Minufiya J. Agric. Res. Vol.41 No. 1(2): 217 – 236 (2016) "http://www.mujar.net"

IMPACT OF SULPHUR AND BIOGAS MANURE APPLICATION ON THE PHYSICAL PROPERTIES OF SALT AFFECTED AND CALCAREOUS SOILS AND PLANT GROWTH

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(Received: Nov. 1 , 2015)

ABSTRACT: *This investigation was carried out at Gemmeiza Agric. Res. Station, during 2010/2011 season on three salt affected soils varied in their content of salinity and sodicity and three calcareous soils varied in their content of $CaCO_3$ (%) to study the effect of soil amendments (sulphur and biogas manure) and incubation periods on some physical properties {Bulk density(Bd), Total porosity(Tp), Hydraulic conductivity (Hc) and Total water stable aggregates(TWSA)} of these soils and yield (grain and straw) of barley plants. A pot experiment was carried out in split split plot design with three replicates, where the main plots were the used salt affected and calcareous soils, the sub plots were application rates of sulphur or biogas manure and the sub sub plots were incubation periods. Sulphur application was at rates 0, 2.38, 4.76 and 7.14 ton hectare^{1}. While, biogas manure was applied at 0, 23.80, 47.60 to 71.40 ton hectare^{-1}. The previous treated soil were incubated for 0, 2 and 4 months before cultivation. The obtained results showed that sulphur and biogas manure application in any rate improved soil physical properties (Bd, Tp, Hc and TWSA) and induced significant or highly significant increases in barley grain and straw yield of salt affected and calcareous soils. The incubation of biogas manure or sulphur in soil before sowing, especially at four incubation, appeared a pronounced increases in the values of Tp, Hc, TWSA and significant increase in yield of barley. On the contrary, values of Bd tended to minimize with the prolonging the incubation periods.*

Key words: *Salt affected soils, calcareous soils, biogas manure, sulphur, physical properties and barley plants.*

INTRODUCTION

Total salt affected area in Egypt is about 0.9 M ha. The majority of salt-affected soils in Egypt are located in north. Wherever, fifty-five percent of cultivated lands of the northern Delta regions, twenty percent of the southern Delta and middle Egypt region and twenty five percent of the upper Egypt region are salt- affected soils. (El-Banna *et al.,* 2004) reported that Salinity is one of major environmental factor reducing plant growth and productivity worldwide in arid and semi-arid regions (Munns, 2002). Tavakoli (2011) saline sodic soils are subject to structural degradation and restrict plant performance through poor soil- water and soil-air relation. The structure transformation of the aggregates that occurs upon their hydration may include swelling, swelling and dispersion. Dispersion involves the breakdown of a soil into particles of <2 mm. Which than diffuse through the dispersing solution. Also, increasing salinity and sodicity in soils including reduced hydraulic conductivity, soil aeration, water infiltration and poor soil drainage and increased susceptibility to surface crusting, runoff, hard-salting and soil erosion. Calcareous soils are of wide occurrence in these regions, and most of newly reclaimed calcareous soil are mainly found in western part at fringe of the Nile Delta. The calcareous soils are those with high content of $CaCO_3$, especially the active fraction with high specific surface area which causes physical problem of land and water use for crop production. A soil is considered “calcareous” from the chemical point of view when it is in equilibrium with excess of $CaCO_3$ at the partial pressure of the atmospheric CO_2. In the context of agricultural problem soil, calcareous soils are soil in which a high amount of calcium carbonate dominates the problem related to agricultural land use. The formation of crusts is a problem in the carbonate – rich soils newly put under cultivation especially the active fraction with high specific surface area which causes soil physical problem of resulting low water production. Also, high content of $CaCO_3$ the formation of crusts is a problem in the carbonate rich soils put under cultivation. Crusting which takes place at the soil surface hinders seeding rate of emergence and percentage. The adverse effect of crust depends on their strength and thickness. (Imas, 2000).

El-Shouny (2006) carried out a field experiment in the Sakha Agric., Res., Station to study the effect of some soil amendments (sulphur and farmyard manure) on physical and chemical properties and wheat productivity. Data showed, soil amendments application improved the physical soil properties and increased its productivity. Wahdan *et al.* (2005) showed that the effect of sulphur addition at rates 0.7, 1.5 and 2.5 ton/fed on calcareous soil physical properties and barely plants.

The best condition, which recorded improves soil physical properties and yield of barely, occurred at the rate of 2.5ton fed^{-1}. Harvey (2012) mentioned that applied of compost at rate 30 ton/fed in calcareous soils increase the percentage of soil water stable aggregates and saturated the hydraulic conductivity as compared with the treatments 15 ton/fed and control. Hashemimajd *et al.* (2012) found that incubation sulphur in soil at 16 and 32 weeks improve soil physical properties. In the laboratory, Mzazewa *et al.* (2003) found that bulk density values were decreased and improve stable aggregates and cumulative infiltration in soil after reclamation with applied soil amendments (sulphur and gypsum). Yadvia *et al.* (2004) observed that incubation biogas manure in soil up to 100 days gave a large volume of hydraulic conductivity than incubation 10 and 20 days. Popadopoulos *et al.* (2006) observed that soil bulk density was decreased as results of incubation organic but total porosity and hydraulic conductivity were increased in calcareous soils. El-Sodany *et al.* (2012) noticed that the highest values of grain and straw yield barley plants and all growth characters with applied of sulphur or organic manure in alluvial soil. Bona *et al.* (2011) found that applied of sulphur in soil can enhance increased grain and straw yield of barley plants in calcareous soils. These results are in accordance with these reported by Froseth *et al.* (2014) to evaluate the effect of organic manure incubation periods on the yield and N recovery of a subsequent spring barley crop. Data observed the increasing organic manure incubation periods before sowing gave the highest values of grain and straw yield in alluvial soils. Lat *et al.* (2008) revealed that application organic manure gave significantly high grain and straw yield of barley plants in loamy sand soil, especially when increase incubation organic manure before sowing in calcareous soil. So, the object of this investigation was to reveal the beneficial influence of different amendments such as sulphur and biogas on the physical properties of saline sodic and calcareous soils and the barley plants grown on this soil.

MATERIALS AND METHODS

A pot experiment was conducted at Gemmeiza Agric Res. Station, during

2010/2011 season to investigate the effect of sulphur (natural chemical amendment) and biogas manure (natural organic fertilizer) and incubation periods on some physical properties and yield of barley plants in saline sodic and calcareous soils. The three salt affected soils were taken from different locations of El-Hamoul area Kafer El-Sheikh Governorate: 1) Village of Abosekken, 2) Village of Khaled Eben El-Waled and 3) Section El-Mansour part 10. On the other hand, three calcareous soils were taken from: 1) At Kilo 48 Cairo – Alexandria desert road –Nubaria –Bahira

