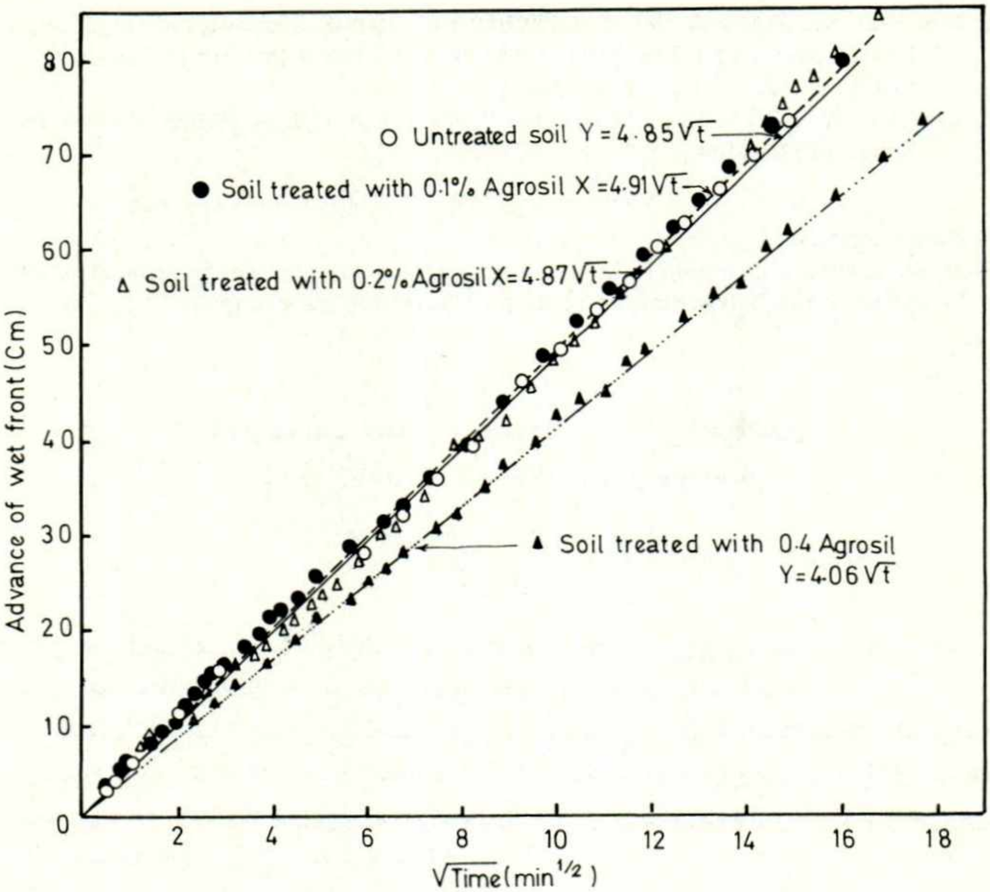

Fig. 4. Effect of Agrosil treatment on the advance of the wetting front during infiltration rate of water in the soil.

as saturated hydraulic conductivity though not to the same extent (due to the capillarity effect under unsaturated flow). The main reason for the reduction in flow both under saturated and unsaturated conditions was the change in porosity and pore size distribution of soil when treated with Agrosil. The change was only appreciable at a higher rate of addition, namely 0.4%.

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Acknowledgement:–
The authors express their appreciation to prof. Joe B. Dixon from the Department of Soil and Crop Sciences, College Station, Texas, for reading the manuscript.

تأثير زيادة نسب مختلفة من مستصلح التربة (اجروزيل) على العلاقة بين التربة والماء في تربة جيرية ذات قوام رملى لومية السطح

محمد شعبان السيد ، الجيلاني عبد الجواد

المستخلص

في هذا البحث تمت دراسة تأثير زيادة معدلات مختلفة من مادة (اجروزيل) (صفر–×٠,١٪ ، ٠,٢٪ ، ٠,٤٪) عن علاقة التربة بالماء وتوزيع الفراغ الحبيبي الدقيق ونسبة احتفاظ التربة بالرطوبة) .

وقد دلت نتائج هذا البحث بأن نسبة احتفاظ التربة بالماء قد زادت زيادة طردية بالنسبة للمعاملات فقد ارتفعت بين نسب تتراوح من ٨ إلى ١٥٪ بالنسبة للمعاملة ٠,٤٪ و٨٪ بالنسبة للمعاملة ٠,٢٪ وبين واحد واثنين في المادة عند إضافته إلى ٠,١٪ من مادة الاجروزيل بين مائة وخمسين وثلاثمائة جزء في الألف من البار (البار هو عبارة عن وحدة قياس لنسبة شد التوتر المائي في التربة في هذه الحالة) .

وهذه الزيادة الخاصة بزيادة احتفاظ التربة بالرطوبة نتيجة :—

١ — انخفاض درجة التوصيل الهيدروليكى في التربة حيث انخفض بنسبة ٥٠٪ للمعاملة ٠,٤٪ ، ١٧٪ بالنسبة للمعاملة ٠,٢٪ .

٢ — كذلك نتيجة لزيادة فراغ الحبيبات التي حجمها أقل من أربع ميكرون حيث زادت ١٩٪ بالنسبة للمعاملة ٠,٤٪ على غير المعاملة .