Governorate, 2) At Kilo 72 Cairo – Alexandria desert road –Alameria – Alexandria Governorate and 3) Borg Elarab- Alexandria Governorate. In this experiment, plastic pots were uniformly packed with ten kilogram of the investigated soils. Surface soil area in each pot was $0.049M^2$(30 cm high × 25 cm diameter). The applied treatments were 0, 2.38, 4.76 and 7.14 t/he for elemental sulphur; 0, 23.80, 47.60 and 71.40 t/he for biogas manure and thoroughly well mixed with the studied experimental soils. The pots were incubated for four months, received amount of water equal 120% field capacity at zero, two and four months of incubation periods, with three replicates and arranged in a split split plot design. Each pot was sown after the end of the three incubation periods at one December 2010 with barley (*Hordum Vulgare L.*) cultivar Giza 126. Each pot was sown with 15 seeds of barley. After 12 days, the plants of each pot were thinned to 10 plants. Throughout the growth, moisture content of the soil was maintained at 60% of W.H.C. All pots were fertilized with recommended dose of NPK as defined by Agriculture Ministry, which were ammonium nitrate (33.5%N) at rate of 60 kg N/fed, superphosphate (15.5%P_2O_5) at rate 30 kg P/fed and potassium sulphate (48% K_2O) at rate of 48 kg K/fed. At the end of the growing seasons, the barley plants shoot of each pot were harvested above the surface soil in the 10^{th} of May 2011 and separated into grains and straw and air-dried. The air-dry weight of straw and grain were recorded. Also, soil sample were taken for physical properties analysis. The soil physical properties of bulk density, Hydraulic conductivity and Total water stable aggregates were determined as described by Black and Hartge (1986), Klute and Dirksen (1986) and Kemper and Rosenau (1986), respectively. Total porosity (%) was calculated as described by Vomocil (1965) as follows:

Total porosity (%) = 1- (bulk density / particle density) × 100

Some initial soil properties of the studied soils and biogas manure were determined according to Page *et al.* (1982) and data are given in Tables (1 to 3). All obtained data were statistically analyzed according to (Costat 6.311, Copyright (C) (1988-2005). Mean values were compared for each other using the least significant differences. This material which supplied by El-Help company, Egypt. Sulphur was applied to the soils in different rates based on the required gypsum amounts reclamation each soil. Biogas manure was applied to the soils as a source of organic matter to these soils. A relatively high rates were applied to the studies soils because these soils are very poor in their contents form organic carbon. It was obtained from waste recycling center Moshtohor – Banha city- Qaliubiya Governorate.

RESULTS AND DISCUSSION

1-Bluk density (Bd) and Total porosity (Tp):

The results in Table (4) indicated that application of different sulphur rates decreased significantly on bulk density however total porosity was increased significantly. The average values of bulk

Table 1

Table 2 , 3

density decreased by 2.90, 2.76 and 3.70 in (SAS1, SAS2 and SAS3) salt affected soils respectively and, 2.44, 2.63 and 4.14% in (CS1, CS2 and CS3) calcareous soils respectively, when sulphur application as 7.14 t/he as compared with control. On opposite, total porosity increased by 3.16, 3.32 and 3.59% in salt affected soils (SAS1, SAS2 and SAS3), respectively and, 3.61, 3.85 and 5.03% in calcareous soils (CS1, CS2 and CS3), respectively with application of sulphur at 7.14 t/he compared with the control respectively. This may be due to the roll of sulphur in increasing the aggregates formation, consequently augmenting the soil porosity. This trend was previously reported by Wahdan *et al.* (2005) and El-Shouny (2006).

The data in Table (5) showed that, the mean values of bulk density decreased significantly by 5.80, 5.55 and 5.92% in salt affected soils (SAS1, SAS2 and SAS3), respectively and decrease by 3.66, 3.97 and 4.83% in calcareous soils (CS1, CS2 and CS3), respectively with application of biogas manure at 71.40 t/he compared with control. While, total porosity increased significantly by 6.82, 6.05 and 5.62% in salt affected soils (SAS1, SAS2 and SAS3), respectively and increased from 6.29, 4.76 and 6.12% in calcareous soils (CS1, CS2 and CS3), respectively after application of biogas manure at rate 71.40 t/he respectively as compared with control. These results of bulk density and total porosity may be due to applied of biogas manure led to produce organic acid i.e humic acid which had aggregating effect on soil particles, which create more aggregates leading to increase of apparent volume and consequently improve bulk density and total porosity. These results are in harmony with El-Sedfy (2008) and Abdel-Aziz (2010).

In regarded to the effect of incubation period with sulphur and biogas manure on bulk density and total porosity in salt affected and calcareous soils, data in Tables (4 and 5) show that the mean values of bulk density were decreased with increasing incubation period. While, total porosity were increased by increasing incubation period. This may be due to that the increase of the incubation periods ledto decomposition of biogas manure or sulphur soil aggregation status and soil structure, consequently, enlarged the apparent volume, so, the soil porosity The results are in a close agreement with those obtained by Abdel-Fattah (2011) and Dai *et al.* (2013).

2-Hydraulic conductivity (Hc) and Total water stable aggregates (TWSA).

Data in Tables (6 and 7) illustrated the effect of sulphur treatments on hydraulic conductivity and Total water stable aggregates in salt affected and calcareous soils. These results show that hydraulic conductivity was increased significantly under sulphur treatments comparing with control treatment. The mean of increases were 85.96, 74.00 and 264.28% in salt affected soils (SAS1, SAS2 and SAS3), respectively and, increased by 9.54 and 21.77 % in calcareous soils (CS2 and CS3), respectively but, CS1 decreased by 3.60% with application of sulphur at rate 7.14 t/he in comparison with the control. From these tables, it can be noticed that an increase in Twsa values 7.51, 11.36 and 9.44% in salt affected soils (SAS1, SAS2 and SAS3), respectively and increased by 17.50, 15.37 and 14.09% in calcareous soils (CS1, CS2 and CS3), respectively with the incremental addition of sulphur at the rate of 7.14 t/he as compared with the control. This may be due either to roll of sulphur in enhancing soil organic matter decomposition or diminishing soil pH in soils, so stimulating microbial activing that results in promoting Twsa in the both tested soils. The obtained data in agreement with those reported by Abdel-Halim (2001), El-sherbiny (2007) and Abdel-Hafez (2008).

Table 4

Table 5

Table 6

Table 7

Data presented in Tables (6 and 7) show the effect of biogas manure rates on Hc and TWSA in salt affected and calcareous soils. The values of Hc and TWSA of the tested soils were positively influenced due to increasing rates of biogas manure when compared with the control treatment in SAS and CS soils. However, application biogas manure of in coarse calcareous number CS1casue a decrease in Hc and increase in fine calcareous number CS2 and CS3. This increase may be due to organic matter that lead to synthesis of compound that bind soil particles and produce stable aggregates. These aggregates help maintain a loose open, granular condition. Water is the better able to infiltrate and percolate downward through the soil. This results supported by Abdel-Maboud (2004), Mohamad *et al.* (2007) Fernandez *et al.* (2009) and Harvey (2012).

The influence of incubation period with sulphur and biogas manure on Hc and Twsa in salt affected and calcareous soils are presented in Tables (6 and 7). The data clear that incubation sulphur or biogas manure in soils at 4 months before sowing improved Hc and TWSA in the studied soils. This may be due to the elongation the incubation periods led to stimulate the rate of organic matter decomposition, which affect on soil aggregation consequently, improved soil structure and permeability. These results are in agreement with those obtained by Mzazewa *et al.* (2003), zhao (2009), Abdel-Rahman *et al.* (2012) and Darwich *et al.* (2012).

3- Grain and straw yield

With the respect of the impact of sulphur treatments on grain and straw yield of barley plants in salt affected and calcareous soils. It is obvious from data in Tables (8 and 9) and Fig. (1) that barley grain and straw yield were significantly increased with application of sulphur. Application sulphur at rate 7.14 t/he led to augment grain yield by 12.44, 22.19 and 118.99% and straw yield increased by 11.31, 14.61 and 41.85% in salt affected soils (SAS1, SAS2 and SAS3), respectively. On the other hand, the grain yield in calcareous soils (CS1, CS2 and CS3) increased by 11.87, 35.32 and 57.49% and straw yield increased by 21.49, 24.91 and 46.21%, respectively than control. This may be due to the effective role of sulphur on decreasing soil pH via release of sulpate during the biological oxidation of sulphur so its beneficial effect on the activity of soil microorganisms and consequently improving action of sulphur on physical and chemical properties as well as nutrients status in the soil.. These results are in agreement with those obtained by Badawy *et al.* (2011) and El-Sodany *et al.* (2012).

Data in Tables (8 and 9) and Fig. (2) reveal that the induce of biogas manure treatments on grain and straw yield of barley plants grown in alluvial and calcareous soils. Results showed that biogas manure treatments significantly increased grain yield as compared with control. Increasing the rates of biogas manure up to 71.40 t/he led to increase of grain yield by 16.29, 25.97 and 128.02% and straw yield increased by 14.77, 23.28 and 41.46% in salt affected soils (SAS1, SAS2 and SAS3), respectively. While, the barley grain yield grown in calcareous soils (CS1, CS2 and CS3) increased by 19.12, 27.41 and 44.11% and straw yield increased from 23.35, 27.06 and 34.21%, respectively as compared to the control. This increase in grain and straw yield was due to the beneficial effect of biogas manure added to a raising soil fertility. Also, organic manure applied would be improve soil physical and chemical properties in alluvial and calcareous soils. Organic manure also considered as source of essential nutrient for plant growth. These results were similar to those findings by Urselmans *et al.* (2009) Yadav *et al.* (2013).

Table 8

Table 9

Fig 1

Fig 2

The impact of incubation periods with biogas manure on grain and straw yield of barley plants in salt affected and calcareous soils are presented in Tables (8 and 9). The obtained data show that significant increase of grain and straw yield was found. The data clear that incubation sulphur at 4 months before sowing led to the greatest values of grain and straw yield, these increase in grain yield were 4.95, 18.05 and 33.03% and straw yield increased by 6.77, 13.52 and 28.29% in salt affected soils (SAS1, SAS2 and SAS3), respectively than zero incubation. While, the values of grain yield in calcareous soils (CS1, CS2 and CS3) increased by 9.67, 21.86 and 43.46% and straw yield increased by 11.25, 29.43 and 32.41%, respectively when incubation sulphur at 4 months than zero incubation. Also, the same trend was observed with incubation biogas manure at 4 months wherever it gives the highest grain yield percentage reached 6.09, 20.94 and 38.44% and straw yield increased by 9.15, 13.69 and 22.34% in salt affected soils (SAS1, SAS2 and SAS3), respectively as compared with without incubation. On the other side, the barley grain yield grown in calcareous soils (CS1, CS2 and CS3) increased by 10.62, 13.49 and 25.00% and straw yield increased by 19.33, 25.38 and 12.96% when incubation biogas manure at 4 months, respectively as compared with zero incubation. This might attribute to elongation the incubation periods of organic manure and sulphure that affect soil biological conditions, so the microorganism activities, which enhance the release of necessary nutrients in available forms throughout their mineralization, in return improves soil fertility status which leads to higher yield of barley plants. Similar results were gained previously by Hellal (2007), El-Sharawy (2008), Astolfi *et al.* (2010) and Froseth *et al.* (2014).

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تأثيرإضافة الكبريت وسماد البيوجاز علي الخواص الطبيعية للأراضي المتأثرة بالأملاح والجيرية ونمو النبات

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الملخص العربى

أجريت هذه الدراسة بمحطة البحوث الزراعية بالجميزة بغرض إستخدام محسنات الأرض(الكبريت الزراعي وسماد البيوجاز) في تحسين الخواص الطبيعية للأراضي بالمتأثرة بالأملاح والأراضي الجيرية وزيادة إنتاجية محصول الشعير

لتحقيق هذه الدراسة جمعت عينات تربة سطحية(٠–٣٠سم) من أراضي متأثرة بالأملاح من ثلاث مناطق (قرية أبو سكين–قرية خالد ابن الوليد– منطقة المنصور رقم ١) مركز الحامول مركز كفر الشيخ وأراضي جيرية من مناطق (الكيلو ٤٨طريق مصر الإسكندرية الصحراوي – الكيلو٧٢طريق مصر الإسكندرية الصحراوي– برج العرب). وتم اجراء تجربة في أصص بها ١٠كجم تربة وصممت التجربة في قطع عديدة الانشقاق. وكان العامل الرئيسي هو الأراضي الرسوبية او الأراضي الجيرية و العامل المنشق اولا محسنات الأرض وهي الكبريت الزراعي بمعدلأت (٠و٢.٣٨و٤.٧٦و٧.١٤طن/للهكتار) أو سماد البيوجاز بمعدلأت (٠و٢٣.٨٠و٤٧.٦٠و٧١.٤٠طن/للهكتار) والعامل المنشق ثانيا فترات التحضين (بدون تحضين و بعد شهرين وبعد اربعة شهور) مع المحسنات السابقة قبل الزراعة وكان الري خلال فترات التحضين عند ١٢٠% من السعة الحقلية وبعد إنتهاء فترات التحضين تم زراعة الشعير (جيزة ١٢٦) في الاول من ديسمبر ٢٠١٠ وتم المحافظة على مستوى الرطوبة عند ٦٠% من السعة التشبعية لكل الأصص وأيضا تم إضافة الاسمدة اليها تبعا لمعدلات التسميد الواردة من وزاه الزراعة وهو ٦٠ وحدة نيتروجين تم وضعها في صورة نترات امونيوم (٣٣.٥%)و٣١ وحدة فوسفور في صورة سوبر فوسفات الكالسيوم ١٥.٥% P_2O_5 والبوتاسيوم بمعدل ٤٨ وحدة بوتاسيوم فى صورة وحدة سلفات البوتاسيوم (K_2O٤٨) وتم حصاد المحصول في ١٠ مايو ٢٠١١ بعد تمام النضج وتم بعد ذلك وزن كلا من الحبوب والقش بعد الجفاف واخذت عينات التربة لتقدير الخواص الطبيعية.

لاحظ عن إضافة الكبريت وسماد البيوجاز الى التربة إنخفاض فى قيم الكثافة الظاهرية وبالتالي زيادة المسامية الكلية للتربة مقارنة بالكنترول وذلك بعد حصاد محصول الشعيروقد ظهر هذا بوضوح مع إضافة ٧.١٤ طن كبريت للهكتار و٧١.٤٠ طن للهكتار من سماد البيوجاز. والتحضين الكبريت وسماد البيوجاز في التربة لمدة ٤ شهور قبل الزراعة سواء في الأراضي المتأثرة بالأملاح أو الجيرية مقارنة بالكنترول.

وجد أيضا أن إضافة الكبريت بمعدل٧.١٤ طن للهكتار و٧١.٤٠ طن للهكتار من سماد البيوجاز أدى الى زيادة قيم كلا من التوصيل الهيدروليكي والتجمعات الكلية الثابتة في الماء في الأراضي المتأثرة والجيرية. أيضا أدى زيادة فترات تحضين الكبريت وسماد البيوجاز بالتربة في الأراضي تحت الدراسة الى تحسين ملحوظ في قيم التجمعات الكلية الثابتة في الماء.

كذلك حدث زيادة في محصول الحبوب والقش نتيجة لإضافة الكبريت وخاصة مع إستخدام المعدل٧.١٤طن للهكتار وقد حقق إضافة سماد البيوجاز بمعدل ٧١.٤٠ طن للهكتار أعظم محصول للحبوب والقش. كذلك سجلت أطول فترة تحضين (عند ٤ شهور) أعظم قيم للحبوب والقش وعلى العكس من ذلك فان اقل قيم للحبوب والقش وجد مع معاملة التربة بدون تحضين.

Table (1): particle size distribution (%) and some physical properties of the studied soil

soil type	soil .No.	particle size distribution				Textural grade	H.C cm/h	Moisture contents (%)				Bulk density g/cm^3	Total porosity (%)	Total aggregates (%)
		c. sand	f. sand	silt	clay			WHC	FC	WP	AW			
Salt affected soils	SAS1	3.42	7.83	29.40	59.35	clay	0.46	76.26	44.72	23.11	21.61	1.41	45.80	57.11
	SAS2	2.81	18.20	25.60	53.39	clay	0.28	84.74	43.68	24.35	19.33	1.46	43.80	45.75
	SAS3	4.40	5.84	33.80	55.96	clay	0.08	92.55	46.34	25.14	21.20	1.39	46.50	39.55
calcareous soils	CS1	43.51	32.60	8.95	9.88	SL	18.27	36.18	17.82	9.27	8.22	1.69	35.00	13.66
	CS2	26.43	40.70	10.30	22.57	SL	5.37	48.33	25.23	13.38	11.85	1.54	40.80	22.99
	CS3	14.71	44.00	14.00	27.29	SLC	2.64	54.52	27.72	15.25	12.47	1.50	43.40	27.85

S=sandy, L= Loamy, C=Clay. H.C= hydraulic conductivity. WHC= water holding capacity, FC= Field capacity, WP= wilting point, AW= available water.
SAS1, SAS2, SAS3= salt affected soils, CS1, CS2, CS3 = calcareous soils.

Table (2): Some chemical properies of the studied soils.

soil type	soil NO.	pH(1:2.5)	EC dS/m	soluble cations(meq/L)				soluble anions(meq/L)				CEC (Cmol/Kg)	Exchangable cations(Cmol/Kg)				ESP(%)	OM(%)	$CaCO_3$ (%)	GR t/he	SR t/he
				Ca^{++}	Mg^{++}	Na^{+}	k^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}	So_4^{-}		Ca^{++}	Mg^{++}	Na^{+}	k^{+}					
Salt affected soils	SAS1	8.14	8.25	18.50	20.50	42.56	0.35	55.00	N.D	12.59	14.32	46.11	15.70	17.86	11.31	1.03	24.53	1.17	5.26	13.45	2.50
	SAS2	8.34	17.40	34.80	37.20	98.65	0.88	123.50	N.D	24.88	23.15	52.20	14.50	16.24	20.01	1.23	38.33	1.44	4.06	28.30	5.26
	SAS3	8.43	24.90	45.40	40.00	161.50	1.07	180.00	N.D	26.23	41.71	48.72	10.10	12.15	25.26	1.12	51.82	1.34	6.06	47.83	8.89
calcareous soils	CS1	8.21	5.87	15.50	11.50	30.74	0.31	46.50	N.D	5.88	5.67	9.57	4.24	3.15	1.91	0.21	19.96	0.81	11.50	11.40	2.12
	CS2	7.88	11.60	21.50	25.00	62.83	0.57	78.00	N.D	10.20	22.70	17.84	6.96	4.68	5.66	0.48	31.73	2.00	34.20	20.71	3.85
	CS3	8.29	18.30	36.20	32.80	113.00	0.98	153.30	N.D	8.75	20.99	23.49	8.18	5.38	9.14	0.64	38.91	1.95	47.90	40.35	7.50

N.D= No Detected GR= Gypsum requirements SR= Sulphur requirements.

Table (3): some properties of the used biogas manure.

EC (1:10)	pH (1:10)	Bulk density (g/cm)	Organic Carbon (%)	Organic matter (%)	Macronutrients (%)						C/N ratio	Micronutrients (mg /kg)			
					Total N	Total P	Total K	Total S	Total Ca^{++}	Total Mg^{++}		Total Fe	Total Zn	Total Mn	Total Cu
2.88	6.25	0.62	11.75	20.26	1.13	0.49	1.39	1.35	1.25	0.85	10.40	1455.0	609.0	352.00	88.00

Table (4): Influence of sulphur application and incubation periods on bulk density and total porosity values (%) in salt affected and calcareous soils after harvesting.

Bulk density g/cm^3

Salt affected soils	Sulphur	Incubation periods P0	P2	P4	Mean	Calcareous soils	Sulphur	Incubation periods P0	P2	P4	Mean
SAS1	S0	1.41	1.38	1.36	1.38	CS1	S0	1.66	1.64	1.61	1.64
	S1	1.40	1.37	1.33	1.37		S1	1.64	1.62	1.59	1.62
	S2	1.40	1.35	1.31	1.35		S2	1.62	1.62	1.58	1.61
	S3	1.40	1.35	1.28	1.34		S3	1.62	1.61	1.57	1.60
Mean		1.40	1.36	1.32	1.36	Mean		1.64	1.62	1.59	1.62
SAS2	S0	1.47	1.44	1.43	1.45	CS2	S0	1.54	1.52	1.50	1.52
	S1	1.46	1.44	1.40	1.43		S1	1.52	1.51	1.48	1.50
	S2	1.45	1.45	1.39	1.43		S2	1.52	1.50	1.46	1.49
	S3	1.44	1.43	1.35	1.41		S3	1.51	1.47	1.45	1.48
Mean		1.46	1.44	1.39	1.43	Mean		1.52	1.50	1.47	1.50
SAS3	S0	1.37	1.35	1.33	1.35	CS3	S0	1.48	1.46	1.42	1.45
	S1	1.36	1.33	1.29	1.33		S1	1.45	1.42	1.39	1.42
	S2	1.34	1.32	1.28	1.31		S2	1.46	1.40	1.36	1.41
	S3	1.35	1.31	1.25	1.30		S3	1.44	1.38	1.36	1.39
Mean		1.36	1.33	1.29	1.32	Mean		1.46	1.42	1.38	1.42

Total porosity (%)

Salt affected soils	Sulphur	Incubation periods P0	P2	P4	Mean	Calcareous soils	Sulphur	Incubation periods P0	P2	P4	Mean
SAS1	S0	46.79	47.92	48.68	47.80	CS1	S0	37.36	38.11	39.25	38.24
	S1	47.17	48.30	49.81	48.43		S1	38.11	38.87	40.00	38.99
	S2	47.17	49.06	50.57	48.93		S2	38.87	38.87	40.38	39.37
	S3	47.17	49.06	51.70	49.31		S3	38.87	39.25	40.75	39.62
Mean		47.08	48.59	50.19	48.62	Mean		38.30	38.78	40.10	39.06
SAS2	S0	44.53	45.66	46.04	45.41	CS2	S0	41.89	42.64	43.40	42.64
	S1	44.91	45.66	47.17	45.91		S1	42.64	43.02	44.16	43.27
	S2	45.28	45.28	47.55	46.04		S2	42.64	43.40	44.91	43.65
	S3	45.66	46.04	49.06	46.92		S3	43.02	44.53	45.28	44.28
Mean		45.10	45.66	47.46	46.07	Mean		42.55	43.40	44.44	43.46
SAS3	S0	48.30	49.06	49.81	49.06	CS3	S0	44.16	44.91	46.42	45.16
	S1	48.69	49.81	51.32	49.94		S1	45.28	46.42	47.55	46.42
	S2	49.43	50.19	51.70	50.44		S2	44.91	47.71	48.70	47.11
	S3	49.06	50.57	52.83	50.82		S3	45.66	47.92	48.70	47.43
Mean		48.87	49.91	51.42	50.06	Mean		45.00	46.74	47.84	46.53

Bd in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Bd in cs	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.009	0.01	0.087	NS	NS	1.82	NS	L.S.D. 0.01	0.75	0.50	0.29	NS	NS	0.65	NS
L.S.D. 0.05	0.006	0.1	0.065	NS	NS	1.36	NS	L.S.D. 0.05	0.45	0.37	0.22	NS	NS	0.49	NS
Tpin SAS	A	B	C	A*B	A*C	B*C	A*B*C	Tp in CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.016	0.01	0.008	NS	NS	1.65	NS	L.S.D. 0.01	0.62	0.43	0.31	NS	0.63	NS	NS
L.S.D. 0.05	0.010	0.01	0.006	NS	NS	1.25	NS	L.S.D. 0.05	0.37	0.31	0.23	NS	0.47	NS	NS

SAS1,SAS2 and SAS3 = salt affected soils, CS1, CS2 and CS3 = calcareous soils S0, S1, S2 and S3 = rates of sulphur (0, 2.38, 4.76 and 7.14 ton/hectare) , P0, P2 and P4 = incubation periods (0, 2 and 4 months). Bd= bulk density, Tp= total porosity A=Soils, B=sulphur, C=incubation

Table (5): Influence of biogas manure application and incubation periods on bulk density and total porosity values (%) in salt affected and calcareous soils after harvesting.

Bulk density g/cm^3

Salt affected soils	Biogas	P0	P2	P4	Mean	Calcareous soils	Biogas	P0	P2	P4	Mean
SAS1	B0	1.40	1.39	1.36	1.38	CS1	B0	1.66	1.65	1.62	1.64
	B1	1.38	1.33	1.28	1.33		B1	1.64	1.61	1.58	1.61
	B2	1.39	1.32	1.26	1.32		B2	1.63	1.59	1.52	1.58
	B3	1.37	1.29	1.23	1.30		B3	1.64	1.58	1.52	1.58
Mean		1.39	1.33	1.28	1.33	Mean		1.64	1.61	1.56	1.60
SAS2	B0	1.45	1.44	1.42	1.44	CS2	B0	1.53	1.51	1.49	1.51
	B1	1.43	1.41	1.35	1.40		B1	1.52	1.48	1.45	1.48
	B2	1.43	1.37	1.34	1.38		B2	1.51	1.47	1.43	1.47
	B3	1.41	1.36	1.32	1.36		B3	1.49	1.45	1.42	1.45
Mean		1.43	1.40	1.36	1.39	Mean		1.51	1.48	1.45	1.48
SAS3	B0	1.37	1.35	1.33	1.35	CS3	B0	1.48	1.45	1.42	1.45
	B1	1.35	1.31	1.27	1.31		B1	1.45	1.41	1.37	1.41
	B2	1.33	1.29	1.24	1.29		B2	1.43	1.38	1.35	1.39
	B3	1.32	1.27	1.22	1.27		B3	1.42	1.38	1.33	1.38
Mean		1.34	1.31	1.27	1.30	Mean		1.45	1.41	1.37	1.41

Total porosity (%)

Salt affected soils	Biogas	P0	P2	P4	Mean	Calcareous soils	Biogas	P0	P2	P4	Mean
SAS1	B0	47.17	47.55	48.70	47.81	CS1	B0	37.36	37.74	38.87	37.99
	B1	47.92	49.81	51.70	49.81		B1	38.11	39.25	40.38	39.25
	B2	47.55	50.19	52.45	50.06		B2	38.49	40.00	42.64	40.38
	B3	48.30	51.32	53.58	51.07		B3	38.11	40.38	42.64	40.38
Mean		47.74	49.72	51.61	49.69	Mean		38.02	39.34	41.13	39.50
SAS2	B0	45.28	45.66	46.42	45.79	CS2	B0	42.26	43.02	43.77	43.02
	B1	46.04	46.79	49.06	47.30		B1	42.64	44.15	45.28	44.02
	B2	46.04	48.30	49.43	47.92		B2	43.02	44.53	46.04	44.53
	B3	46.79	48.70	50.19	48.56		B3	43.77	45.28	46.15	45.07
Mean		46.04	47.36	48.78	47.39	Mean		42.92	44.25	45.31	44.16
SAS3	B0	48.30	49.06	49.81	49.06	CS3	B0	44.15	45.28	46.42	45.28
	B1	49.06	50.57	52.08	50.57		B1	45.28	46.79	48.30	46.79
	B2	49.81	51.32	53.21	51.45		B2	46.04	47.92	49.06	47.67
	B3	50.19	51.32	53.96	51.82		B3	46.42	47.92	49.81	48.05
Mean		49.34	50.57	52.27	50.72	Mean		45.47	46.98	48.40	46.95

Bd in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Bd in cs	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.014	0.01	0.008	NS	1.39	1.72	NS	L.S.D. 0.01	0.87	0.67	0.48	NS	0.62	0.89	NS
L.S.D. 0.05	0.008	0.01	0.006	NS	1.04	1.29	NS	L.S.D. 0.05	0.38	0.47	0.30	NS	0.47	0.67	NS
Tp in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Tp in CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.011	0.02	0.008	NS	0.47	2.21	NS	L.S.D. 0.01	0.62	0.43	0.31	NS	NS	0.82	0.47
L.S.D. 0.05	0.007	0.01	0.006	NS	0.36	1.66	NS	L.S.D. 0.05	0.37	0.31	0.23	NS	NS	0.62	0.36

B0, B1, B2 and B3 rates of biogas manure (0, 23.80, 47.60 and 71.40 t/he) A=Soils, B=Biogas manure, C=incubation

Table (6): Influence of sulphur and biogas application and incubation periods on hydraulic conductivity (cm/h) in salt affected and calcareous soils after harvesting.

Sulphur application											
Salt affected soils						Calcareous soils					
Salt affected soils	Sulphur	Incubation periods			Mean	Calcareous soils	Sulphur	Incubation periods			Mean
		P0	P2	P4				P0	P2	P4	
SAS1	S0	0.48	0.56	0.67	0.57	CS1	S0	17.95	17.77	17.52	17.75
	S1	0.62	0.70	0.92	0.75		S1	17.55	17.54	17.32	17.47
	S2	0.70	0.80	1.13	0.88		S2	17.23	17.17	17.07	17.16
	S3	0.69	1.03	1.47	1.06		S3	17.23	17.13	16.96	17.11
Mean		0.62	0.77	1.05	0.81	Mean		17.49	17.40	17.22	17.37
SAS2	S0	0.36	0.52	0.63	0.50	CS2	S0	5.35	5.44	5.57	5.45
	S1	0.43	0.62	0.73	0.59		S1	5.45	5.83	6.03	5.77
	S2	0.59	0.79	0.92	0.77		S2	5.71	5.85	6.00	5.85
	S3	0.68	0.88	1.06	0.87		S3	5.77	5.95	6.19	5.97
Mean		0.52	0.70	0.84	0.68	Mean		5.57	5.77	5.95	5.76
SAS3	S0	0.09	0.14	0.19	0.14	CS3	S0	2.62	2.71	2.79	2.71
	S1	0.16	0.24	0.41	0.27		S1	2.78	3.05	3.32	3.05
	S2	0.20	0.39	0.63	0.41		S2	2.76	3.21	3.43	3.13
	S3	0.28	0.51	0.73	0.51		S3	2.87	3.42	3.62	3.30
Mean		0.18	0.32	0.49	0.33	Mean		2.76	3.10	3.29	3.05

Biogas manure application											
Salt affected soils						Calcareous soils					
Salt affected soils	Biogas	Incubation periods			Mean	Calcareous soils	Biogas	Incubation periods			Mean
		P0	P2	P4				P0	P2	P4	
SAS1	Bo	0.52	0.60	0.69	0.60	CS1	Bo	18.12	17.64	17.40	17.72
	B1	0.69	0.73	0.93	0.78		B1	17.41	17.08	16.67	17.05
	B2	0.80	0.89	1.07	0.92		B2	17.15	16.73	16.31	16.73
	B3	0.84	0.93	1.28	1.02		B3	16.95	16.47	15.58	16.33
Mean		0.71	0.79	0.99	0.83	Mean		17.41	16.98	16.49	16.96
SAS2	Bo	0.34	0.49	0.62	0.48	CS2	Bo	5.37	5.50	5.57	5.48
	B1	0.35	0.65	0.74	0.58		B1	5.50	5.69	5.79	5.66
	B2	0.59	0.75	0.88	0.74		B2	5.71	5.84	5.87	5.81
	B3	0.68	0.86	0.99	0.84		B3	5.79	5.84	5.96	5.86
Mean		0.49	0.69	0.81	0.66	Mean		5.59	5.72	5.80	5.70
SAS3	Bo	0.09	0.16	0.19	0.15	CS3	Bo	2.65	2.74	2.80	2.73
	B1	0.16	0.27	0.40	0.28		B1	2.82	2.96	2.09	2.62
	B2	0.22	0.39	0.53	0.38		B2	2.89	3.07	3.30	3.09
	B3	0.34	0.53	0.59	0.49		B3	3.02	3.37	3.37	3.25
Mean		0.20	0.34	0.43	0.32	Mean		2.85	3.04	2.89	2.92

HC in SAS (sulphur)	A	B	C	A*B	A*C	B*C	A*B*C	HC in cs (sulphur)	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.055	0.04	0.032	0.072	0.055	0.19	0.11	L.S.D. 0.01	0.23	0.11	0.08	0.060	0.23	0.049	NS
L.S.D. 0.05	0.033	0.03	0.024	0.053	0.041	0.14	0.080	L.S.D. 0.05	0.14	0.08	0.06	0.044	0.17	0.036	NS
HC in SAS(biogas)	A	B	C	A*B	A*C	B*C	A*B*C	HC in CS (Biogas)	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.021	0.04	0.028	NS	2.09	0.049	0.028	L.S.D. 0.01	0.13	0.083	0.067	0.022	0.12	0.12	0.016
L.S.D. 0.05	0.012	0.020	0.021	NS	1.57	0.036	0.021	L.S.D. 0.05	0.075	0.060	0.050	0.16	0.094	0.088	0.012

HC= hydraulic conductivity

Table (7): Influence of sulphur and biogas treatments and incubation periods on total water stable aggregates (%) in salt affected and calcareous soils after harvesting.

Sulphur application

Salt affected soils	Sulphur	Incubation periods P0	P2	P4	Mean	Calcareous soils	Sulphur	Incubation periods P0	P2	P4	Mean
SAS1	S0	59.04	61.62	61.52	60.73	CS1	S0	15.56	15.49	16.07	15.71
	S1	60.67	62.71	66.64	63.34		S1	15.60	16.99	17.92	16.84
	S2	59.30	64.57	67.50	63.79		S2	16.43	17.45	18.88	17.59
	S3	62.81	64.94	68.13	65.29		S3	17.47	17.74	20.18	18.46
Mean		60.46	63.46	65.95	63.29	Mean		16.27	16.92	18.26	17.15
SAS2	S0	49.69	50.26	50.61	50.19	CS2	S0	26.57	28.02	27.18	27.26
	S1	51.32	53.01	55.60	53.31		S1	26.86	27.66	29.81	28.11
	S2	52.67	54.34	60.76	55.92		S2	27.83	29.30	31.64	29.59
	S3	54.11	53.86	59.70	55.89		S3	28.53	31.69	34.13	31.45
Mean		51.95	52.87	56.67	53.83	Mean		27.45	29.17	30.69	29.10
SAS3	S0	41.68	42.01	42.43	42.04	CS3	S0	35.73	36.70	37.26	36.56
	S1	43.30	43.78	44.99	44.02		S1	36.81	39.22	40.67	38.90
	S2	44.28	44.83	45.53	44.88		S2	38.27	40.43	43.45	40.72
	S3	44.20	46.18	47.65	46.01		S3	39.22	41.50	44.42	41.71
Mean		43.37	44.20	45.15	44.24	Mean		37.51	39.46	41.45	39.47

Biogas manure application

Salt affected soils	Biogas	Incubation periods P0	P2	P4	Mean	Calcareous soils	Biogas	Incubation periods P0	P2	P4	Mean
SAS1	Bo	60.51	62.39	62.72	61.87	CS1	Bo	15.77	15.97	16.08	15.94
	B1	63.71	66.56	69.60	66.62		B1	16.73	17.61	17.72	17.35
	B2	65.93	70.01	76.29	70.74		B2	17.32	18.55	20.17	18.68
	B3	67.55	72.34	78.72	72.87		B3	17.17	18.85	22.47	19.50
Mean		64.43	67.83	71.83	68.03	Mean		16.75	17.75	19.11	17.87
SAS2	Bo	45.32	45.88	46.41	45.87	CS2	Bo	26.82	27.29	27.35	27.15
	B1	47.60	49.71	53.42	50.24		B1	27.85	29.27	30.92	29.35
	B2	49.67	51.21	55.70	52.19		B2	29.10	30.91	35.42	31.81
	B3	50.18	53.76	58.85	54.26		B3	29.48	34.38	37.31	33.72
Mean		48.19	50.14	53.60	50.64	Mean		28.31	30.46	32.75	30.51
SAS3	Bo	42.70	42.61	43.46	42.92	CS3	Bo	36.06	38.31	38.86	37.74
	B1	45.75	47.22	48.26	47.08		B1	37.78	40.81	42.72	40.44
	B2	48.40	49.61	52.47	50.16		B2	39.79	42.77	45.11	42.56
	B3	49.99	52.38	56.15	52.84		B3	40.02	44.31	47.18	43.84
Mean		46.71	47.96	50.09	48.25	Mean		38.41	41.55	43.47	41.14

TG in SAS (sulphur)	A	B	C	A*B	A*C	B*C	A*B*C	TG in cs (sulphur)	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	1.84	1.08	0.86	NS	1.86	1.52	NS	L.S.D. 0.01	0.37	0.34	0.24	0.580	0.48	0.46	0.27
L.S.D. 0.05	1.11	0.79	0.64	NS	1.39	1.14	NS	L.S.D. 0.05	0.23	0.24	0.18	0.42	0.28	0.34	0.20
TG in SAS(biogas)	A	B	C	A*B	A*C	B*C	A*B*C	TG in CS (Biogas)	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	1.99	0.66	0.98	1.15	2.00	0.93	NS	L.S.D. 0.01	0.44	0.5	0.35	0.86	0.44	0.69	0.40
L.S.D. 0.05	1.20	0.48	0.74	0.84	1.50	0.70	NS	L.S.D. 0.05	0.26	0.36	0.26	0.63	0.33	0.52	0.30

TG= total aggregates

Table (8): Influence of sulphur application on grain and straw yield of barley plant in salt affected and calcareous soils after harvesting.

Grain (g/pot)

Salt affected soils	Sulphur	P0	P2	P4	Mean	Calcareous soils	Sulphur	P0	P2	P4	Mean
SAS1	S0	22.63	22.84	23.27	22.91	CS1	S0	16.04	16.52	16.97	16.51
	S1	24.83	24.92	26.19	25.31		S1	17.00	17.50	18.56	17.69
	S2	24.54	25.78	26.19	25.50		S2	16.89	18.57	19.61	18.36
	S3	25.03	26.06	26.19	25.76		S3	17.89	18.26	19.26	18.47
Mean		24.26	24.90	25.46	24.87	Mean		16.96	17.71	18.60	17.76
SAS2	S0	13.62	13.96	14.87	14.15	CS2	S0	11.41	11.81	12.53	11.92
	S1	15.00	16.31	17.42	16.24		S1	13.07	14.34	15.37	14.26
	S2	14.93	16.11	17.78	16.27		S2	13.45	13.77	17.07	14.76
	S3	15.39	16.95	19.53	17.29		S3	14.01	16.02	18.36	16.13
Mean		14.74	15.83	17.40	15.99	Mean		12.99	13.99	15.83	14.27
SAS3	S0	3.73	3.89	4.22	3.95	CS3	S0	5.60	5.98	6.64	6.07
	S1	5.39	6.13	6.74	6.09		S1	5.71	7.39	9.13	7.41
	S2	6.21	6.40	7.83	6.81		S2	6.53	7.69	8.76	7.66
	S3	6.71	8.73	10.52	8.65		S3	7.57	9.21	11.91	9.56
Mean		5.51	6.29	7.33	6.38	Mean		6.35	7.57	9.11	7.68

Straw (g/pot)

Salt affected soils	Sulphur	P0	P2	P4	Mean	Calcareous soils	Sulphur	P0	P2	P4	Mean
SAS1	S0	51.30	51.94	52.46	51.90	CS1	S0	39.39	39.57	40.22	39.73
	S1	52.29	53.82	56.17	54.09		S1	41.06	43.67	45.11	43.28
	S2	52.32	55.40	54.77	54.16		S2	41.83	44.43	48.65	44.97
	S3	54.39	54.77	61.14	56.77		S3	44.84	48.01	51.95	48.27
Mean		52.58	53.98	56.14	54.23	Mean		41.78	43.92	46.48	44.06
SAS2	S0	35.25	35.94	36.79	35.99	CS2	S0	26.79	27.53	29.02	27.78
	S1	36.58	39.91	41.23	39.24		S1	27.61	28.99	33.69	30.10
	S2	37.88	41.06	45.53	41.49		S2	28.63	32.29	38.69	33.20
	S3	37.65	42.36	43.74	41.25		S3	28.11	33.51	42.49	34.70
Mean		36.84	39.82	41.82	39.49	Mean		27.79	30.58	35.97	31.45
SAS3	S0	10.35	11.31	11.67	11.11	CS3	S0	14.10	14.57	14.83	14.50
	S1	11.98	14.15	13.78	13.30		S1	15.28	16.92	18.99	17.06
	S2	11.91	13.23	15.69	13.61		S2	16.27	16.82	22.96	18.68
	S3	12.56	15.82	18.89	15.76		S3	17.78	18.60	27.23	21.20
Mean		11.70	13.63	15.01	13.45	Mean		15.86	16.73	21.00	17.86

Grain in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Grain in CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.72	0.7	0.44	1.21	0.77	0.88	NS	L.S.D. 0.01	1.45	0.54	0.46	0.93	0.80	0.93	NS
L.S.D. 0.05	0.43	0.51	0.33	0.88	0.58	0.66	NS	L.S.D. 0.05	0.87	0.39	0.35	0.68	0.6	0.7	NS
Straw SAS	A	B	C	A*B	A*C	B*C	A*B*C	Strawin CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	2.62	1.99	1.11	NS	NS	2.23	NS	L.S.D. 0.01	2.43	1.49	1.03	NS	1.78	2.05	NS
L.S.D. 0.05	1.58	1.45	0.83	NS	NS	1.67	NS	L.S.D. 0.05	1.47	1.08	0.77	NS	1.33	1.54	NS

A= soil B=Sulphur additioin C= incubation periods

Table (9): Influence of biogas manure application on grain and straw yield of barley plants in alluvial and calcareous soils after harvesting.

Grain (g/pot)											
Salt affected soils						Calcareous soils					
Salt affected soils	Biogas	Incubation periods P0	P2	P4	Mean	Calcareous soils	Biogas	Incubation periods P0	P2	P4	Mean
SAS1	B0	21.71	22.66	23.22	22.53	CS1	B0	16.04	16.61	17.09	16.58
	B1	24.82	25.08	25.54	25.15		B1	17.03	18.34	19.53	18.30
	B2	24.94	25.82	26.55	25.77		B2	18.04	19.54	19.25	18.94
	B3	25.01	26.55	27.05	26.20		B3	18.58	19.46	21.20	19.75
Mean		24.12	25.03	25.59	24.91	Mean		17.42	18.49	19.27	18.39
SAS2	B0	13.36	14.04	14.88	14.09	CS2	B0	11.57	11.84	12.39	11.93
	B1	15.01	16.56	17.57	16.38		B1	12.95	13.16	13.63	13.25
	B2	15.49	17.57	20.41	17.82		B2	13.34	13.24	15.40	13.99
	B3	16.31	17.04	19.89	17.75		B3	13.75	14.69	17.15	15.20
Mean		15.04	16.30	18.19	16.51	Mean		12.90	13.23	14.64	13.59
SAS3	B0	3.95	4.26	4.96	4.39	CS3	B0	5.48	5.91	6.42	5.94
	B1	5.92	6.77	8.73	7.14		B1	6.28	7.03	8.45	7.25
	B2	7.16	8.95	9.95	8.69		B2	6.53	7.85	8.10	7.49
	B3	8.55	9.68	11.79	10.01		B3	8.11	7.55	10.01	8.56
Mean		6.40	7.42	8.86	7.56	Mean		6.60	7.09	8.25	7.31

Straw (g/pot)											
Salt affected soils						Calcareous soils					
Salt affected soils	Biogas	Incubation periods P0	P2	P4	Mean	Calcareous soils	Biogas	Incubation periods P0	P2	P4	Mean
SAS1	B0	50.71	51.43	51.98	51.37	CS1	B0	37.85	40.12	40.73	39.57
	B1	52.59	55.26	59.60	55.82		B1	38.87	42.93	46.95	42.92
	B2	55.26	59.31	59.01	57.86		B2	40.66	41.88	50.15	44.23
	B3	55.52	58.28	63.09	58.96		B3	43.56	48.64	54.24	48.81
Mean		53.52	56.07	58.42	56.00	Mean		40.24	43.39	48.02	43.88
SAS2	B0	35.67	37.21	37.32	36.73	CS2	B0	26.52	27.38	29.15	27.68
	B1	38.43	41.83	45.54	41.93		B1	28.01	28.38	31.86	29.42
	B2	40.90	43.44	46.27	43.54		B2	29.09	31.12	36.85	32.35
	B3	42.21	44.07	49.57	45.28		B3	28.41	34.48	42.61	35.17
Mean		39.30	41.64	44.68	41.87	Mean		28.01	30.34	35.12	31.16
SAS3	B0	11.84	11.57	12.25	11.89	CS3	B0	13.89	14.56	15.06	14.50
	B1	12.88	12.91	14.87	13.55		B1	15.40	16.98	18.72	17.03
	B2	13.52	15.30	16.36	15.06		B2	17.37	20.17	18.15	18.56
	B3	13.68	16.74	20.05	16.82		B3	18.15	18.97	21.27	19.46
Mean		12.98	14.13	15.88	14.33	Mean		16.20	17.67	18.30	17.39

Grain in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Grain in CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	0.44	0.69	0.43	1.11	0.75	0.86	NS	L.S.D. 0.01	1.03	0.74	0.56	NS	NS	NS	NS
L.S.D. 0.05	0.27	0.47	0.32	0.81	0.56	0.65	NS	L.S.D. 0.05	0.62	0.54	0.42	NS	NS	NS	NS
Staw in SAS	A	B	C	A*B	A*C	B*C	A*B*C	Straw in CS	A	B	C	A*B	A*C	B*C	A*B*C
L.S.D. 0.01	2.25	1.79	1.27	NS	NS	2.56	NS	L.S.D. 0.01	1.6	1.15	0.91	1.99	1.58	1.82	3.15
L.S.D. 0.05	1.36	1.31	0.96	NS	NS	1.92	NS	L.S.D. 0.05	0.97	0.84	0.68	1.45	1.19	1.36	2.36

A= soil B= biogas manure additioin C= incubation periods

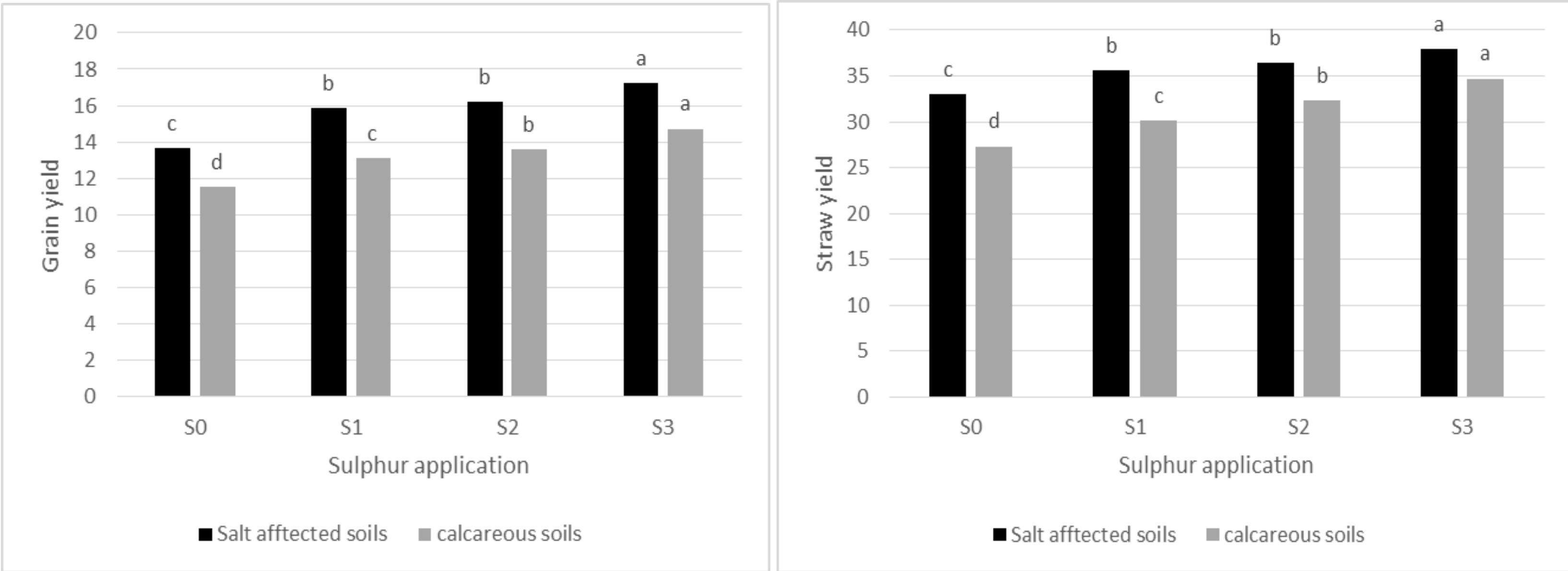

Fig.(1): Impact of sulphur application on barley grain and straw (g/pot) in salt affected and calcareous soils.

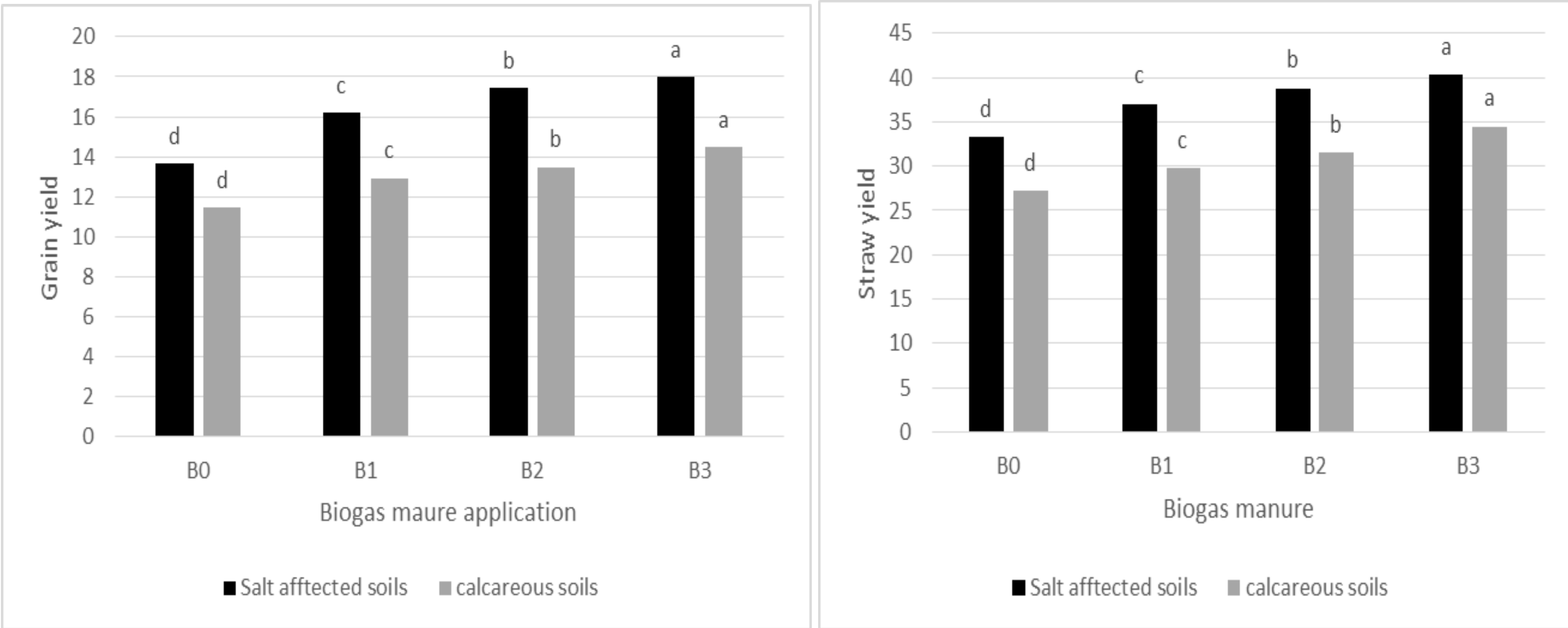

Fig.(2): Impact of biogas manure application on barley grain and straw (g/pot) in salt affected and calcareous soils